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**ICES/EuroGOOS North Sea Pilot Project
– NORSEPP
ICES/EuroGOOS Planning Group
for NORSEPP (PGNSP)**

**Update report on
North Sea conditions –
1st quarter 2006**

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Contributors and acknowledgements

Morten Skogen (IMR) provided the NORWECOM model data for water fluxes. Vidar Lien (IMR) produced the plots of sea level air pressure and IBTS hydrography. Didrik Danielsen (IMR) provided the plot of daily temperature recordings at Flødevigen, Arendal. Stephan Dick (BSH) provided the North Sea plots of sea surface temperature and the seasonal temperature development in the German Bight. Liam Fernand (CEFAS) provided the time series of salinities in the Southern Bight. Virginie Pison (MUMM) provided modeled flux through the Channel and the modeled temperature distributions in the Channel and southern North Sea. Youngje Park and Kevin Ruddick (MUMM) provided the map of satellite-derived monthly mean chlorophyll *a* concentration for March.

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Summary description

The air pressure over western Europe in winter 2005/06 was characterised by a change from high to low NAO index conditions from January to March. This was associated with a change in the strength of the modelled water circulation in the North Sea during the 1st quarter. The inflow across the northern boundary was strong in January, with a pronounced slackening up to March. The circulation through Skagerrak was weaker (by about 1/3) than the long-term average, as were the water flows in the middle and southern parts of the North Sea. The counter-clockwise circulation around the Dogger Bank was, however, intensified between February and March. The net flux through the Channel was directed westwards out of the North Sea in February, whereas it changed to eastwards inflow in March.

The North Sea was warm in the autumn 2005, by about 2°C above long-term mean values in the southeastern area. This changed during the winter, with sea surface temperatures being slightly above average in March for the northern and central North Sea while being cooler in the southern and eastern areas. The bottom temperatures recorded during the IBTS in January/February were 1.0-1.5°C above the average climatology. Distributions of modelled monthly mean bottom temperatures are presented, as is a map of satellite-derived chlorophyll a for the Southern Bight and the Channel.

Preface

ICES and EuroGOOS established in autumn 2001 a Joint ICES/EuroGOOS Planning Group on the North Sea Pilot Project (PGNSP). Establishment of the Pilot Project was one of the recommendations from an ICES/OSPAR/IOC/EuroGOOS Strategic Workshop held in Bergen, 5-7 September 2001.

The Pilot Project - NORSEPP - is focussing on the relationships between oceanography and fish stocks and is promoting the development of operational oceanography for biological applications such as in fish stock assessments.

PGNSP (the Planning Group for NORSEPP) decided in 2005 to start producing quarterly update reports on the conditions of the North Sea, with emphasis on the physical conditions as drivers for biological variability. The quarterly reports for 2005 are available at the ICES web-page: <http://www.ices.dk/marineworld/norsepp.asp>

The editor and PGNSP are happy to receive comments and feedback on the quarterly reports so that we can shape them in scope and content to suit the needs of users both within and outside the ICES community.

Air pressure

The NAO (North Atlantic Oscillation) winter index (calculated for the December-March period) was negative this last winter. The index values from the Climate Prediction Center of the US NOAA National Weather Service were:

- December 2005 -0.4
- January 2006 +1.3
- February 2006 -0.5
- March 2006 -1.3

The mean winter index was -0.225 .

(http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/bulletin/table3.html)

The monthly means and quarterly mean sea level air pressures for the first quarter of 2006 are shown in Fig. 1. The mean for January showed pronounced gradients between a deep Iceland Low and the High off Portugal, with the strongest gradients to the northwest of the North Sea. In February a high pressure over Greenland developed that became even stronger in March, pushing the Low south in the North Atlantic. This led to a reversal of the typical pressure gradients over the northeast Atlantic, with higher pressure at Iceland than west of the British Isles. The mean pressure distribution for the 1st quarter resembled the transitional distribution during February.

