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## ZOOPLANKTON MONITORING RESULTS IN THE ICES AREA: SUMMARY STATUS REPORT 2003/2004

PREPARED BY THE ICES WORKING GROUP ON ZOOPLANKTON ECOLOGY

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## 1 Background

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The ICES strategic plan recognised the ICES role in making scientific information accessible to the public in addition to the fisheries and environmental assessment groups. Thus, during the 1999 Annual Science Conference a general request was made from ICES to the Oceanography Committee Working Groups to develop data products and summaries that could be provided on a routine basis to the ICES community via the ICES website. The Working Group on Zooplankton Ecology (WGZE) considers it a priority action to produce a summary report on zooplankton activities in the ICES area based on the time-series obtained in the national monitoring programmes. The WGZE has edited such an annual report since 2000.

This is the fifth summary on zooplankton monitoring results in the ICES area. Phytoplankton and temperature data for some locations corresponding to the zooplankton sampling sites are also included in this report. The final goal will be the production, in the near future, of a Plankton Status Report with environmental variables.

In addition we have improved this year's report with several new series on the Barents and Baltic Seas, the presentation of annual means of zooplankton abundance in terms of anomalies, and the inclusion of a general overview of SST, phytoplankton colour index, and copepod abundance for the entire North Atlantic provided by SAHFOS, which serves to discuss the regional description of the time-series results from the monitoring programmes and also places the data in a basin scale context.

The work in preparing this report is based on contributions from members of the ICES Working Group on Zooplankton Ecology (WGZE) and from colleagues in ICES Member Countries, who are leading zooplankton time-series programmes. In addition to the editors, the following people have contributed or provided comments on the contents:

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## 2 Regional coverage

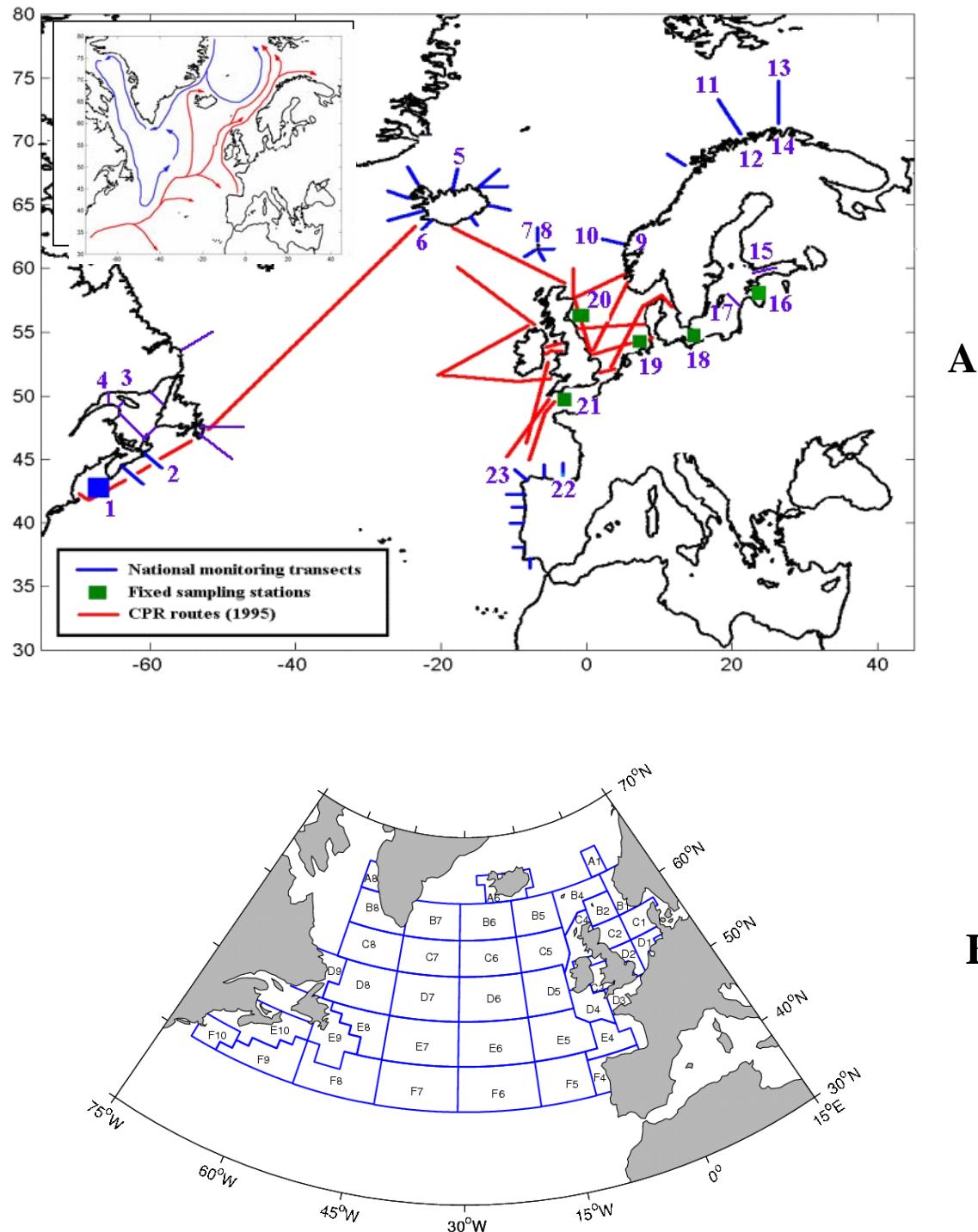
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The information collated by the ICES WGZE are derived from zooplankton sampling programmes in the ICES area which include 5 fixed stations and 35 standard sections (approx. 350 sampling stations) distributed on the continental margins of both America and Europe and covering an area from the temperate latitudes south of Portugal to the colder regions north of Norway, Iceland, and Canada. In addition, there are several fixed CPR routes that cover coastal and oceanic waters in the Atlantic. The sampling networks and the collections used in this report are shown in Figure 1.

As shown in the time-series presented here, zooplankton abundance is very variable between years. Temperature can have a large influence on the community structure and production of zooplankton and can cause large seasonal, annual, and decadal changes in zooplankton population size and species distribution. Other factors that explain biogeographical differences in species distribution, in plankton abundance, and in biological processes are the extent of exposure to sun light (latitude), the timing of the spring bloom, the length of the season of water column stratification, etc. It was for these reasons that data sets included in this report are presented by affinities in temperature and biogeographical areas, which correspond to regional seas or basins, and are discussed under this biogeographical scheme.

The main characteristic of the zooplankton monitoring programmes is the temporal resolution of observations. Zooplankton is also sampled with a variety of nets and over a variety of temporal and spatial scales, so a comprehensive interpretation of the data sets requires information on metadata to describe the content, quality, and other data characteristics (sampling gear, mesh size, depth, sampling site, dates, ancillary data, person responsible for the data, etc.). These metadata can be found in Section 6 and will help a reader to locate and understand the data presented in this document.

Data are presented in biomass (Icelandic–Norwegian basin and Barents Sea) or abundance (Canada, Baltic Sea, North Sea, English Channel, Bay of Biscay, and Iberian coast), with only one data set expressed as abundance in number of organisms per sample (CPR), and another expressed in plankton volume (Georges Bank). Abundance and biomass are structural variables that allow for easy comparison.



**Figure 1: A: Zooplankton sampling network in the ICES area (only sampling programmes reported in the WGZE); numbers make reference to the collections used in this report. Map in the upper left corner represents the schematic general circulation of the North Atlantic. B: Map of CPR standard areas in the North Atlantic.**

### 3 Regional descriptions

#### 3.1 Western Atlantic

##### 1: Georges Bank

The Northeast Fisheries Science Center conducts two types of zooplankton monitoring programmes, operated by the Laboratory in Narragansett. The first is CPR transects across the Gulf of Maine and across the shelf from New York City towards Bermuda.

The second type of monitoring is by Bongo net (333  $\mu\text{m}$  mesh) samples, which are collected six times per year in a polygon of stations over the shelf region. Figure 2 shows the median plankton displacement volume on Georges Bank in the early spring and early autumn. The spring 2004 value was nearly three times larger than any other value in the 34-year series. This high volume was due to a phytoplankton bloom that was occurring over a wide area of the Bank at the time of the survey. The annual mean values combining the spring and fall data sets are quite stable around 40  $\text{ml m}^{-3}$  of displacement volume. The yearly differences in the annual mean anomalies are also shown in the same figure.

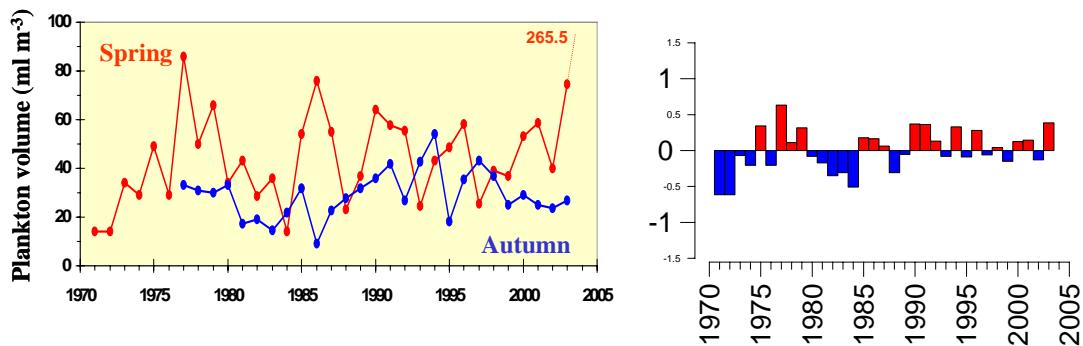


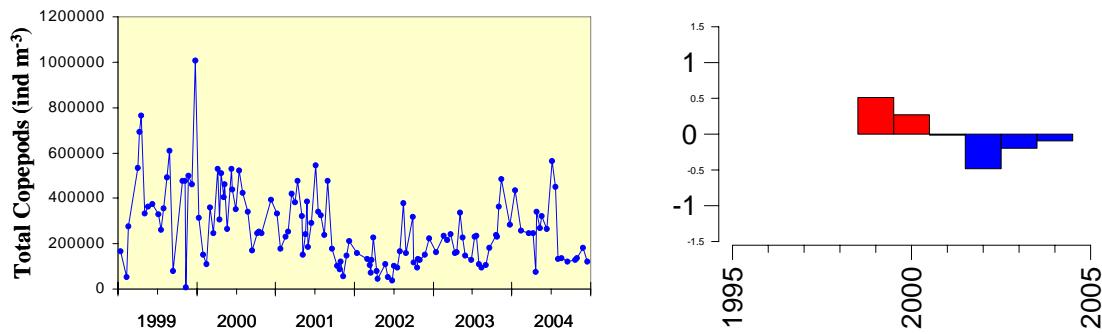
Figure 2: Plankton displacement volume on Georges Bank in the early spring and early autumn (left), and interannual variability in terms of normalised anomalies combining the spring and autumn data sets (right).

##### 2: Halifax Line Station 2 (West Atlantic, Scotian Shelf)

Zooplankton are sampled every 2–4 weeks (if possible) using research ships, trawlers, and a small SAR vessel with a net of 0.75 m diameter ring mounted with a 200  $\mu\text{m}$  mesh. Sampling is carried out on a number of stations on a series of transects that run perpendicular to the coast of Nova Scotia across the Scotian Shelf. The most frequently sampled station is in HL2 on the inshore edge of Emerald Basin, a 150-m depth station approximately 20 miles offshore from Halifax. CTD profiles are recorded, and also samples for phytoplankton, nutrients, and extracted chlorophyll are collected using Niskin bottles at fixed depths. Sub-samples are combined to give an integrated sample.

Zooplankton samples are split and one half is used for wet/dry weight determination. The second split is sub-sampled to give at least 200 organisms, which are identified, to genus or species, and enumerated. Another sub-sample is taken that contains at least 100 *Calanus* spp., which are identified and enumerated to species and stage. Biomass of the dominant groups are calculated using dry weights of various groupings (*Calanus*, *Oithona*, *Pseudocalanus*, and *Metridia*) and abundance data. The data are entered into the “BioChem” database at the DFO.

An ecosystem status report on the state of the phytoplankton and zooplankton in Canadian Atlantic waters is prepared every year. This report is also published on the web at <http://www.dfo-mpo.gc.ca/csas/Csas/English>Status/general.htm>. During 1998 and 1999 the population was at high levels, decreasing to a low in 2002. This is also noted when the total population of copepods is plotted (Figure 3). In spring 2003 *Calanus finmarchicus* values were close to or a bit above the mean of the time-series. Copepods also increased in 2003 and 2004, but they are still below the mean (Figure 3, right).



**Figure 3: Abundance of copepods at HL2 (1999–2004) (left), and interannual variability in terms of normalised anomalies of annual means (right).**

### 3–4: Gaspé Current and Anticosti Gyre (Northwest Gulf of St. Lawrence)

The Atlantic Zone Monitoring Programme (AZMP) was implemented in 1998 with the aim of collecting and analysing the biological, chemical, and physical field data that are necessary to (1) characterize and understand the causes of oceanic variability at the seasonal, interannual, and decadal scales, (2) provide multidisciplinary data sets that can be used to establish relationships among the biological, chemical, and physical variables, and (3) provide adequate data to support the sound development of ocean activities. The key element of the AZMP sampling strategy is the oceanographic sampling at fixed stations and along sections. The fixed stations are occupied about every two weeks, conditions permitting, and the sections are sampled from one to three times during the year. The location of the regular sections is shown in Figure 1. The zooplankton samples are analyzed following the same protocol as the one described above for the Halifax Line Station 2. An ecosystem status report on the state of the phytoplankton and zooplankton is also prepared every year and published on the web at <http://www.dfo-mpo.gc.ca/csas/Csas/English>Status/general.htm>.

Data presented in the present status report (Figure 4) are from two sampling stations: the Gaspé Current and the Anticosti Gyre, both in the northwest Gulf of St. Lawrence (GSL). The GSL is a coastal marine environment with a particularly high zooplankton biomass relative to other coastal areas, dominated by *Calanus* species (de Lafontaine *et al.*, 1991). In 2004, the overall abundance and biomass of zooplankton observed in the Gaspé Current and the Anticosti Gyre were comparable with what we observed from 1999 to 2003. Likewise, the mean annual zooplankton abundance and biomass observed in late spring and fall 2004 along all sections were comparable with observations made in 2000, 2001, 2002, and 2003 (Harvey *et al.*, 2005). Zooplankton abundance and biomass do not follow the same pattern as the concentration of chlorophyll *a*, e.g., the zooplankton peak observed in the Gaspé Current in 2003 corresponded to a chlorophyll *a* minimum and the chlorophyll *a* peak in the Anticosti Gyre in 2001 corresponded to a zooplankton minimum. This absence of coupling between zooplankton and algal biomass has been previously observed in the GSL (de Lafontaine *et al.*, 1991; Roy *et al.*, 2000) and was attributed to the complex estuarine circulation pattern observed in both the Gaspé Current and the Anticosti Gyre. Annual cycles of surface temperature in both cases are similar, with values below 0°C in winter and peaks above 14°C during the summer.