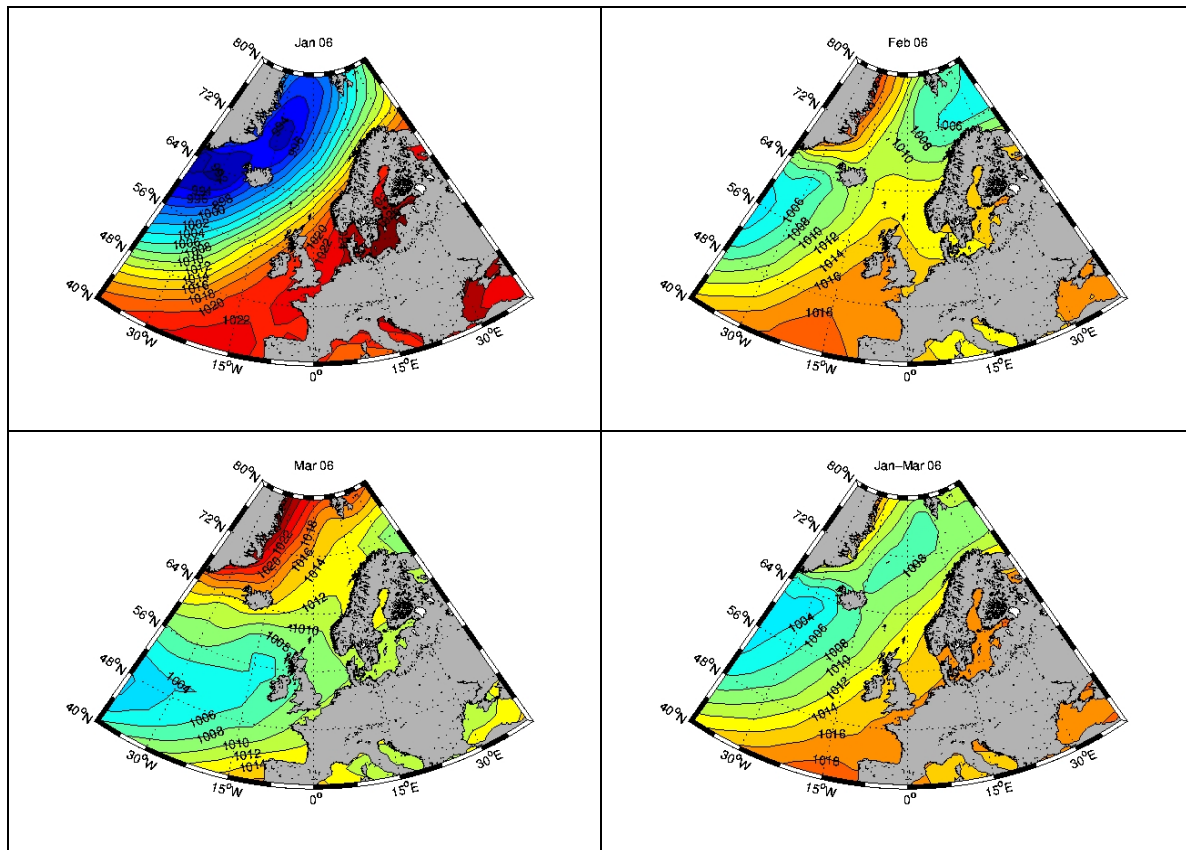


Fig. 1. Monthly mean sea level air pressures for January, February and March 2006 (upper left, right and lower left panels) and the mean for the 1st quarter (January-March) 2006 (lower right panel).

Modelled water circulation

The NORWECOM model has been run with historical meteorological driving forces to simulate the circulation of the North Sea over the period 1955-2004. Monthly mean flux values over this period were presented by Skjoldal *et al.* (2005; REGNS 2005 working paper). The 50-years mean values for monthly and quarterly fluxes across sections (see Fig. 3 for their locations) have been used for comparison with the estimated monthly and 1st quarterly fluxes for 2006.

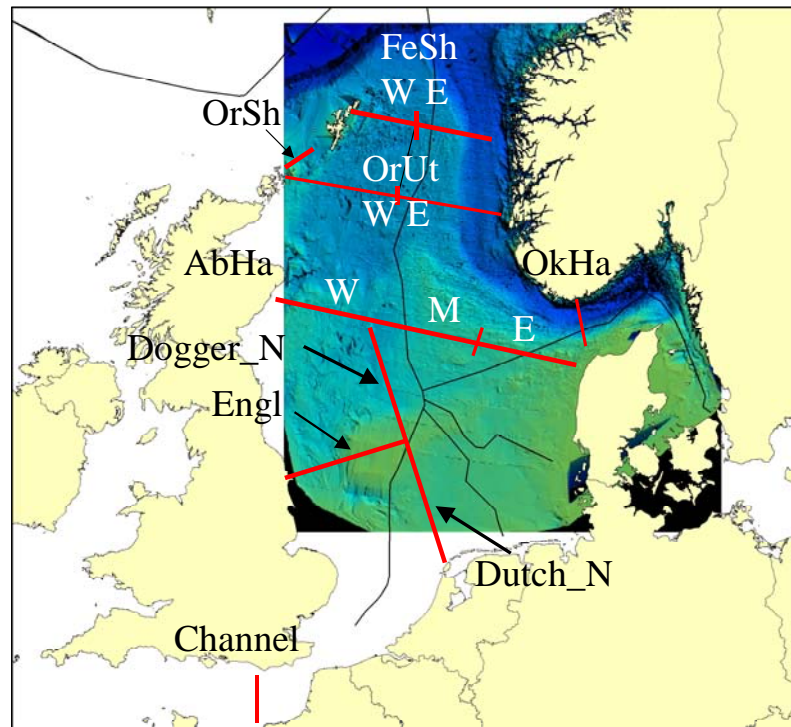


Fig. 3. Sections across various parts of the North Sea used to calculate fluxes of water with the 3-D mathematical circulation model NORWECOM.