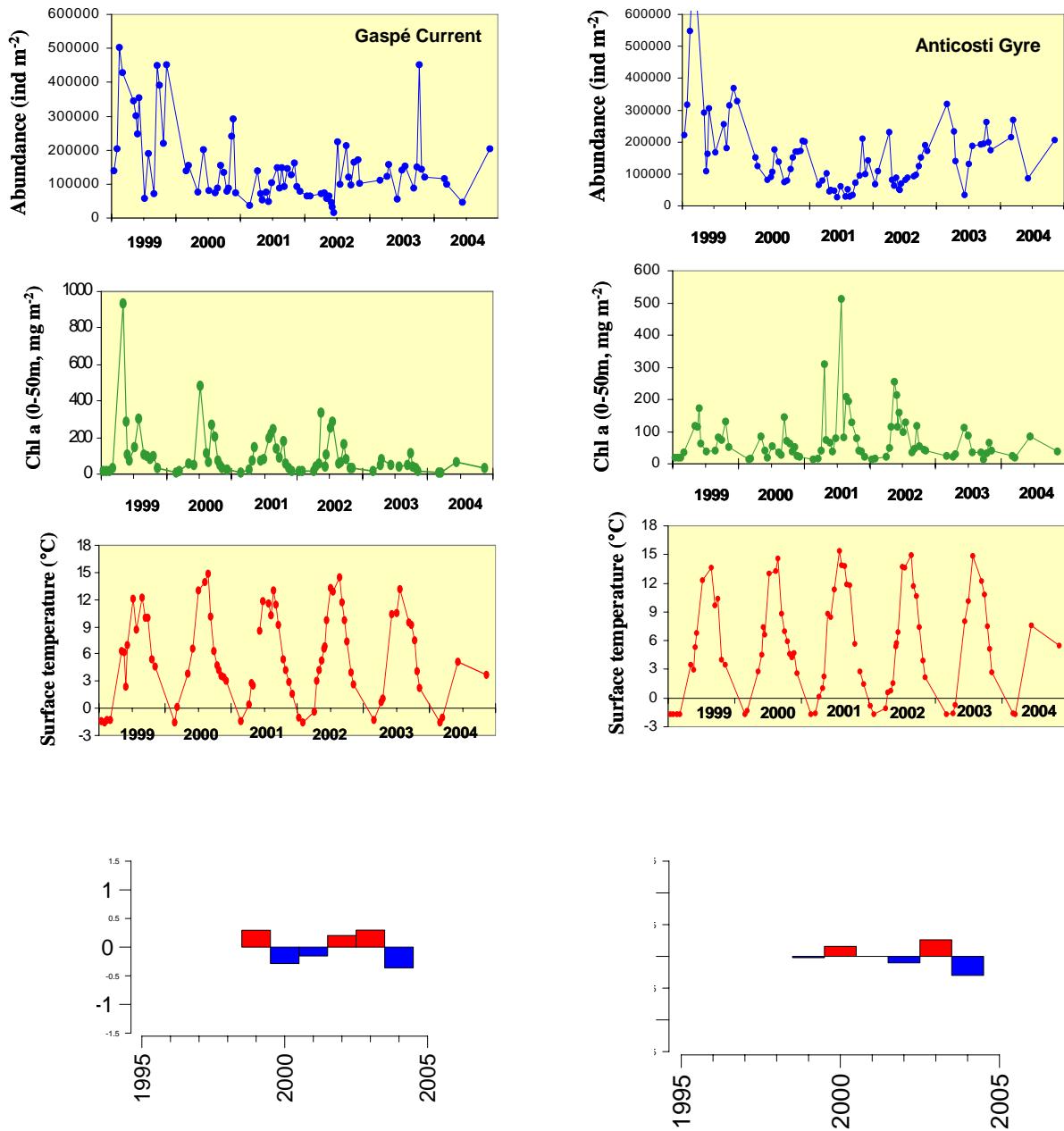


Figure 4: Time-series of zooplankton abundance and biomass, chlorophyll, and temperature in the northwest Gulf of St. Lawrence. Lower plots show interannual variability in terms of normalised anomalies of annual means.

### 3.2 Icelandic-Norwegian basin

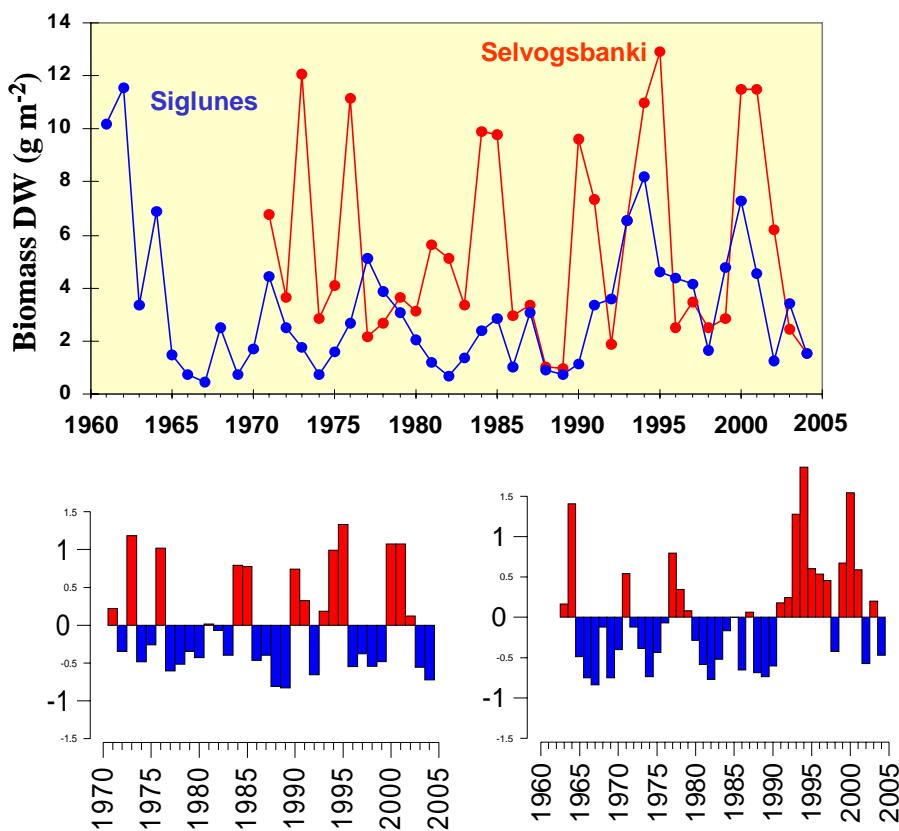
#### 5–6: Siglunes (North Iceland) and Selvogsbanki (South Iceland)

The Icelandic monitoring programme for zooplankton consists of a series of transects perpendicular to the coastline. Sampling of the transects to the north and east of Iceland was started in the 1960s. Additional section lines to the south and west were added in the 1970s. There are now about 90 stations in total. Zooplankton investigations are carried out at these stations every year in May–June. Long-term changes in zooplankton biomass at Siglunes transect from the north of Iceland and at Selvogsbanki from the south are shown in Figure 5. At Siglunes the values are averages from eight stations, while on Selvogsbanki the values represent averages from five stations.

At the Selvogsbanki transect the zooplankton biomass showed a peak during the early 1980s while a low was observed during the late 1980s. Peaks were also observed around 1995 and 2000–2001. The time period between the zooplankton peaks on the Selvogsbanki transect has been 5–10 years.

North of Iceland (Siglunes transect) the high values of zooplankton in the beginning of the series dropped drastically with the onset of the Great Salinity Anomaly of the 1960s. Since then zooplankton biomass has varied with highs at approximately 7–10 year intervals. The last peak in zooplankton biomass occurred around 2000. In 2004 the values at both Siglunes and Selvogsbanki transects were among the lowest of the time-series.

The zooplankton biomass north of Iceland is influenced by the inflow of warm Atlantic Water to the area. Thus, in warm years, when the flow of Atlantic Water onto the northern shelf is high, the zooplankton biomass is almost two times higher than in cold years, when this inflow is not as evident (Astthorsson and Gislason, 1998; Astthorsson and Vilhjalmsson, 2002). The reason for this may be the better feeding conditions of the zooplankton due to increased primary production in warm years, advection of zooplankton with the Atlantic Water from the south, and faster temperature-dependent growth of the zooplankton in warm years. During both 2000 and 2001, when the biomass of zooplankton north of Iceland was particularly high, the inflow of warm Atlantic water onto the northern shelf was also high. South of Iceland the links between climate and zooplankton biomass are not as evident as north of Iceland. Most likely the variability off the south and west coasts is related to the timing and magnitude of the primary productivity on the banks, which is in turn influenced by the freshwater efflux from rivers and by the wind force and direction.



**Figure 5: Year-to-year variability of zooplankton biomass at Siglunes and Selvogsbanki (upper panel), and interannual variability in terms of normalised anomalies of annual means (lower panel) of Siglunes (left) and Selvogsbanki (right).**

Comparison with other data from the northern North Atlantic shows that observed zooplankton biomass in spring is descriptive of the mean copepod biomass in that year. Recent research also shows that the variation of zooplankton biomass in the Icelandic area is in tune with long-term variability of zooplankton abundance over a much larger area, i.e. in the northern North Atlantic in general (Asthorsson and Gislason, 1995), as shown in Section 4 of the present Status Report.

## 7–8: Faroe Islands

The Faroese Fisheries Laboratory operates four standard sections radiating northwards, eastwards, southwards, and south-westwards from the Faroes. These sections are sampled four times per year: in February, May, June/July, and November.

The northwards section penetrating into the Norwegian basin (which is presented here) contains 14 stations with a distance of 10 nautical miles between each station. The southernmost end of the section is on the Faroe shelf and is covered by warm Atlantic Water (AW), which in most years contains essentially neritic zooplankton, mixed with variable abundance of oceanic zooplankton. The abundance of oceanic zooplankton (mainly *Calanus finmarchicus*) on the shelf is highly variable between years. From the slope and northwards, the northernmost part of the section is covered by cold East Atlantic Current Water (EICW).

Figure 6 shows the average zooplankton biomass in the upper 50 m in these two water masses in the oceanic part of the section in May 1990–2004. This usually is close to phytoplankton spring bloom. *C. finmarchicus* is the dominant species in both water masses. With the exception of 1993, the biomass was clearly higher in the cold water mass in the northern part of the section than in the warmer southern part. The reason is a higher abundance of overwintered *C. finmarchicus* (CV and adults) combined with the presence of *Calanus hyperboreus* in the northern part. In the Atlantic water, much fewer large individuals are present, but higher numbers of small stages in May. Since the reproduction starts earlier in the southern part of the section, the total numbers of *C. finmarchicus* are higher on average in the AW than in the EICW, despite the lower biomass (Gaard, 1996, 1999).

However, in the last two years (May 2003 and 2004) the abundance of young *C. finmarchicus* copepodite stages in the northern part of the section has increased significantly, and there was no clear difference any more in the *C. finmarchicus* stage composition in these two water masses. This indicates an earlier reproduction in the EICW in the last two years compared to previous years. In May 1990–2002 the fraction of *C. finmarchicus* recruits in this water mass was only ~10%, but in 2003 it increased to ~45% and in 2004 to ~75%. Another change in the last two years is that no *C. hyperboreus* were found in the northern part of the section. These were quite numerous in most previous years.

Apparently the lower temperatures in the northern part of the section (Figure 6 lower panel, left) have been a main reason for the generally later *C. finmarchicus* reproduction between the two water masses in previous years. The difference does not seem to be explained by phytoplankton abundance, since the chlorophyll *a* concentrations in most years were higher in the cold EICW than in the warmer AW (Figure 6 lower panel, right).

Similarly, a possible reason for the apparently early reproduction of *C. finmarchicus*, and for the disappearance of *C. hyperboreus*, in the EICW in 2003 and 2004 compared to the previous years in the time-series may be that the temperature in this water mass has increased significantly. The average temperature in the upper 50 m in this water mass in May 2003 and 2004 was 5.5°C, which is 1.6°C higher than in 2002. This is also the highest temperature recorded in the time-series in the EICW part of the section (Figure 6 lower panel, left).

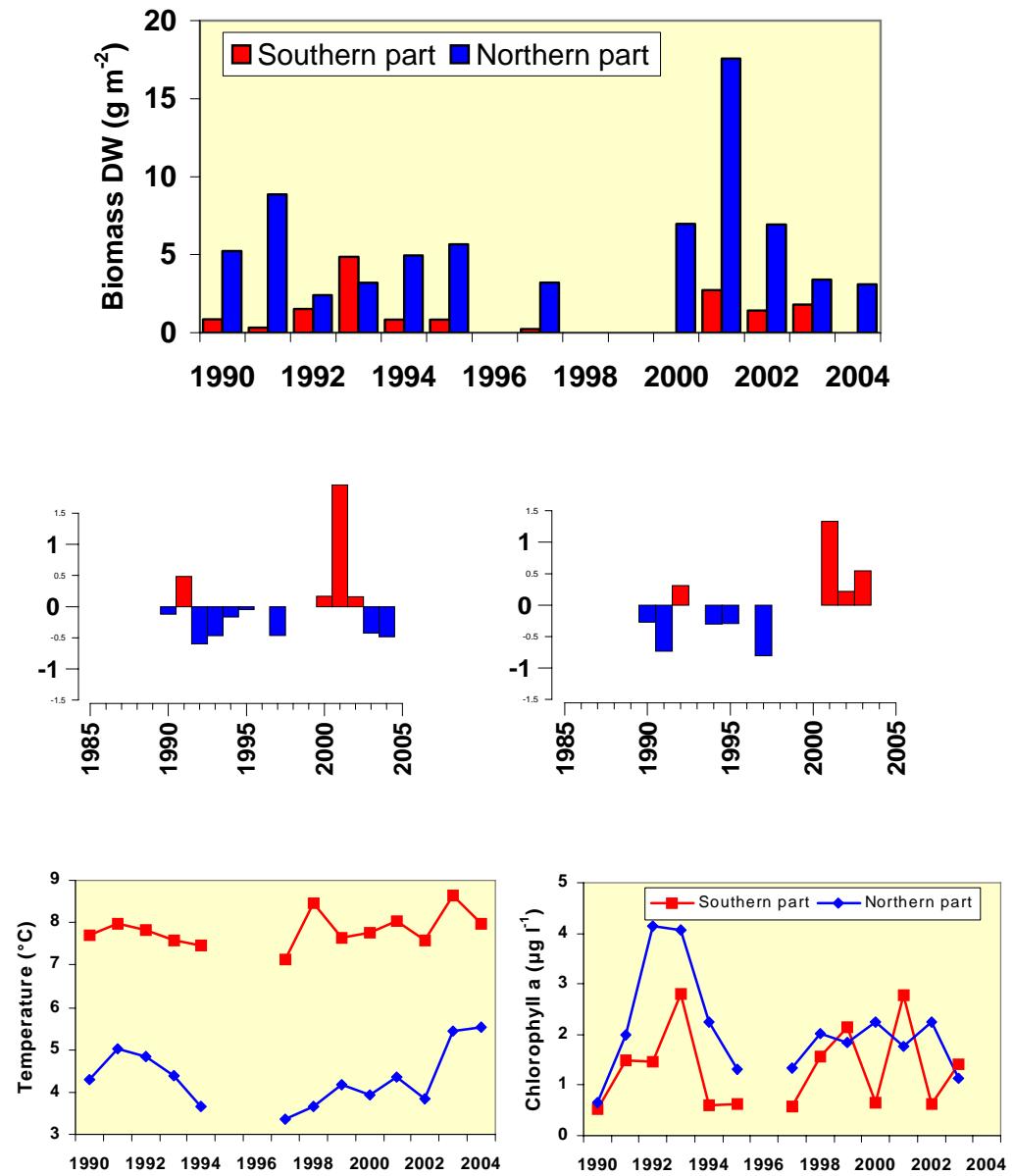


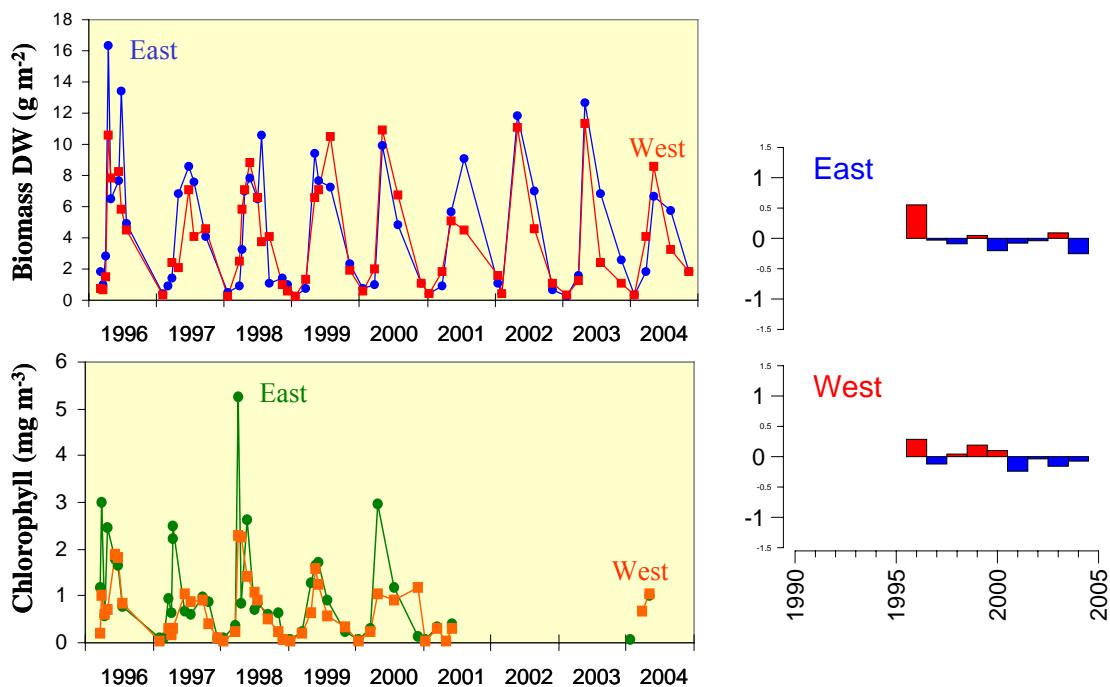
Figure 6: (upper panel) Zooplankton biomass at 0- to 50-m depth in Atlantic Water (southern part) and the East Icelandic Current Water (northern part) on Faroe section North in May 1990–2004. No data is available from 1996, 1998, 1999, 2000, and 2004 south due to too high phytoplankton abundance in the net samples. (middle panels) Interannual variability in terms of normalised anomalies of annual means, North and South (left and right, respectively). (lower panels) Temperature (left) and chlorophyll a (right) concentrations at 0- to 50-m depth on section North.

### 9–10: East and West off Svinøy (Norwegian Sea)

Two fixed transects are sampled within the “IMR Monitoring Programme” in the Norwegian Sea: the Svinøy transect (15 stations) and the Gimsoy transect (10 stations). These Norwegian Sea transects are sampled 4–10 times/yr. Additionally the Norwegian Sea is surveyed in May and July–August, both surveys ca. 50–100 stations. Data are stored at the TINDOR database at IMR. Periodic reports are made annually to the Ministry of Fisheries and in the IMR’s Annual Report on Marine Ecosystems.

The development of zooplankton biomass in spring at the Svinøy transect showed very small variations among years in the period 1997–2004 (Figure 7), and the maximum biomass in early summer varied from 8 to 9.3 g DW m<sup>-2</sup>. In 2002, the biomass as an average for all stations was 11.32 g DW m<sup>-2</sup> (28–30 April) higher than previous years. The maximum biomasses were 11.8 and 111 g DW m<sup>-2</sup> as an average for the eastern and western part, respectively. In 2003 the highest biomasses were observed in the second part of April, 12.6 g DW m<sup>-2</sup> in the eastern part, and 11.3 g DW m<sup>-2</sup> in the western part, i.e. almost similar to the previous year.

Chlorophyll at 10-m depth show that the bloom at the Svinøy transect occurs in late April and early May. A protracted post-bloom period persists through summer and early autumn, which is typical for the southern Norwegian Sea.



**Figure 7: Left:** Zooplankton biomass and chlorophyll at Svinøy transect. **Right:** Interannual variability in terms of normalised anomalies of annual means.

### 3.3 Barents Sea

Two standard sections are sampled within the “IMR Monitoring Programme” in the Barents Sea: the Fu-gløya-Bjørnøya transect (7 stations) and the Vardø N transect (8 stations). These Norwegian transects are usually sampled 3–6 and 2–3 times/yr, respectively. The zooplankton are sampled with two WP2-net hauls from 100 m to the surface, and from the bottom to the surface. Data are stored at the TINDOR database at IMR.

### 11–12: North and South off Fugløya-Bjørnøya

The data presented in Figure 8 stems from bottom-to-surface hauls. During the mid-1990s zooplankton biomass was high. Since then biomass has decreased, and the biomass in 2004 is the lowest observed in the sampling period. Fluctuations in biomass from year to year have also decreased over the years. Maximum biomass in the Barents Sea occurs somewhat later than in the Norwegian Sea.

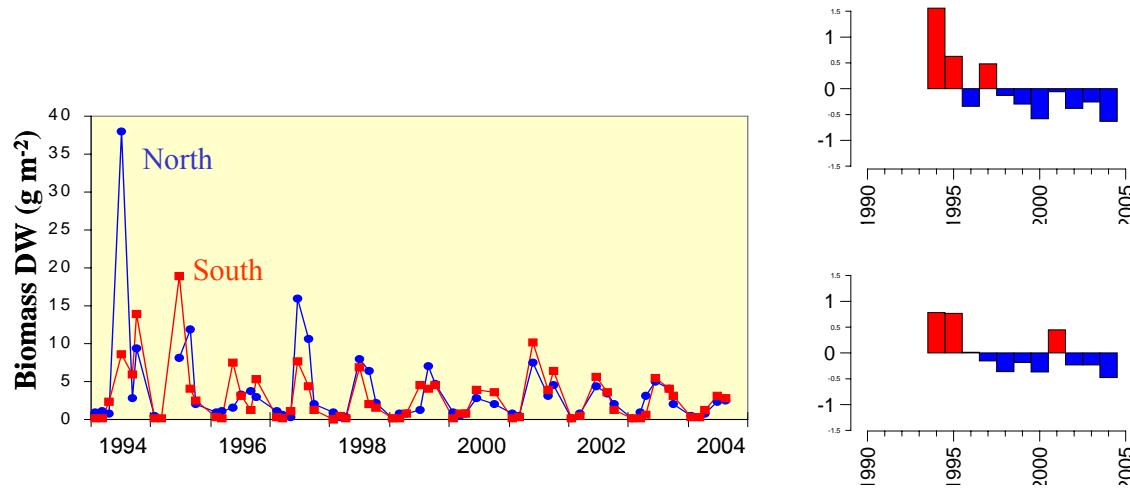


Figure 8: Left: Zooplankton biomass at Fugløya-Bjørnøya transect, divided in northern and southern sections. Right: Interannual variability in terms of normalised anomalies of annual means.

### 13–14: North and South off Vardø

Zooplankton biomass of the Vardø N standard section is high during the first three years, and low during the following years, except for 2003 (Figure 9). Low sampling frequency makes comparison with the other time-series difficult. Neither is the timing of seasonal cycles properly resolved with a sampling frequency of 2–3 per year.

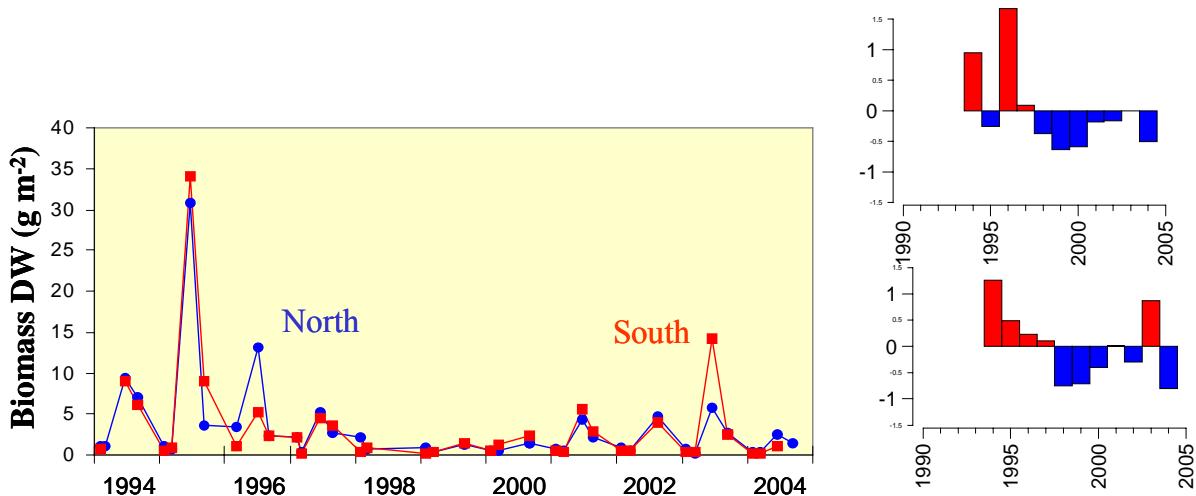


Figure 9: Left: Zooplankton biomass at Vardø transect, divided in northern and southern sections. Right: Interannual variability in terms of normalised anomalies of annual means.

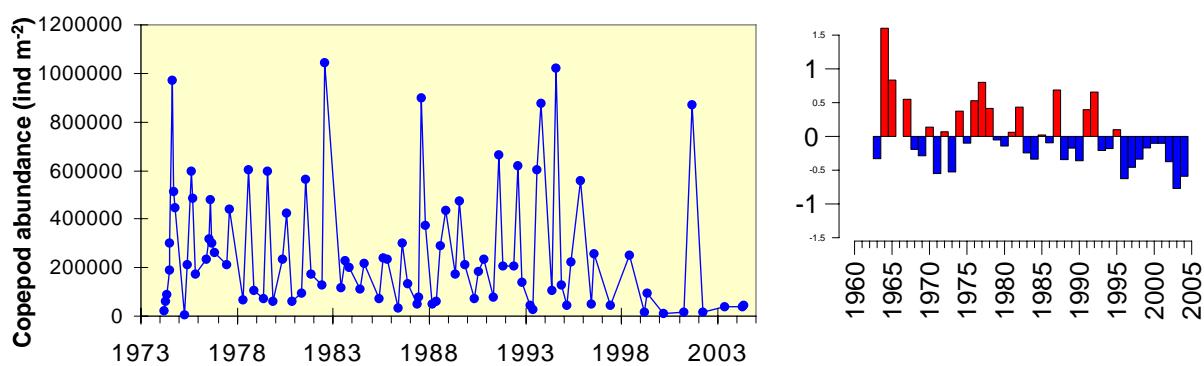
### 3.4 Baltic Sea

The Baltic Sea Monitoring Programme (BMP) consists of 24 international stations. The stations cover the different sub-areas of the Baltic Sea from the south-westerly Mecklenburg Bay to the north-easterly Gulf of Finland. Each station is sampled at least 4 times a year, but laboratories of all Baltic States contribute to the BMP increasing the amount and the frequency of data. Data are stored at HELCOM (Helsinki Commission) and will be stored at ICES in the future. Periodic Assessment Reports are prepared every 5 years by contributions from all HELCOM member states (<http://www.helcom.fi>; HELCOM, 1996).

#### 15: Gulf of Finland (Estonia)

One sampling location was selected from the Estonian national monitoring programme to represent the Gulf of Finland. Zooplankton was collected by means of vertical hauls of Juday plankton net (mouth opening 38 cm and mesh size 168  $\mu\text{m}$ ). In recent years sampling stations have been visited at least 10 times per year, but sampling has been very infrequent in some years. Data are available since 1963, but because a good temporal coverage is needed to plot a time-series, only data since 1974 were used to illustrate the abundance of copepods (Figure 10).

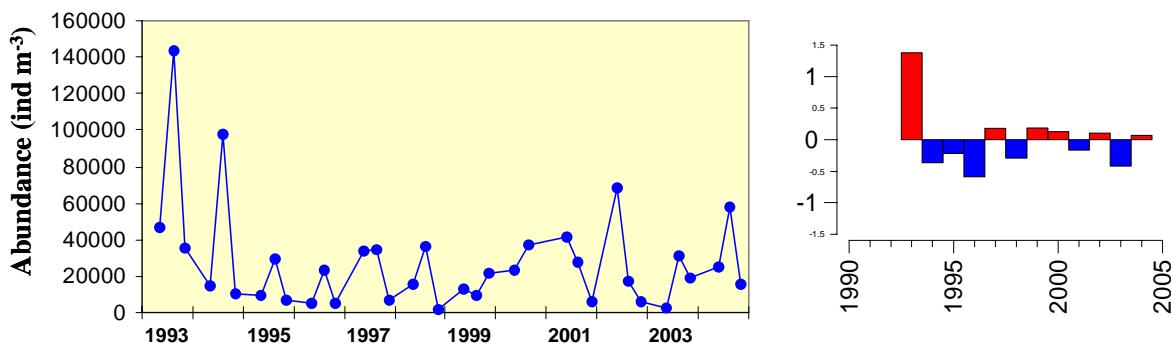
Zooplankton in the Baltic Sea are typically rather small in size. The dominating copepod species in Estonian waters are *Eurytemora affinis* and *Acartia bifilosa*, the most numerous cladoceran is *Bosmina coregoni*, and rotifers also constitute a rather big share of the total zooplankton abundance. The maximum zooplankton biomass is usually observed in late summer; the abundance may reach in some years high numbers already in spring. The zooplankton abundance has been higher in the 1970s and lower in the 1980s. The decrease in zooplankton numbers in the early 1980s has been explained primarily by the beginning of stagnant conditions and lowered salinity (Lumberg and Ojaveer, 1991). The chlorophyll *a* in May as well as in August shows a slight increase, and water transparency has decreased.