The modelled mean quarterly fluxes across the different sections are shown in Fig. 4, compared to the long-term (50-year; 1955-2004) modelled mean 1Q flux in 2006. The mean monthly fluxes for January, February and March in 2006 are shown in Fig. 5.

The inflow to the North Sea between the Orkneys and Shetland was about 30 % less than the long-term mean (Fig. 4, upper panel). This reflected a marked change from a strong inflow in January to a weak outflow (northwestward) in March (Fig. 5, upper panel). The inflow across the Feie-Shetland transect was close to the long-term average, and decreased from January to March as did the outflow (northwards) in the eastern part of the section. The circulation trough Skagerrak as indicated by the fluxes across the Oksøy-Hanstholm section, was about 1/3 less than the long-term average. This circulation was reduced by about 50 % between January and March (Figs 4 and 5, upper panels).

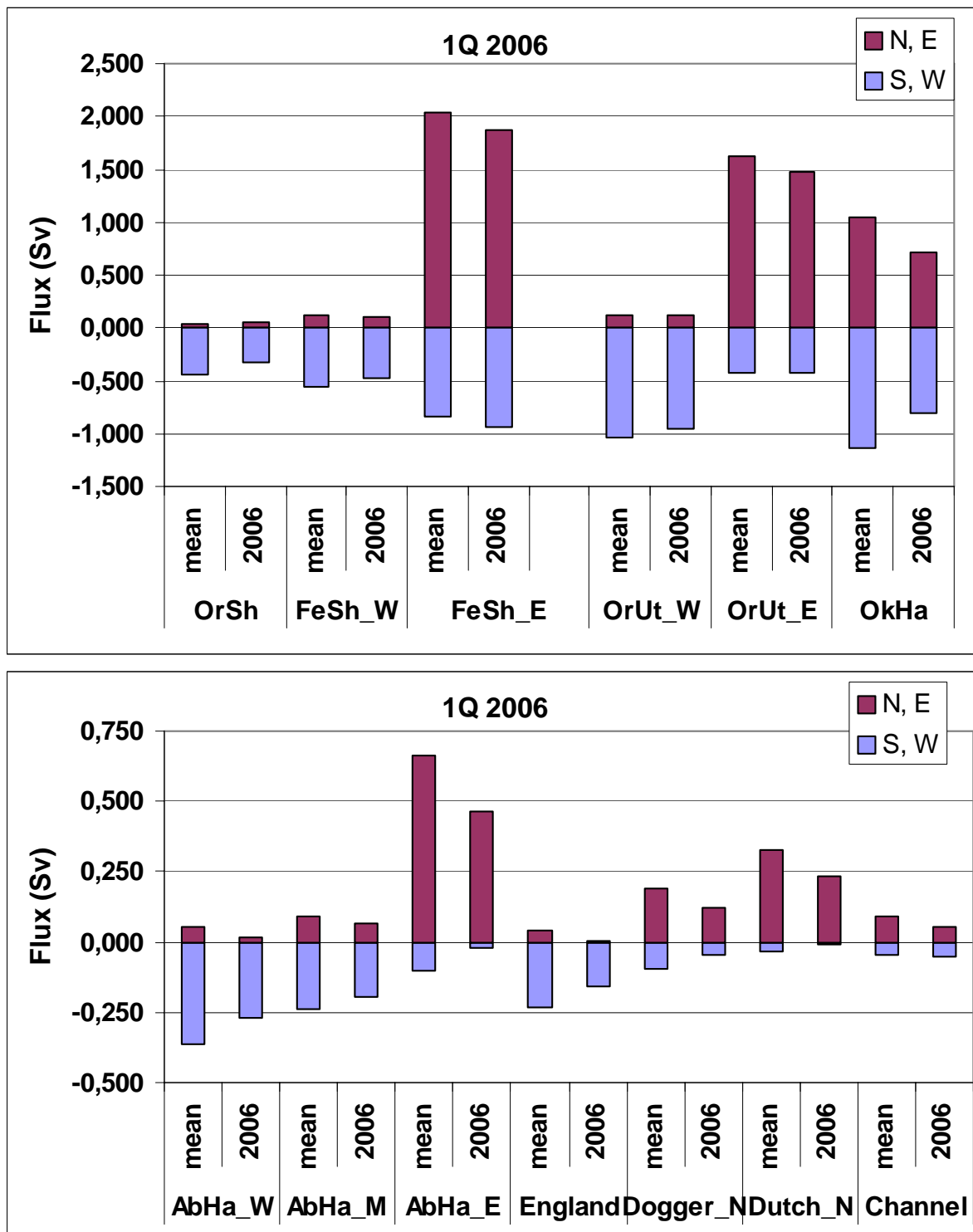


Fig. 4. The 2006 mean 1st quarterly water fluxes across sections in the North Sea compared to the long-term mean fluxes for the 1st quarter (1955-2004). NORWECOM model estimates. See Fig. 3 for the location of the sections. Positive values denote northwards or eastwards transport while negative values denote southwards or westwards transport.