**Figure 10:** Left: Copepod abundance in the Gulf of Finland for the period 1974–2004. Right: Interannual variability in terms of normalised anomalies of annual means since 1963.

#### 16: Gulf of Riga (Latvia)

The Gulf of Riga is the third largest gulf of the Baltic Sea and its monitoring is shared between Latvia and Estonia. The Latvian monitoring programme has ten monitoring stations for zooplankton sampled with various frequencies from three to fifteen times a year. The present data are from a station in the central Gulf, and months with the best data coverage through the years (May, August, and November) are used for illustration. The average abundance and biomass in May has always been low, as in 1996 and 2003 when the Gulf was covered with ice during the winter (Figure 11). The level of summer biomass is determined by the abundance of the cladoceran species *Bosmina longispina* and rotifers of the *Keratella* genus.

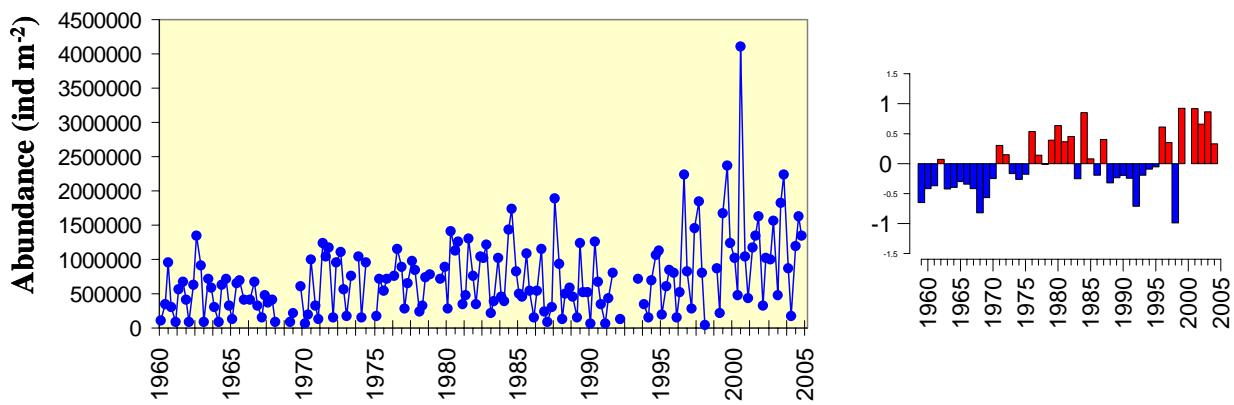


**Figure 11:** Left: Zooplankton abundance in the Gulf of Riga for the period 1993–2004. Right: Interannual variability in terms of normalised anomalies of annual means.

### 17: Central Baltic Sea (Latvia)

The mesozooplankton monitoring performed by the Latvian Fisheries Research Agency (LatFRA) has been conducted with varying intensity since 1959 with the goal to understand the effect of zooplankton on local commercial fish populations. Figure 12 shows the combined biomass development of the dominating calanoid copepods (*Pseudocalanus* sp., *Acartia* spp., *Temora longicornis*, *Centropages hamatus*) in the different seasons. Biomass was low at the beginning of the time-series and increased during the late 1970s/early 1980s. After a decreasing stock in the late 1980s/early 1990s the calanoid biomass has peaked in recent years.

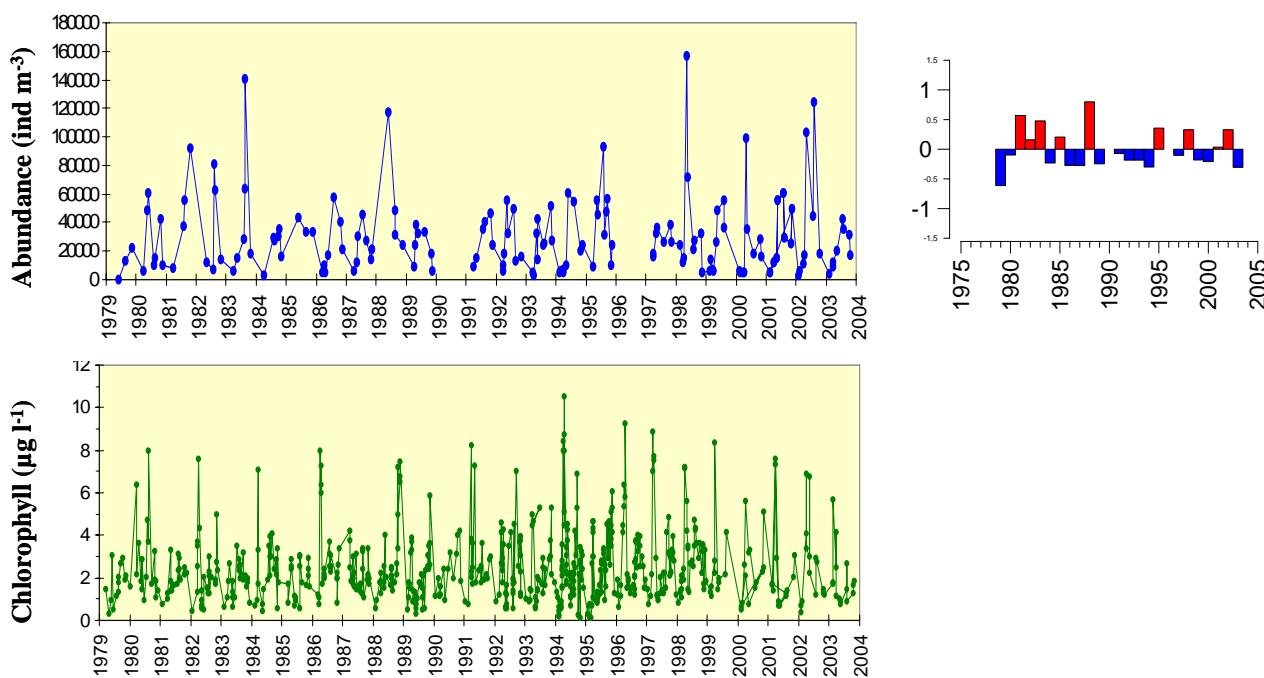
A change in the dominance from *Pseudocalanus* sp. to *T. longicornis*/*Acartia* spp. during the last two decades has been documented. A decrease in *Pseudocalanus* sp. standing stocks has been caused by decreasing salinities due to the reduced inflow frequency of North Sea waters, while *Acartia* spp. and *T. longicornis* increased due to warmer temperatures (Möllmann *et al.*, 2000, 2003a). Both hydrographic effects were ultimately driven by climate changes (Matthäus and Nausch, 2003). The trends in these copepod species have been shown to affect cod recruitment (Hinrichsen *et al.*, 2002) as well as pelagic fish growth (Rönkkönen *et al.*, 2004; Möllmann *et al.*, 2003b, 2005).



**Figure 12:** Left: Abundance of the main calanoid copepods in the Central Baltic Sea since 1960. Right: Interannual variability in terms of normalised anomalies of annual means.

## 18: Arkona Basin (Germany)

This station in Arkona Basin ( $54^{\circ}55'N$ ,  $13^{\circ}30'E$ , Germany) is sampled from the surface down to 25 m or to the depth of the seasonal thermocline (30 m). The total series covers the period from 1973 to the present. In some years the sampling coverage is quite poor (e.g., 1995 and 1996). Variations in the range of 10 000–50 000 ind  $m^{-3}$  are typically observed during the seasonal cycle in the western Baltic Sea (Figure 13). Peaks of plankton observed in spring in years 1983, 1988, 1995, 1998, 2000, and 2002 were due to mass developments of rotifers, which often happens after mild winters. In spite of these peaks, the cladoceran *Bosmina coregonii* is the dominant species during summer when water temperature reaches  $16^{\circ}C$  (HELCOM, 1996). Although no statistical trend is observed, 4 of the 6 spring peaks mentioned above have occurred in the last 10 years. Chlorophyll concentration at the Arkona Basin shows high values all year round, with seasonal spring blooms over  $6 \mu g l^{-1}$  and over  $2 \mu g l^{-1}$  most of the year (Figure 13). A decreasing trend has been noted, however, since 1994 where maximum values reach  $11 \mu g l^{-1}$  (Wasmund and Uhlig, 2003). Normalised anomalies of annual means in Figure 13 (right) show that with the exception of the low values in 1979 and 2003 and the high values in 1989, the time-series is quite stable and no trends are apparent.



**Figure 13: Left:** Zooplankton and phytoplankton abundance in the Arkona Basin (Baltic Sea) in 1979–2003. **Right:** Interannual variability of zooplankton in terms of normalised anomalies of annual means.

## 3.5 North Sea and English Channel

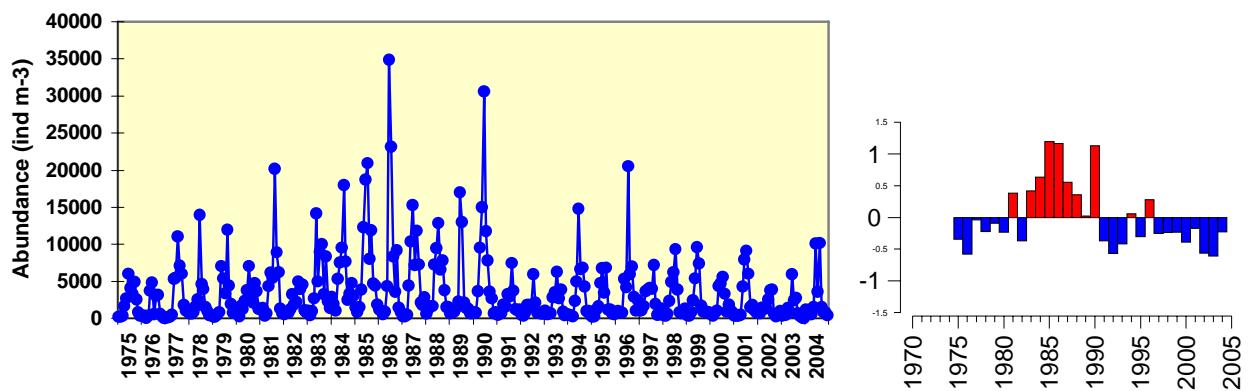
### 19: Helgoland (SE, North Sea)

Since 1975 every Monday, Wednesday, and Friday two oblique plankton net samples (150  $\mu m$ , 500  $\mu m$ ) have been collected at the station Helgoland Roads ( $54^{\circ}11'18''N$ ,  $7^{\circ}54'E$ ), Helgoland being the only offshore island of the North Sea. Almost 400 taxonomic entities of holoplankton and meroplankton (benthic and fish larvae) are counted. The time-series were started at the Biologische Anstalt Helgoland and have been continued after the institutional re-organisation in cooperation with the German Centre for Marine Biodiversity and the Federal Maritime and Hydrographic Agency.

The purpose of the program is to document plankton population dynamics for the recognition of regularities and variances in the abundance distribution. This will allow plankton prognoses in season, dimension, and finally abundance, and for the detection of biodiversity changes possibly caused by external forcing.

Examples of results using several analytical techniques, types of information extracted from the data and models on prognosis for zooplankton dynamics on several time-scales can be found in Greve (1994), Greve *et al.* (2001, 2004), Heyen *et al.* (1998), and Johannsen *et al.* (1999).

Small copepods represent a significant fraction of the total zooplankton in Helgoland. Seasonal cycles and year-to-year variability of small copepods can be observed in Figure 14. The ~30-year time-series 1975–2003 shows two periods (Figure 14, right). A first period 1975–1990 when the copepods showed an increasing trend; since then (1991–2003), the population has been oscillating quite regularly with the average values of abundances around halfway through the first period (4293 vs. 2441 ind m<sup>-3</sup> in the first and second periods, respectively).



**Figure 14: Left: Abundance of small copepods at Helgoland. Right: Yearly differences in the annual mean value.**

In 2004 the composition of the mesozooplankton abundance was influenced by the mass recruitment of the warm water cladoceran *Penilia avirostris* that first appeared in the North Sea in 1990 in negligible numbers, reappeared at the end of the nineties at a higher abundance level, and reached an abundance level exceeding 10 000 ind m<sup>-3</sup> in the last year. In addition to the higher abundance the population increase also happened earlier than in the preceding years.

Also in 2004 the calanoid copepods were less abundant (e.g., *Acartia* spp. reached 13% and *Temora longicornis* 67% less than their long-term mean abundance). The *Oithona* spp. ranked higher with almost twice the long-term mean. The abundance dynamics display a higher winter dynamics and a retarded spring increase of calanoid copepods. The summer abundance exceeds the long-term mean.

The response in seasonality of plankton to changing temperatures (which is common to all populations) is not the same in all species. Some copepod species (e.g., *Centropages* spp. and *Temora longicornis*) were observed much earlier in the year 2004; others like the *Acartia* spp., *Paracalanus* spp., and *Pseudocalanus elongatus* had their start of season six to eight weeks later than in mean years.

A paradigmatic example is that of the appendicularian *Oikopleura dioica*. This abundant filter-feeder depends on the winter temperatures in its phenological “start of season”. A trend can be observed in the shift of the “start of season” from week 27 to week 24 in recent years. This trend is hardly seen in the “middle of season” and in the “end of season”. The distance from the “start of season” to the “end of season” is a measure of the length of the season. While *Oikopleura dioica* was present in the plankton in the 1970s for eight to nine weeks, the length of the season has now reached a mean length of 12 weeks (Figure 15). This improves the living conditions of fish larvae predating upon the Appendicularia.