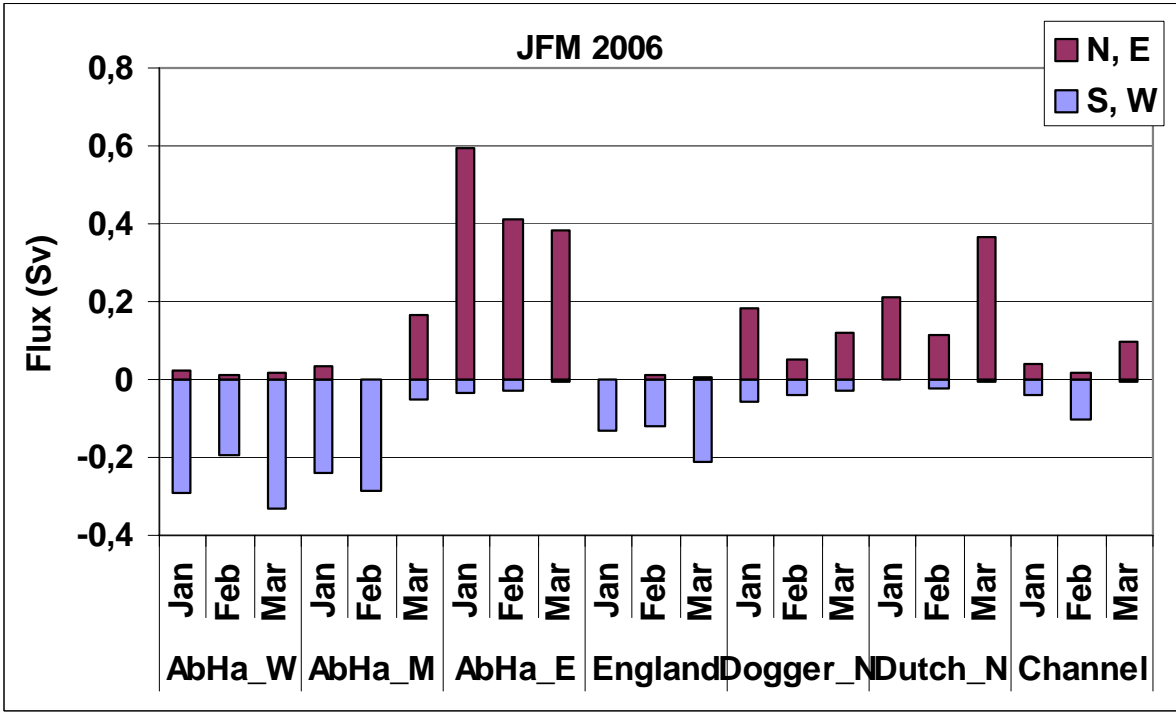
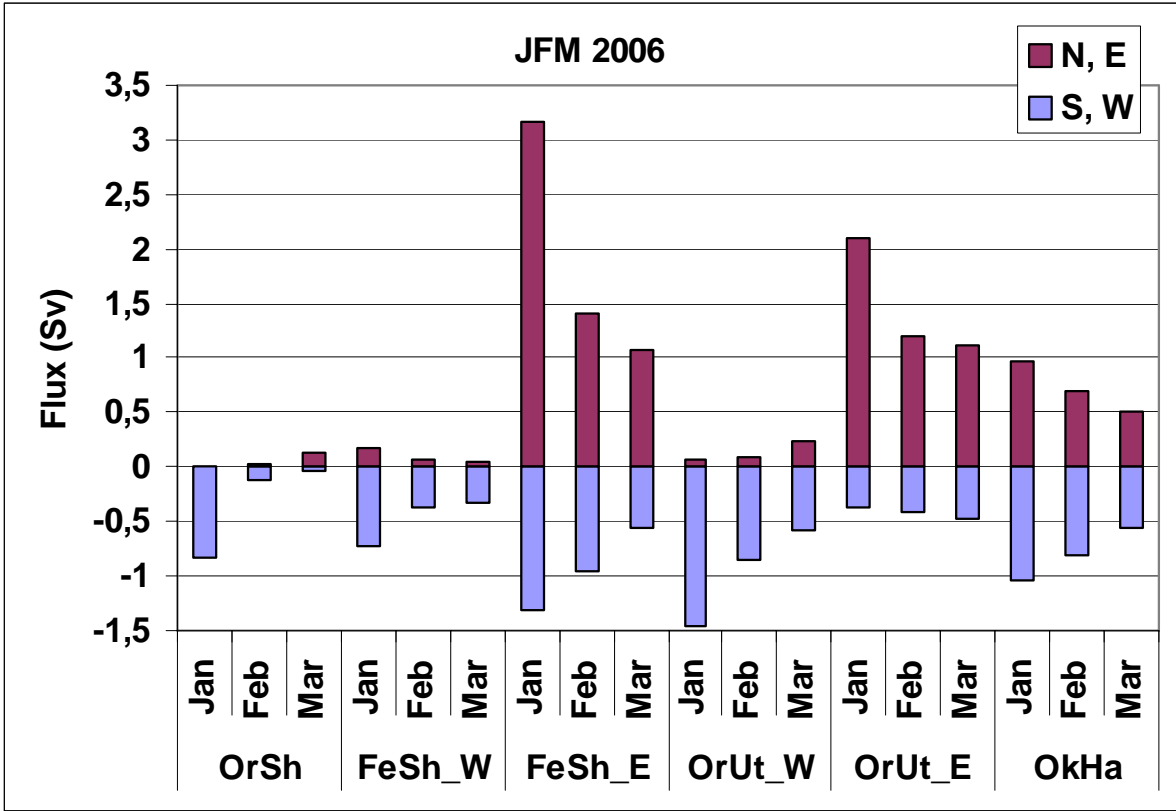


Fig. 5. The mean monthly water fluxes for January, February and March 2006 across sections in the North Sea (see Fig. 3 for their locations). NORWECOM model estimates. Positive values denote northwards or eastwards transport while negative values denote southwards or westwards transport.

The circulation in the middle and southern parts of the North Sea was generally weaker than the long-term average (Fig. 4, lower panel). The typical counter-clockwise circulation around the Dogger Bank was intensified between February and March, as indicated by increased southward fluxes in the western part of the Aberdeen-Hanstholm section and the England section and increased easterly transport in the Dutch_N section (Fig. 5, lower panel). The flux across the mid part of the Aberdeen-Hansthold section also changed, from southerly transport in February to predominantly northerly transport in March. The flux through the Channel was predominantly out of the North Sea (westwards) in February and into the North Sea in March.

The monthly mean fluxes for January, February and March 2006 are shown in Figs 6 and 7 as part of 15 months time series (from January 2005), projected onto the long-term (50-years) mean monthly fluxes. These figures show net fluxes, except for the Norwegian Trench (in the eastern part of the Feie-Shetland section) where inflow (south) and outflow (north) are shown separately, and for the flux across Skagerrak (the Oksøy-Hanstholm section) where the outflow (west) is shown.

The mean long-term pattern is stronger fluxes during winter than during summer. The net flow into the North Sea between the Orkneys and Shetland was stronger than average in January, but much less than average in February and March. This pattern resembled that calculated also for the 1st quarter in 2005 (Fig. 6). The net transport into the North Sea over the plateau in the western part of the section between Shetland and Feie showed the same pattern although less pronounced. The transport into the North Sea through the Norwegian Trench in the eastern part of this section was considerably stronger (by about 35 %) than the long-term average in January, while being weaker than the average in March.

Reflecting these patterns of inflow, the main outflow from the North Sea through the Norwegian Trench in the eastern part of the Feie-Shetland section was about 30 % above average in January and 30-35 % less than average in February and March. The transport through Skagerrak as reflected in the flux across the Oksøy-Hanstholm section, was considerably less than average, most pronounced for March when the transport was reduced to almost half of the average (Fig. 6).

The typical circulation of the southern North Sea is a counter-clockwise flow around the Dogger Bank. This flow can be followed from the fluxes across the western part of the Aberdeen-Hanstholm section, continuing through the England section between Dogger Bank and England and through the Dutch_N section to the south of the Dogger Bank. This flow pattern was weak in December 2005 and this situation with lower than average net fluxes continued in January and February 2006 (Fig. 7). In March, however, these flows were stronger than average.

The net flow through the mid portion of the Aberdeen-Hanstholm section was stronger than average in February, while being much lower in March when the direction of the net flow was reversed to northwards (Fig. 7). The net flow through the Dogger_N section was low in February. The main outflow from the southern half of the North Sea takes place through the eastern part of

the Aberdeen-Hansthholm section. Here the flow was lower than average in January and February but close to average in March.