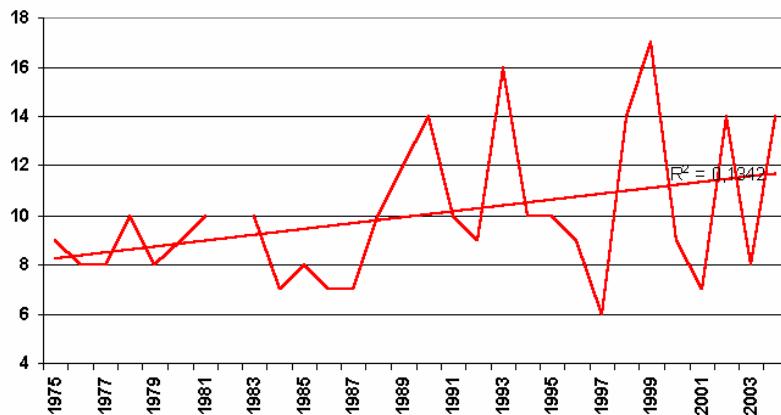


Figure 15: *Oikopleura dioica*, length of season at Helgoland Roads; yearly measurements and trend.

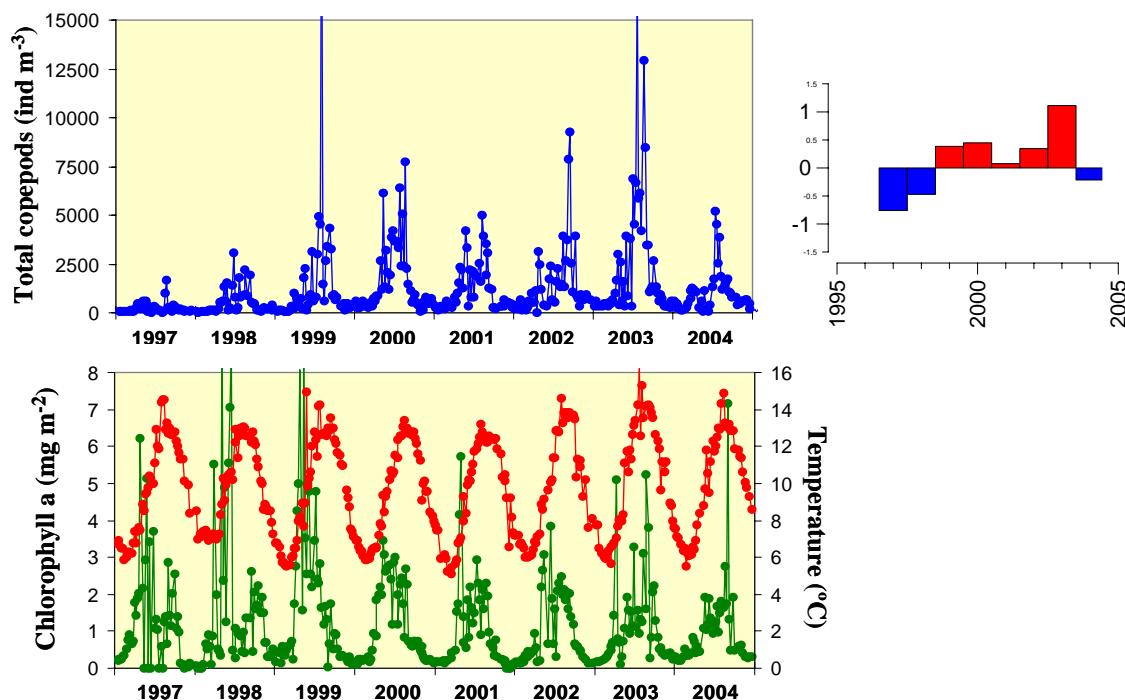
## 20: Stonehaven (Scotland, NW North Sea)

The Stonehaven sampling site is located at 56°57.80'N, 02°06.20'W, approximately 5 km offshore from Stonehaven which is a fishing harbour 28 km to the south of Aberdeen. The water depth at the site is 50 m. Sampling for hydrographic parameters, concentrations of inorganic chemical nutrients and the abundance of phytoplankton and zooplankton species has been carried out on a weekly basis off Stonehaven since January 1997. The objective of the programme is to establish a monitoring base for assessing the status of the Scottish coastal waters ecosystem, and the responses to climate change. Comparison of the results with archive regional data on temperature, salinity, and nutrients and phytoplankton biomass, indicates that the site off Stonehaven provides a reasonable index of the state of the coastal waters. The biological data illustrate the consistencies and variability in seasonal succession of plankton species and their abundance. It is evident that there are significant differences among seasons and years.

The water column at the sampling site remains well mixed throughout much of the year, except in late summer and autumn when surface heating and settled weather often cause temporary thermoclines to appear. The seasonal minimum temperature generally occurs in the last week of February/first week of March. Water movement is generally southerly with quite strong tidal currents. In the late summer and through autumn of most years, water with a high Atlantic Ocean content passes down the Scottish East Coast. These events are particularly observable in the salinity signal. For example 1997 showed a strong salinity increase in the late summer, whereas 1998 showed very little. These influxes often bring oceanic species, for example the chaetognath *Sagitta serratodentata* and the siphonophore *Muggiaea atlantica* are indicators of this oceanic influence.

The seasonal pattern of plankton production is clearly evident in these data, as is the variability among years in its extent. Nutrient data also show strong seasonal cycles but again there is interesting inter-annual variability evident. This is also seen in the variations observed in the phytoplankton and chlorophyll data (Figure 16). Large differences can be seen between years in the observed biomass of many common species of zooplankton, with a general increase from 1997–2000 (Figure 16) but a lower observed abundance overall in 2001 and 2002. In 2003 zooplankton peaks again with the second highest values of the time-series.

The time-series, although short, is at a fairly high observational frequency, thus allowing insight into the seasonal dynamics and succession of species throughout the annual cycle. This provides an excellent background against which to carry out process studies, modelling, and comparisons with other sites. Data also provide assessment of the extent of local variability and allow consideration of the local effects of broader patterns of ocean climate change.



**Figure 16: Left:** weekly abundance of copepods and chlorophyll at Stonehaven and values of sea surface temperature. **Right:** Interannual variability in terms of normalised anomalies of annual means.

Several zooplankton species are of particular interest in that they show wide variations in their abundance. For example the important common copepod genus *Calanus* is represented by two species off Stonehaven. Firstly and most abundantly in the spring and summer is *C. finmarchicus*, an important species in that the large spring influx and production provides food for fish larvae in spring. However, its congener *C. helgolandicus*, a more southern species and generally most abundant in summer and autumn, has shown evidence of increased productivity and extended survival through the winter months. This is most likely a reflection of changes in the physical environment through the last few months of the year, with faster or slower cooling of the sea affecting the strongly temperature-dependent physiology of these small plankton. Interannual variability in over-winter survival is likely to affect the population dynamics for a number of species, and may “kick start” the production cycle when it begins in spring each year. Such dynamics may have for example, considerable implications for larval survival and recruitment to fish populations as well as consequences for assessments of the effects of local eutrophication pressures on the coastal marine ecosystems of eastern Scotland.

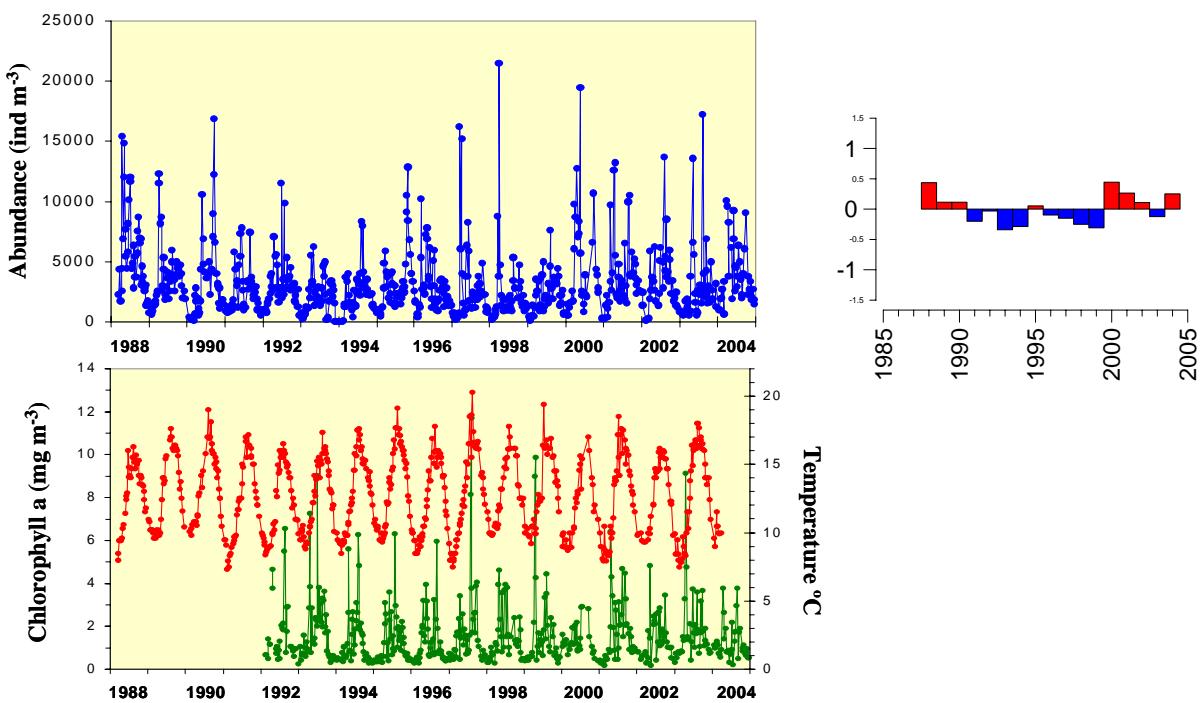
Data are regularly processed in the FRS MLA database and some of these data are displayed on the MLA website (<http://www.marlab.ac.uk/Monitoring/Stonehaven/Stoneframe.html>) and published in periodic reports (e.g., Heath *et al.*, 1999).

## 21: Plymouth (English Channel)

Zooplankton is collected weekly at station L4 ( $04^{\circ}13'W$ ,  $50^{\circ}15'N$ ) about 10 miles SW of Plymouth in the Western English Channel. The station is about 50 m deep and influenced by seasonally stratified and transitional mixed-stratified waters (Pingree and Griffiths, 1978). Organisms are collected with a 200  $\mu$ m WP2 net towed vertically from sea floor to the surface. Samples are split and counted for major taxonomic groups as well as identifying some groups (particularly copepods) to species level. For chlorophyll *a* measurement, three replicates of 100 ml surface water from L4 are filtered through 25 mm GF/F filters. These filters are then stored in the freezer until extraction in 10 ml acetone. The extract is then analysed using a 10 AU Turner fluorometer. The L4 data are maintained at the Plymouth Marine Laboratory and are publicly available through a website ([www.pml.ac.uk/L4](http://www.pml.ac.uk/L4)).

**Table 1: Percentages and averages of the top copepod species at Plymouth L4 station along the sampling period 1988–2003 time-series and in 2004.**

RANK	TAXA	% TOTAL ZOOPLANKTON 1988–2003	YEARLY AVERAGE 1988–2003 (N/m <sup>3</sup> )	% TOTAL ZOOPLANKTON 2004	2004 AVERAGE (N/m <sup>3</sup> )
1	<i>Pseudocalanus</i>	12.34	393	5.08	202
2	<i>Oithona</i>	12.2	389	11.95	474
3	<i>Paracalanus</i>	10.28	323	4.62	184
4	<i>Oncaea</i>	9.97	318	20.59	818
5	<i>Temora longicornis</i>	9.37	299	6.98	277
6	<i>Cirripede nauplii</i>	8.82	281	7.22	287
7	<i>Acartia clausi</i>	6.39	204	3.37	134
8	<i>Evadne</i>	5.97	190	4.62	183
9	<i>Corycaeus</i>	2.43	77.5	2.96	118
10	Appendicularia	2.41	77	4.81	191
Total		80.18	2551.5	72.2	2867.1
Total zooplankton (N/m <sup>3</sup> )			3188.8		3970.1



**Figure 17: Left:** Weekly zooplankton abundance (upper panel), chlorophyll a concentration (lower panel, green line) and surface temperature (lower panel, red line) at Station L4 (Plymouth). **Right:** Interannual variability in terms of normalised anomalies of the annual means.

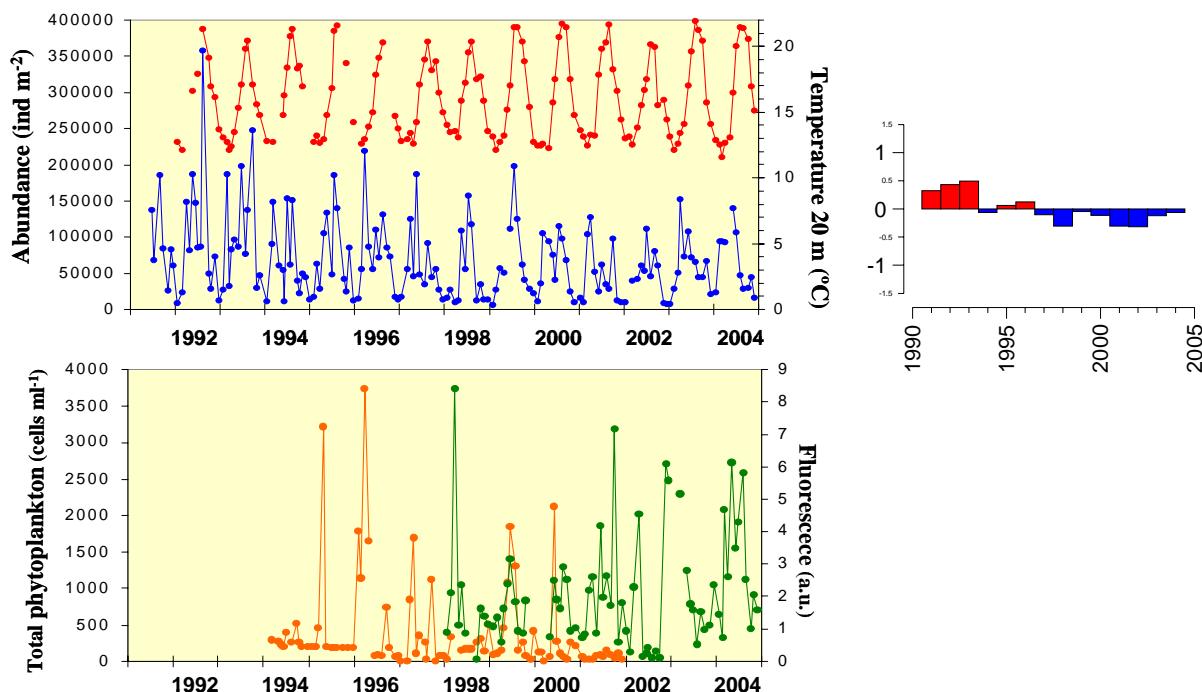
The ten most abundant species at L4 have been ranked according to their annual mean proportion of the total zooplankton (Table 1). In 2004, some drastic changes in the zooplankton composition can be observed within the top 4 species over the time-series. Whereas *Pseudocalanus* and *Paracalanus* contributions to the total population decreased by 49% and 43% respectively, the contribution of *Oncaea* increased by 157%. This is the second time over the time-series that *Oncaea* is the most abundant species in the zooplankton community. In 1995, *Oncaea* abundance reached  $918 \text{ Nm}^{-3}$  representing 27.5% of the zooplankton abundance.