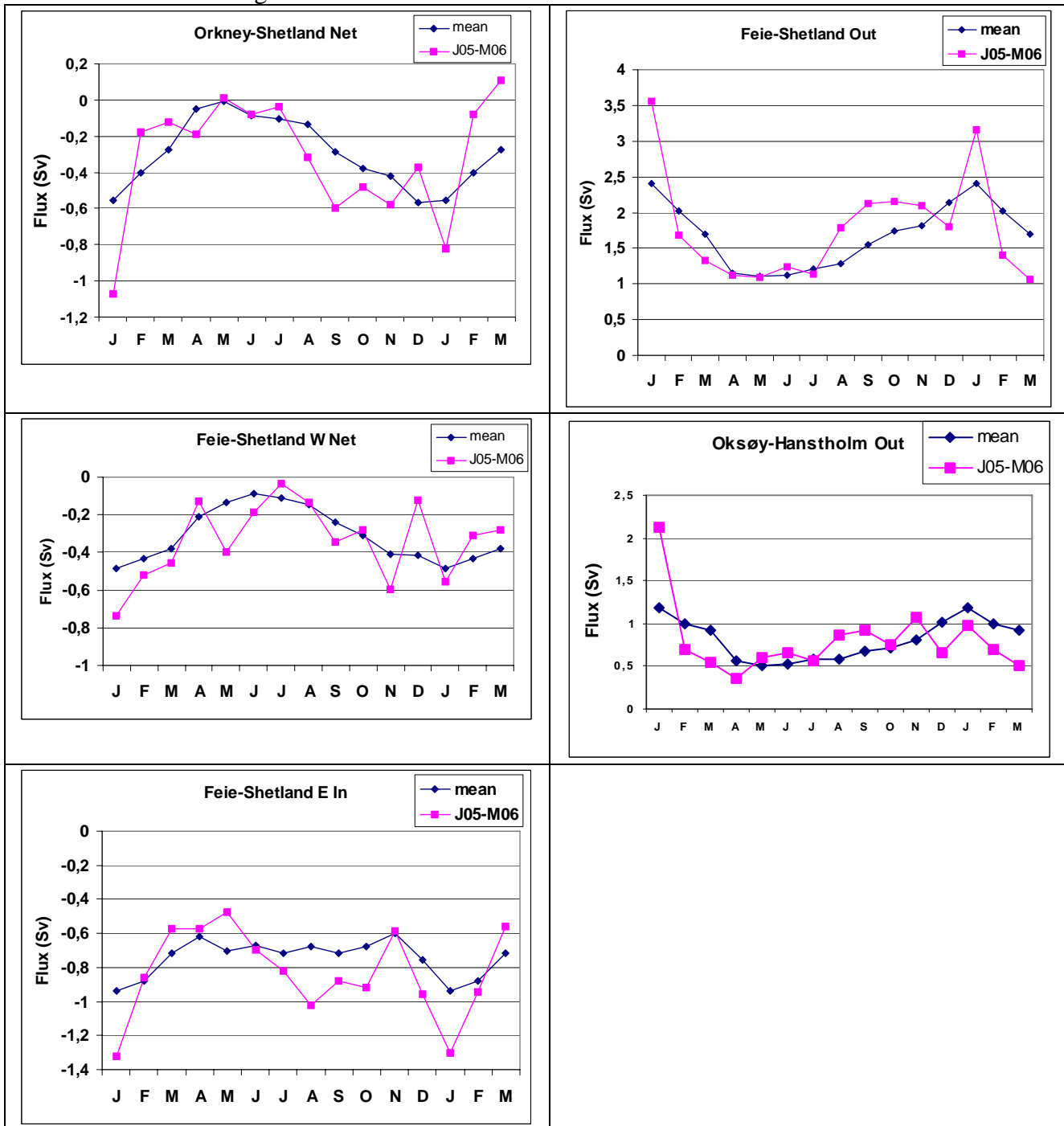


Fig. 6. Modelled fluxes of water across sections in the northern North Sea and in the Skagerrak (see Fig. 3 for their locations). The mean monthly fluxes from January 2005 to March 2006 are shown along with the long-term mean (1955-2004) monthly fluxes. Net flux is the difference between northwards and southwards fluxes for transects oriented in the E-W direction, and between eastwards and westwards fluxes for transects oriented in the N-S direction. *In* and *Out* are used to denote southwards and northwards fluxes into and out of the North Sea across the northern boundaries. *Out* for the Oksøy-Hansthholm section denotes outflow from Skagerrak. Negative

values are southwards and westwards fluxes while positive values are northwards and eastwards fluxes for E-W and N-S oriented sections, respectively.