Weekly zooplankton abundance as well as chlorophyll *a* concentration at L4 shows clear seasonal cycles (Figure 17). Peaks of high zooplankton abundance and Chlorophyll *a* concentration are regularly observed in spring and in late summer to beginning of autumn. Zooplankton abundance at L4 shows two decreasing trends from 1988 to 1995 and from 2001 to 2004 (Figure 17). This is mainly due to relatively low abundances of the spring species *Paracalanus* and *Acartia clausi*. Small copepods like *Oncaea*, *Oithona*, and *Corycaeus* contribute greatly to the total zooplankton population. 2004 shows a decline in zooplankton population with the top ten species all below their typical average values (*Corycaeus* and the Appendicularia showed little difference), apart from *Oncaea* whose abundance increased by 39%.

### 3.6 Bay of Biscay and Iberian coast

#### 22: Santander (Southern Bay of Biscay)

Five transects are monitored in the ICES area off the Spanish coast. This involves an extensive physical, chemical, and biological monthly sampling series at each site, with special attention to the sampling and analysis of hydrographical parameters, nutrients, chlorophyll *a*, and phytoplankton and zooplankton species. Data are regularly entered in the IEO databases, and hydrographic and nutrients data are also available in the ICES database. Depending on the transect, the time-series extend from 1988 (A Coruña and Vigo), 1991 (Santander), 1993 (Cudillero), and 2001 (Gijón) to the present.



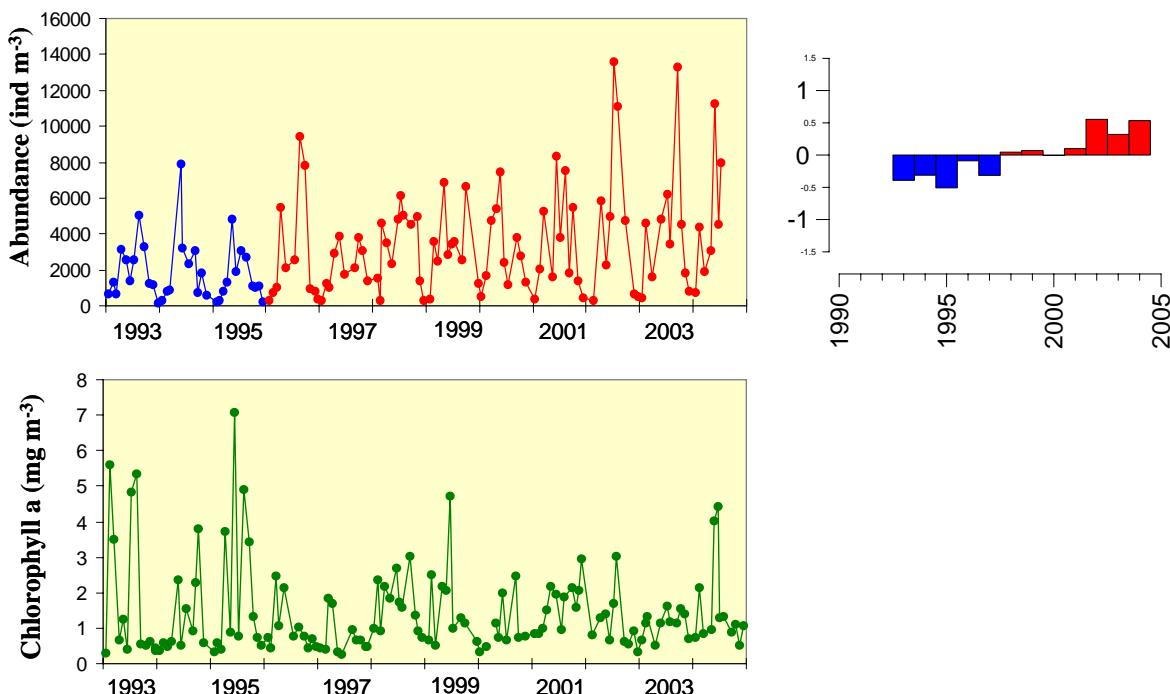
**Figure 18:** Left: (upper panel) Monthly zooplankton abundance and (lower panel) phytoplankton cells (orange line, left scale) and fluorescence in arbitrary units (green line, right scale) in a neritic station off Santander. Right: Interannual variability in terms of normalised anomalies of annual means.

Long-term changes of zooplankton abundance at Santander show a slightly decreasing trend (Figure 18). The result is in opposition to the upward trend shown by the water column stratification index (Lavin *et al.*, 1998). This relationship between zooplankton and environmental conditions highlights the importance that the longer duration of the water column stratification could have in limiting the interchange of nutrients from deeper to surface waters and consequently limiting the growth of phytoplankton and zooplankton (Valdés and Moral, 1998). A similar relationship between an increasing trend in the water column stratification and a decline of zooplankton biomass was reported by Roemmich and McGowan (1995) at the Californian coast (CalCOFI series).

### 23: A Coruña (NW Iberian Peninsula)

In the coastal and neritic regions off Galicia (NW Spain) the classical pattern of seasonal stratification of the water column in temperate regions is masked by upwelling events from May to September. These upwelling events provide zooplankton populations with favourable conditions for development in the summer months, the opposite of what occurs in other temperate seas in this season of the year. Nevertheless, upwelling is highly variable in intensity and frequency, showing a substantial year-to-year variability.

Zooplankton values in A Coruña (Figure 19) differ to those in Santander (Figure 18): zooplankton abundance is higher in A Coruña and the time-series shows an increasing trend since 1997. Both characteristics are partly due to the influence of the seasonal upwelling, which prevents the water column from properly stratifying, reinforces the input of nutrients to the photic layer, enhances the growth of phytoplankton populations and therefore enhances the growth of zooplankton populations. [Note that the time-series shown in Figure 19 is composed of two curves, one for zooplankton  $>250\text{ }\mu\text{m}$ , and the other for zooplankton  $>200\text{ }\mu\text{m}$ ].



**Figure 19: Left:** Monthly zooplankton abundance and chlorophyll in a neritic station off A Coruña. **Right:** Interannual variability in terms of normalised anomalies of annual means.

## 4 Discussion

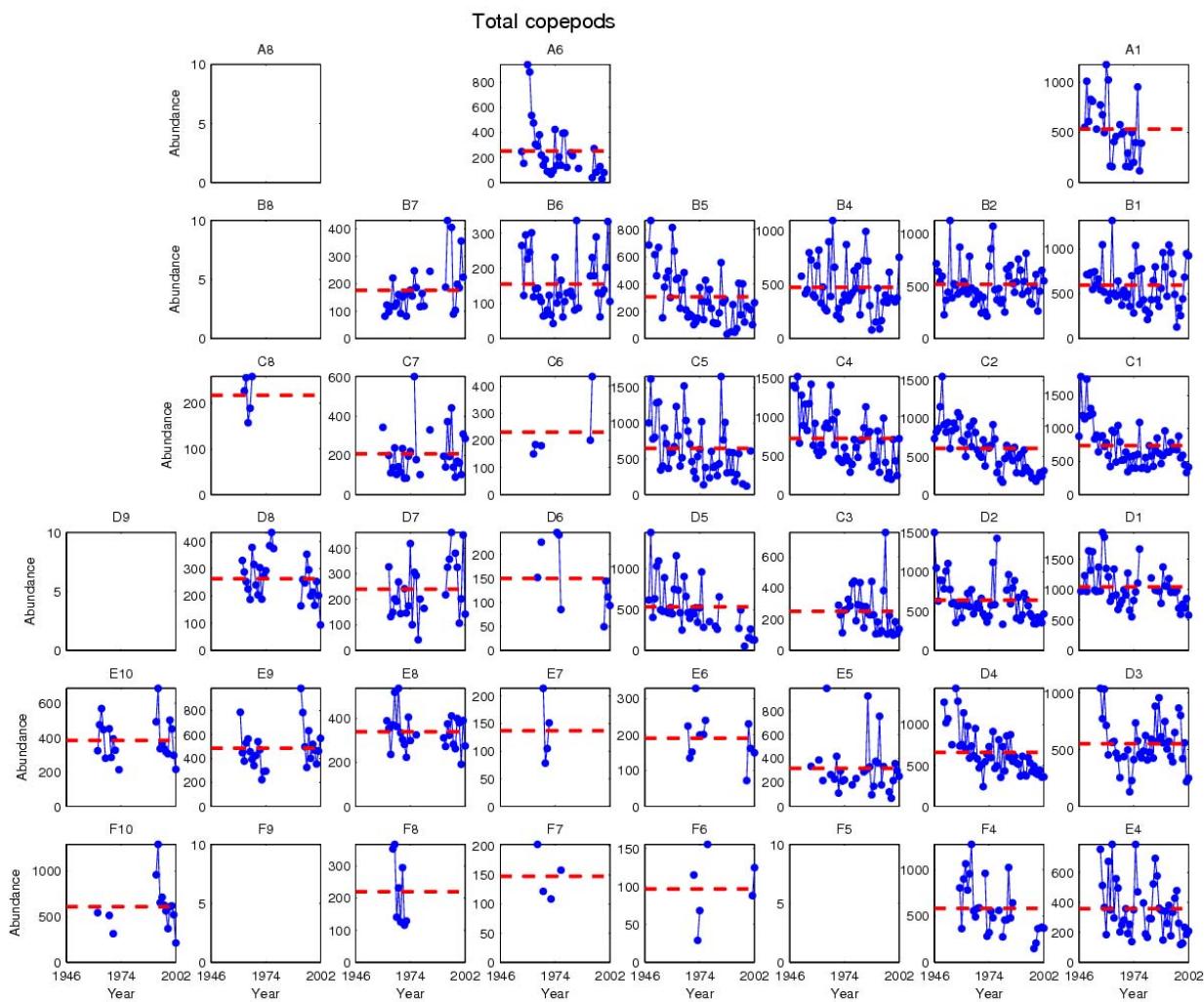
### 4.1 A general overview of the North Atlantic

The time-series of total copepod abundance (numbers per sample ( $\sim 3\text{ m}^{-3}$ )) from 1946 to 2002 in CPR standard areas throughout the North Atlantic (see Figure 1 for map) is shown in Figure 20. Annual means were calculated according to Colebrook (1975). This method excludes years in which data from fewer than eight months were available. The dashed line represents the long-term mean in each standard area. The most striking feature of the time-series is a general long-term decline in total copepod abundance east of Iceland, although some areas shown no trend (e.g., northern North Sea). In the western North Atlantic total copepod abundance has remained relatively unchanged since 1946. Highest copepod abundance is in the eastern North Atlantic, and particularly in the southeastern North Sea. It is clear that the year 2002 is broadly consistent with this trend, with lower than usual copepod abundance throughout most of the stan-

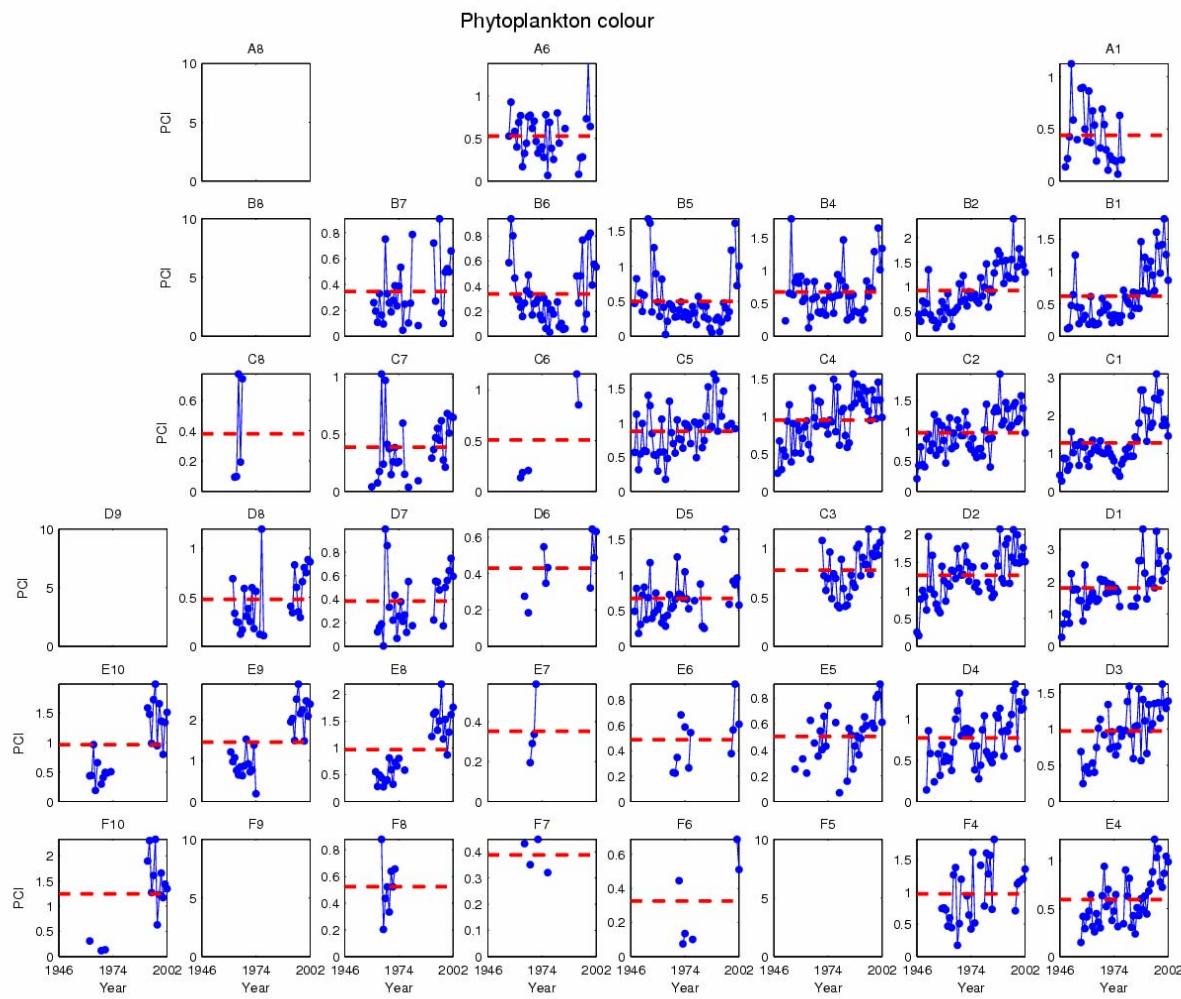
dard areas, particularly in the southeast. Many of the areas in the Northeast Atlantic show a copepod abundance in 2002 that is slightly higher than usual. These results are coherent with the time-series shown in the regional description.

Figure 21 shows the long-term interannual values from 1946 to 2002 of phytoplankton colour in CPR standard areas in the North Atlantic. Phytoplankton colour is the degree of greenness of the CPR silk. It includes the chloroplasts of unbroken and broken cells, as well as small, unarmoured flagellates, which tend to disintegrate on contact with formalin. Phytoplankton colour is a good index of total chlorophyll content (Hays and Lindley, 1994) and is closely related to biomass estimates from satellite observations (Batten *et al.*, 2003). There has been a large increase in Phytoplankton Colour since the late 1980s in most regions (particularly the northeast Atlantic and the Newfoundland shelf). From the late 1940s to the late 1980s, high biomass was restricted to spring and autumn when diatoms dominate (data not shown). Since the late 1980s, however, the biomass has increased throughout the seasonal cycle. Biomass generally dropped in 2002, but was still generally higher than the long-term mean. In other parts of the North Atlantic, high increases in biomass were seen off the Newfoundland Shelf (with an increase in winter blooms), the Scotian Shelf, and the Labrador Sea. In the northern North Atlantic and in the sub-polar gyre, phytoplankton biomass has generally declined over the last two decades, but has shown an increase since 1998.

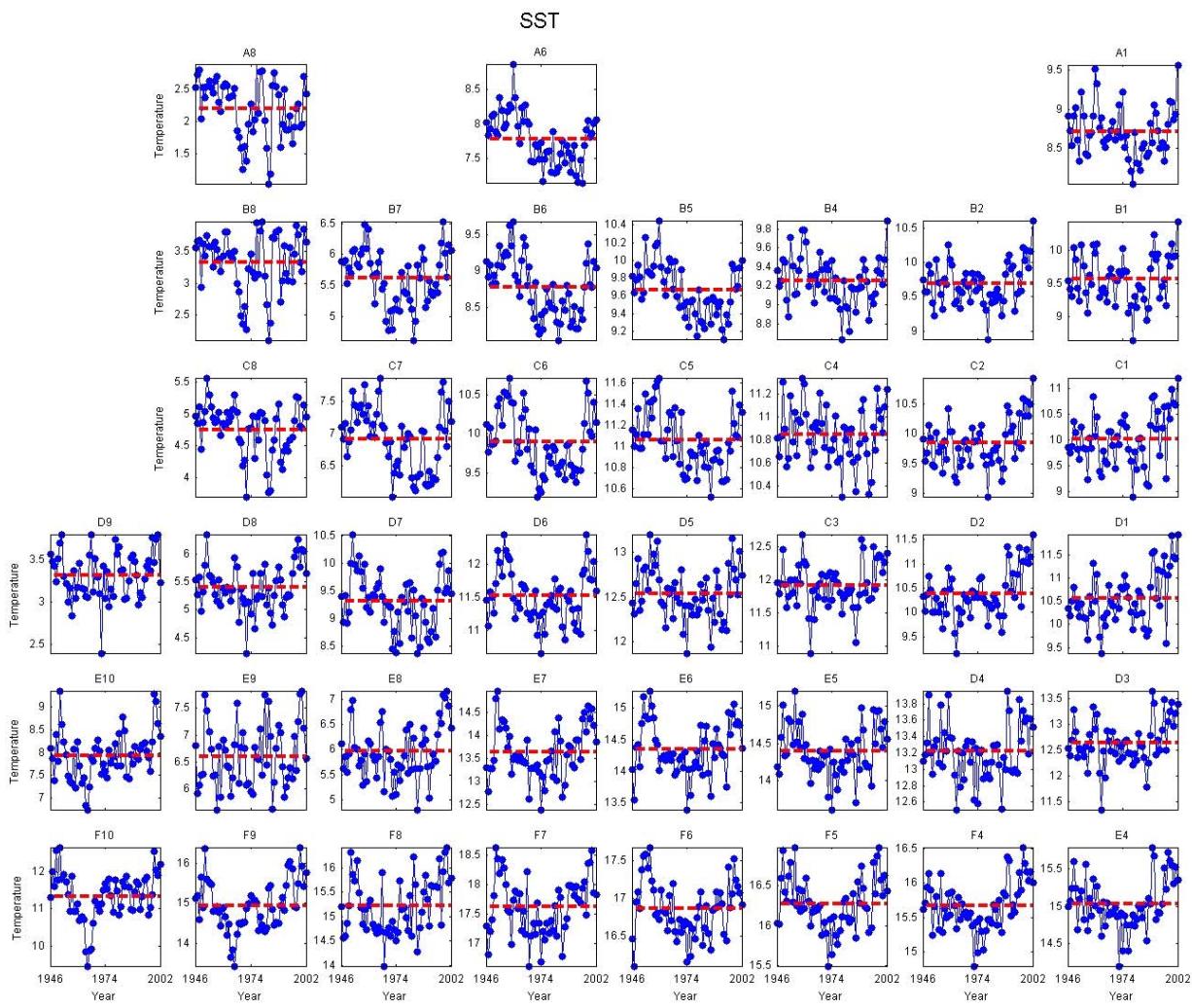
Figure 22 shows the long-term interannual values of Sea Surface Temperature (SST) from 1946 to 2002 in CPR standard areas in the North Atlantic. Temperature shows an overall increase since the early seventies for the whole North Atlantic as indicated by the pronounced positive anomalies. On the other hand, a decreasing trend in SST from the early fifties until the early seventies can be observed particularly in the southern part of the central North Atlantic. This decreasing signal in SST is less relevant in the North Sea where temperatures during this period show no clear trend. This general pattern corresponds well to the division proposed by Beaugrand (2003) on the basis of both SST and scalar wind. Beaugrand (2003) suggested that the northeast Atlantic can be divided into three hydroclimatic regions. The first division lies approximately north and south of a line of 53°N and in the region north of about 53°N, while the two other regions (the subarctic gyre and the North Sea) are defined on the basis of their long-term monthly changes in SST. Both regions have been characterized by an increasing trend in wind intensity, which is highly correlated positively with monthly NAO indices, especially in spring and autumn. In the subarctic gyre south of Iceland, phytoplankton biomass has decreased while in the North Sea phytoplankton biomass has increased (Figure 21; Beaugrand, 2003). This tends to suggest that temperature is an important factor that limits phytoplankton biomass south of Iceland. However, it could also be argued that if we follow a top-down hypothesis instead of an hydrographically driven ecosystem, the decrease in zooplankton abundance in the North Atlantic could be realising the predatory pressure over the phytoplankton and trigger an increase in their biomass, which could explain the increase in the CPR colour index.



**Figure 20:** Time-series from 1946 to 2002 of the total copepod abundance in CPR standard areas in the North Atlantic (see Figure 1 for map).



**Figure 21:** Time-series from 1946 to 2002 of the Phytoplankton Colour Index in CPR standard areas in the North Atlantic (see Figure 1 for map).



**Figure 22: Time-series from 1946 to 2002 of the Sea Surface Temperature in CPR standard areas in the North Atlantic (see Figure 1 for map).**

## 4.2 Latitudinal patterns and relationship with temperature

During the preparation of the anomaly fields for this status report, we noticed that the anomaly plots from times series in higher latitudes tended to have a visually greater span of variability (between the minimum and maximum anomaly values) than those in lower latitudes. To examine this quantitatively, we calculated a “Variability Span” for each time-series by subtracting the minimum yearly anomaly value from the maximum (for example, if a time-series had a minimum anomaly value of -0.5 and a maximum of 1.0, it would have a 1.5 variability span). Plotting these span values against the latitudes of the time-series sites, we found the variability span of most time-series correlated nicely with their location latitude (Figure 23).

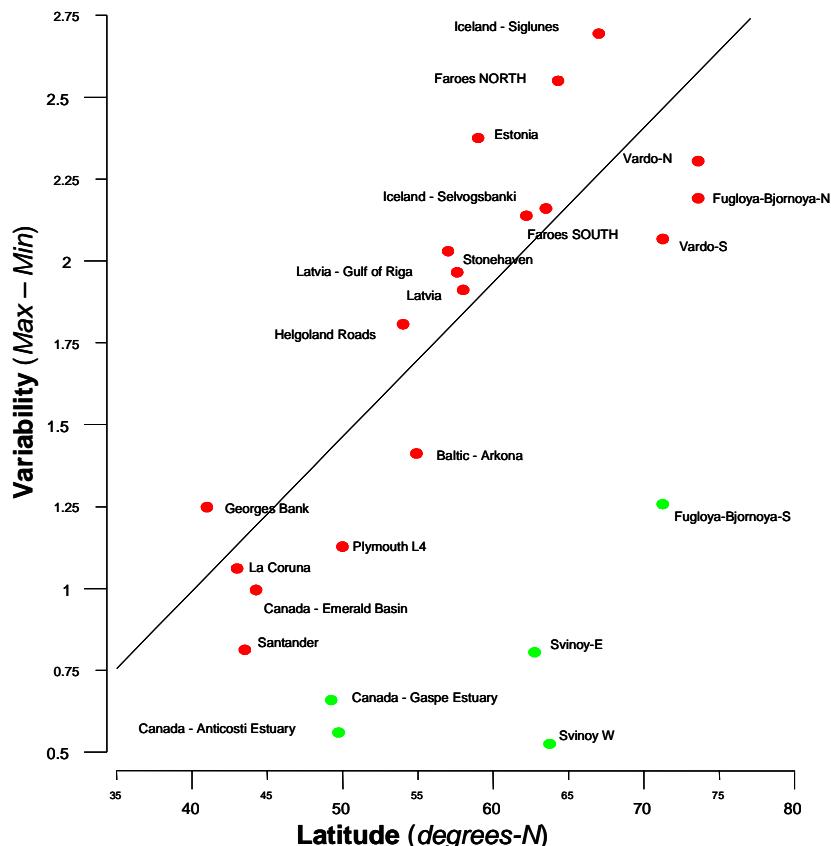
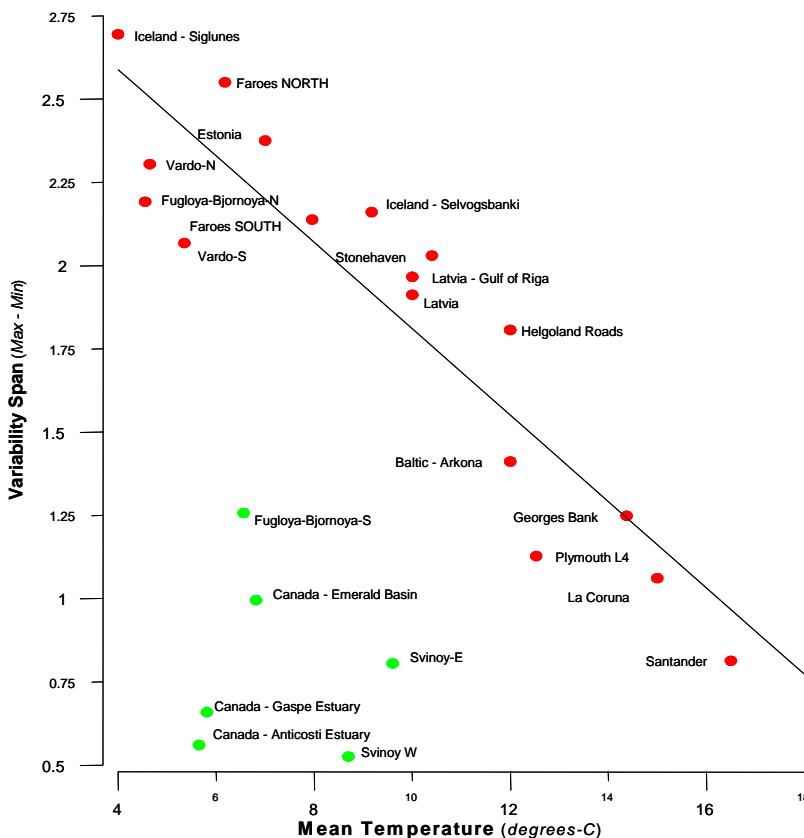


Figure 23: Time-series “variability span” as a function of sampling site latitude. Green dots were excluded from the regression calculation – see discussion below.

As zooplankton production is dependent on water temperature, which is also correlated with latitude, we then examined the variability span as a function of water temperature. Annual mean water temperatures, averaged from all values sampled from 0- to 50-meters depth, were calculated for each time-series using the World Ocean Atlas 2001 temperature fields (Stephens *et al.*, 2002). This average-over-depth value was used instead of surface temperatures because it better represented the vertical environment over which the zooplankton were actually sampled. Plotting the variability span against mean water temperature, we found a strong correlation between variability span and mean water temperature (Figure 24).

In general, the year-to-year relative variability in zooplankton biomass or abundance decreases with increasing mean water temperature. It is already known that the growth and production of zooplankton are dependent on food availability and water temperature. In regions with colder water, the gradient between winter and summer air and water temperatures may be larger than those in the warmer water regions. These larger differences would lead to stronger seasonal winds and mixing between the surface and deeper nutrient-rich waters, resulting in stronger phytoplankton blooms and ultimately stronger zooplankton responses.



**Figure 24:** Time-series “variability span” as a function of sampling site mean temperature. *Green dots were excluded from the regression calculation.*

To examine the “outlying” time-series (green dots) in both figures, we first checked to see if it was an issue of outlying mean water temperatures versus latitude. We plotted the times series mean temperatures against their sampling site latitude (Figure 25).

The three remaining outliers in Figure 25 represent estuarine or very near-shore sampling sites. The dynamic physical environment of these sites is likely responsible for separating them from the other more “open ocean” time-series. Perhaps these environments experience consistently well-mixed (nutrient rich) waters, or are hindered by secondary factors (e.g., large salinity changes).

Unlike Figures 23 and 24, the Svinøy (East and West) sites and Fugløya-Bjørnøya (South) sites now fit nicely along the temperature vs. latitude regression line. Temperature seems to be reasonable, yet these sites exhibit very low “variability spans” relative to other sites in the same latitude and temperature ranges (Figures 23 and 24). Olsen *et al.* (2003) found that strong current patterns off the coast of Norway were responsible for spring bloom differences within and between the Fugløya-Bjørnøya North and South sampling sites (Figure 26). These differences would ultimately affect the zooplankton populations. The same currents also play a role in the Svinøy sites (Webjørn Melle, personal communication).