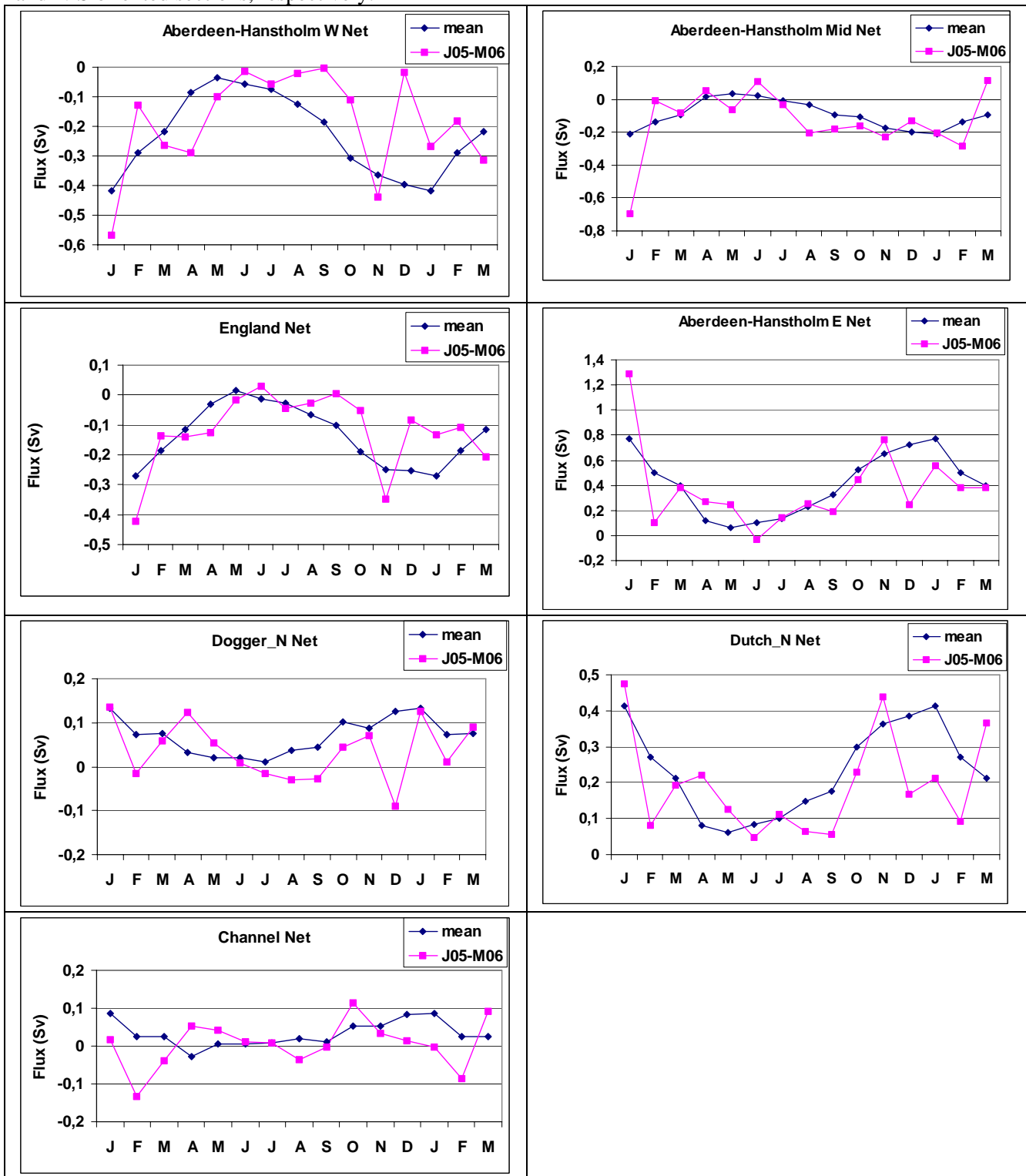


Fig. 7. Modelled fluxes of water across sections in the central and southern North Sea (see Fig. 3 for their locations). The mean monthly fluxes from January 2005 to March 2006 are shown along with the long-term mean (1955-2004) monthly fluxes. Net flux is the difference between northwards and southwards fluxes for transects oriented in the E-W direction, and between eastwards and westwards fluxes for transects oriented in

the N-S direction. Negative values are southwards and westwards fluxes while positive values are northwards and eastwards fluxes for E-W and N-S oriented sections, respectively.

The net transport through the Channel from the NORWECOM model was lower than average in January and February, when it was directed westwards out of the North Sea. This changed in March when the net flux was higher than average and eastwards into the North Sea (Fig. 7).