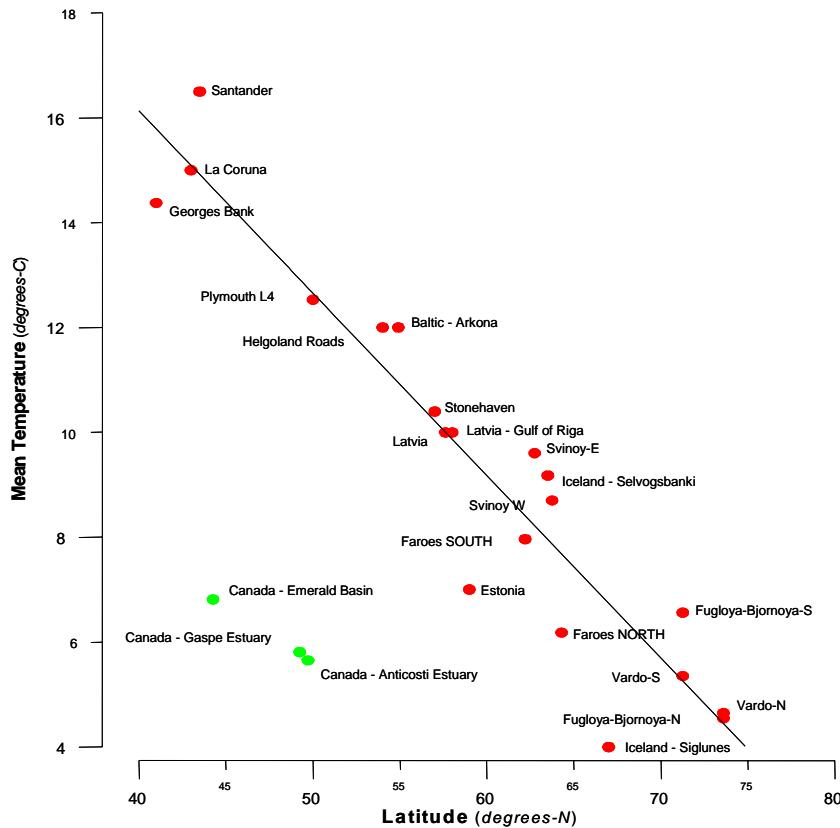


Figure 25: Time-series mean temperature as a function of sampling site latitude. *Green dots were excluded from the regression calculation.*

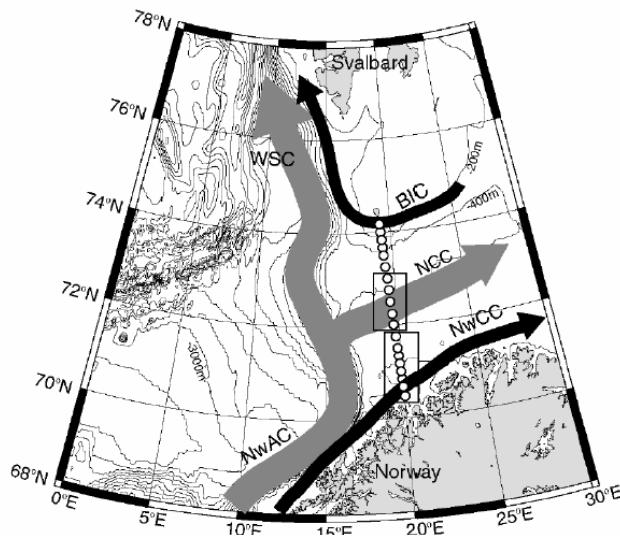


Figure 26: Water mass circulation along the northern Norwegian coast and in the Barents Sea (source: Olsen *et al.*, 2003).

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## 6 Characteristics of the collections used (Table of Metadata)

COUNTRY	USA (1)	CANADA (2)	CANADA (3)	CANADA (4)
<b>Monitoring programme</b>	NFSC, Narragansett, RI	AZMP	AZMP	AZMP
<b>Sampling location</b>	Georges Bank	Halifax Line Stn 2 (HL2) West Atlantic, Scotian Shelf	Gaspé Current	Anticosti Gyre
<b>Latitude (N)</b>		44°16'N	49°24'N	49°72'N
<b>Longitude (E-W)</b>		64°19'W	66°20'W	66°25'W
<b>Station Depth (m)</b>		150	265	265
<b>Period of data available</b>	1971–ongoing	1998–ongoing	1999–ongoing	1999–ongoing
<b>Frequency (number of cruises/yr)</b>	4–6	Monthly/Bi-weekly (~20)	Every two weeks with some gaps	Every two weeks with some gaps
<b>Gear/diam (cm)</b>	Bongo net	Ring/75	Ring/75	Ring/75
<b>Mesh (µm)</b>	333	200	202*	202*
<b>Depth of sampling (m)</b>		150	Bottom-surface	Bottom-surface
<b>Ancillary data</b>		hydrography, nutrients, phytoplankton, chlorophyll		
<b>Contact person</b>	David G. Mountain	Erica Head/Glen Harrison	Michel Harvey	Michel Harvey
<b>Email address</b>	dmountain@whsun1.wh.whoi.edu	HeadE@mar.dfo-mpo.gc.ca	HarveyM@dfo-mpo.gc.ca	HarveyM@dfo-mpo.gc.ca
<b>Location of data</b>		BIOCHEM database*, DFO, BIO	MEDS (Ottawa)	MEDS (Ottawa)
<b>Observations (*)</b>		Data will reside at MEDS in Ottawa, when database development is complete	* the mesh size of the net used in 1999 was 158 µm	* the mesh size of the net used in 1999 was 158 µm

## Characteristics of the collections used (Table of Metadata, continued)

COUNTRY	ICELAND (5)	ICELAND (6)	FAROE (7)	FAROE (8)	NORWAY (9)
<b>Monitoring programme</b>	MRI-Iceland	MRI-Iceland	FFI-Faroe Islands	FFI-Faroe Islands	IMR-Bergen
<b>Sampling location</b>	Siglunes-transect	Selvogsbanki-transect	Faroe Shelf	Faroe Shelf	Svinøy transect East Norwegian Sea
<b>Latitude (N)</b>	*	*	62°20' to 63°N	63° to 64°30'N	*
<b>Longitude (E-W)</b>	*	*	6°05'W	6°05'W	*
<b>Station Depth (m)</b>	*	*	*	*	*
<b>Period of data available</b>	1961–ongoing	1971–ongoing	1989–ongoing	1989–ongoing	1993–ongoing
<b>Frequency (number of cruises/yr)</b>	Yearly (1 May–June)	Yearly (1 May–June)	Yearly (late May)	Yearly (late May)	6–10
<b>Gear/diam (cm)</b>	1971–91: Hensen; 1992–present: WP-2	1971–91: Hensen; 1992–present: WP-2	1990–1991: Hensen; 1992–present: WP-2	1990–1991 Hensen; 1992–present: WP-2	WP-2 (56)
<b>Mesh (µm)</b>	200	200	200	200	180
<b>Depth of sampling (m)</b>	0–50	0–50	0–50	0–50	0–200
<b>Ancillary data</b>	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll
<b>Contact person</b>	Astthor Gislason	Astthor Gislason	Eilif Gaard	Eilif Gaard	Webjørn Melle
<b>Email address</b>	astthor@hafro.is	astthor@hafro.is	eilifg@frs.fo	eilifg@frs.fo	webjorn@imr.no
<b>Location of data</b>	database MRI	database MRI	FFL	FFL	TINDOR database, IMR
<b>Observations (*)</b>	Transect of 8 stns from 66°16'N, 18°50'W (bottom depth: 80 m) to 68°00'N, 18°50'W (bottom depth: 1045 m)	Transect of 5 stns from 63°41'N, 20°41'W (bottom depth: 46 m) to 63°00'N, 21°28'W (bottom depth: 1004 m)	Transect with bottom depth from 50 to 100 m	Transect with bottom depth from 50 to 100 m	4 stations in the eastern part of a transect of 15 stns. 62°22'N, 5°12'E (bottom depth: 160 m) to 63°12'N, 3°24'W (bottom depth: 1000 m)

## Characteristics of the collections used (Table of Metadata, continued)

COUNTRY	NORWAY (10)	NORWAY (11)	NORWAY (12)	NORWAY (13)	NORWAY (14)
<b>Monitoring programme</b>	IMR-Bergen	IMR-Bergen	IMR-Bergen	IMR-Bergen	IMR-Bergen
<b>Sampling location</b>	Svinøy transect West Norwegian Sea	Western Barents Sea (Fugløya-Bjørnøya; North)	Western Barents Sea (Fugløya-Bjørnøya; South)	Eastern Barents Sea (Vardø-North)	Eastern Barents Sea (Vardø-South)
<b>Latitude (N)</b>	*	*	*	*	*
<b>Longitude (E-W)</b>	*	*	*	*	*
<b>Station Depth (m)</b>	*	*	*	*	*
<b>Period of data available</b>	1993–ongoing	1994–ongoing	1994–ongoing	1994–ongoing	1994–ongoing
<b>Frequency (number of cruises/yr)</b>	6–10	4–10	4–10	4–10	4–10
<b>Gear/diam (cm)</b>	WP-2 (56)	WP-2 (56)	WP-2 (56)	WP-2 (56)	WP-2 (56)
<b>Mesh (µm)</b>	180	180	180	180	180
<b>Depth of sampling (m)</b>	0–200	0–100	0–100	0–100	0–100
<b>Ancillary data</b>	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll
<b>Contact person</b>	Webjørn Melle	Webjørn Melle	Webjørn Melle	Webjørn Melle	Webjørn Melle
<b>Email address</b>	webjorn@imr.no	webjorn@imr.no	webjorn@imr.no	webjorn@imr.no	webjorn@imr.no
<b>Location of data</b>	TINDOR database, IMR	TINDOR database, IMR	TINDOR database, IMR	TINDOR database, IMR	TINDOR database, IMR
<b>Observations (*)</b>	4 stations in the western part of a transect of 15 stns. from 62°22'N, 3°08'E (bottom depth: 1100 m) to 64°40'N, 0°00'W (bottom depth: 2700 m)	3 stations in the northern part of a transect from 72°30'N, 19°34'E (depth 380 m) to 74°40'N, 19°13'W (depth 140 m)	4 stations in the southern part of a transect from 70°30'N, 20°00'E (bottom depth: 130 m) to 72°40'N, 19°41'W (bottom depth: 311 m)	7 stations in the northern part of a transect from 73°15'N, 31°13'E (depth 280 m) to 75°30'N, 31°13'W (depth 352 m)	5 stations in the southern part of a transect from 70°30'N, 31°13'E (depth 192 m) to 72°30'N, 31°13'W (depth 298 m)

## Characteristics of the collections used (Table of Metadata, continued)

COUNTRY	ESTONIA (15)	LATVIA (16)	LATVIA (17)	GERMANY (18)	GERMANY (19)
<b>Monitoring programme</b>	Monitoring of fish food resources	National monitoring programme of Latvia	LatFRA-monitoring	IOW	BSH and DZMB
<b>Sampling location</b>	Gulf of Finland Baltic Sea	Gulf of Riga Baltic Sea	Baltic Sea	Arkona Basin, Baltic Sea	Helgoland
<b>Latitude (N)</b>	59°43'N	57°37'N	south of 58°N	54° 55'N	54°11.18'N
<b>Longitude (E-W)</b>	25°01'E	23°37'E	east of 15°E	13° 30'E	7°54'E
<b>Station Depth (m)</b>	100	54	variable, max. 200	48	
<b>Period of data available</b>	1974–2004	1993–present	1959–2004 (with gaps)	1973–ongoing	1975–ongoing
<b>Frequency (number of cruises/yr)</b>	1–4	3–4	seasonally (in general February, May, August, November)	Seasonally (4)	Monday, Wednesday, and Friday
<b>Gear/diam (cm)</b>	Juday net 38cm	WP-2	Juday/36 cm	WP-2	Hydrobios and Calcofi
<b>Mesh (µm)</b>	168	100	160	100	150 and 500
<b>Depth of sampling (m)</b>	0-bottom	50	variable, max. 100 m		
<b>Ancillary data</b>		hydrography, nutrients, chlorophyll a, phytoplankton species composition	temperature, salinity		hydrography, nutrients, chlorophyll, pigments (recently)
<b>Contact person</b>	Arno Põllumäe	Anda Ikauniece	Georgs Kornilovs, Christian Möllmann	Lutz Postel	Wulf Greve
<b>Email address</b>	arno@sea.ee	anda@monit.lu.lv	georgs.kornilovs@latzra.lv, cmo@dfu.min.dk	lutz.postel@io-warnemuende.de	wgreve@meeresforschung.de
<b>Location of data</b>	Estonian Marine Institute, University of Tartu	Institute of Aquatic Ecology, University of Latvia	LatFRA, Riga, Latvia	German Ocean Data Centre, IOW	
<b>Observations (*)</b>			variable number and location of stations		

## Characteristics of the collections used (Table of Metadata, continued)

COUNTRY	UK (20)	UK (21)	UK	SPAIN (22)	SPAIN (23)
<b>Monitoring programme</b>	FRS-MLA	L4-PML/UK	Continuous Plankton Recorder	IEO-SPAIN	IEO-SPAIN
<b>Sampling location</b>	Stonehaven, Aberdeen	Plymouth	North Atlantic	Santander	A Coruña
<b>Latitude (N)</b>	56°57.80'N	50°15'N		43°34.4'N	43°25.3'N
<b>Longitude (E-W)</b>	02°06.80'W	4°13'W		3°47.0'W	8°26.2'W
<b>Station Depth (m)</b>	50	50	*	110	77
<b>Period of data available</b>	1997–ongoing	1988–1997*	1946–ongoing	1991–ongoing	1990–ongoing
<b>Frequency (number of cruises/yr)</b>	Weekly (52)	Weekly (~40)	approx 12, some missing mon/yr	Monthly (12)	Monthly (12)
<b>Gear/diam (cm)</b>	Bongo/40	WP2	CPR, aperture 1.24 cm x 1.24 cm	Juday 50	Juday 50
<b>Mesh (µm)</b>	200	200	280	250	1971–96: 250; 1996–present: 200
<b>Depth of sampling (m)</b>	47	50	7–10	50	50
<b>Ancillary data</b>	hydrography, nutrients, chlorophyll	hydrography, CNH, chlorophyll, <i>Calanus</i> egg production	temperature, colour index	hydrography, nutrients, chlorophyll, phyto. cells.	hydrography, nutrients, chlorophyll, phyto. cells.
<b>Contact person</b>	Steve Hay	Roger Harris/X. Irigoien	Chris Reid	Luis Valdés	Maite Alvarez-Ossorio
<b>Email address</b>	haysj@marlab.ac.uk	rph@ccms.ac.uk	pcre@wpo.nerc.ac.uk	luis.valdes@gi.ieo.es	maite.alvarez@co.ieo.es
<b>Location of data</b>	SERAD, FRS MLA	PML/CCMS	SAHFOS database	Database SIRENO IEO	Database SIRENO IEO
<b>Observations (*)</b>		Later samples in process	Data correspond to several CPR routes and are presented here as the CPR standard areas of the North Atlantic		

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