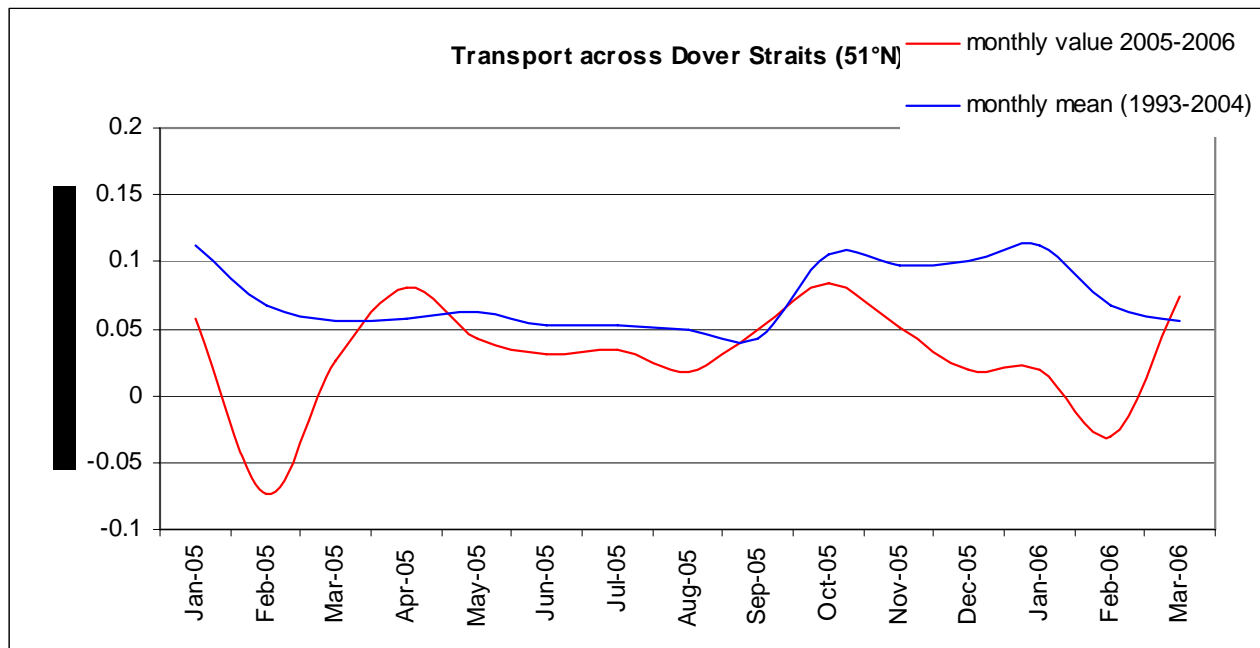


Fig. 8. Monthly transport across Dover Straits computed by the Optos_nos model (MUMM) in red ; long-term (1993-2004) modeled mean in blue.

Similar results were obtained with the **Optos_nos model run by MUMM** (Fig. 8). After the great flux into the North Sea through the Channel in October 2005, the monthly flux decreased in November and December. In February 2006, a negative value is observed (i.e. outflux from the North Sea through the Channel), as was already the case in 2004 and 2005. In March 2006, the flux returned to a positive value that was slightly above the long-term mean.

Distribution and properties of water masses

BSH (Bundesamt für Seeschifffahrt und Hydrographie) in Hamburg compiles information on North Sea temperatures and display them on their web-page as maps for weekly or monthly mean conditions

(<http://www.bsh.de/en/Marine%20data/Observations/Sea%20surface%20temperatures/index.jsp>).

Monthly mean sea surface temperatures for each month from July 2005 to April 2006 are shown in Fig. 9, while temperature anomalies (deviation from long-term means) for the same months are shown in Fig. 10.

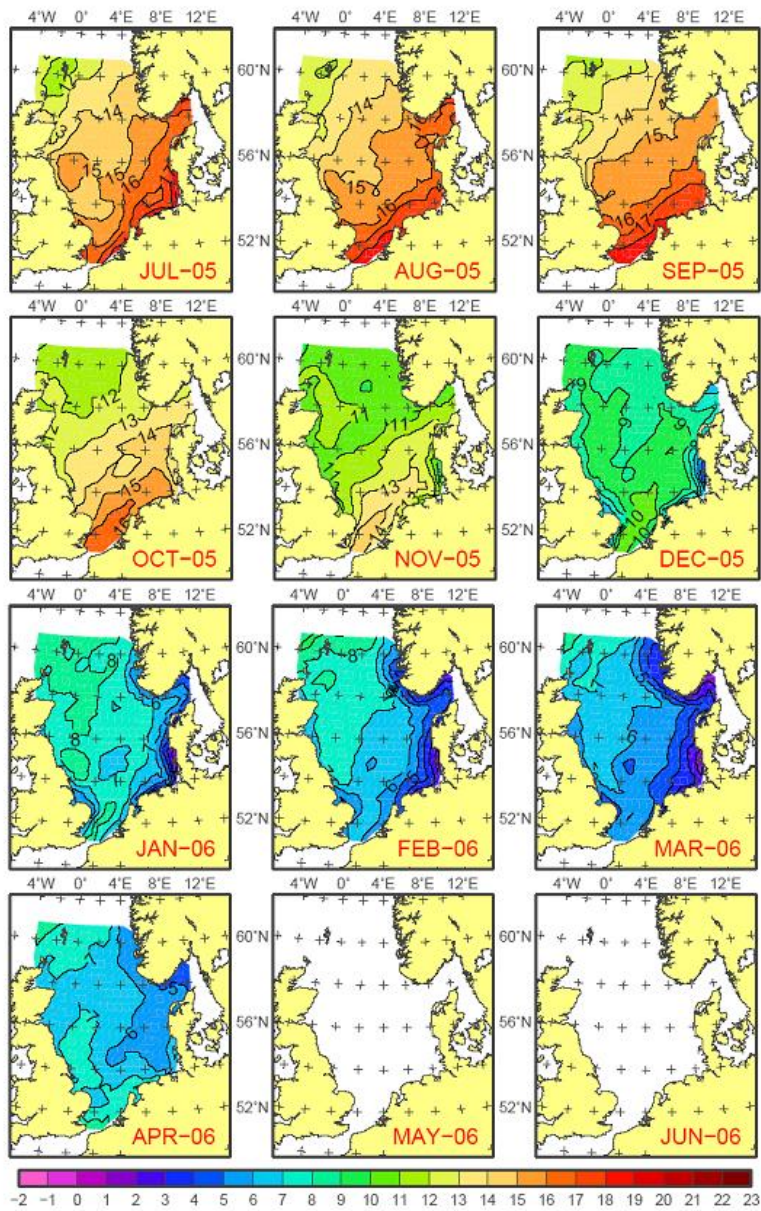


Fig. 9. Monthly mean sea surface temperature for July 2005 - April 2006. Data from BSH.

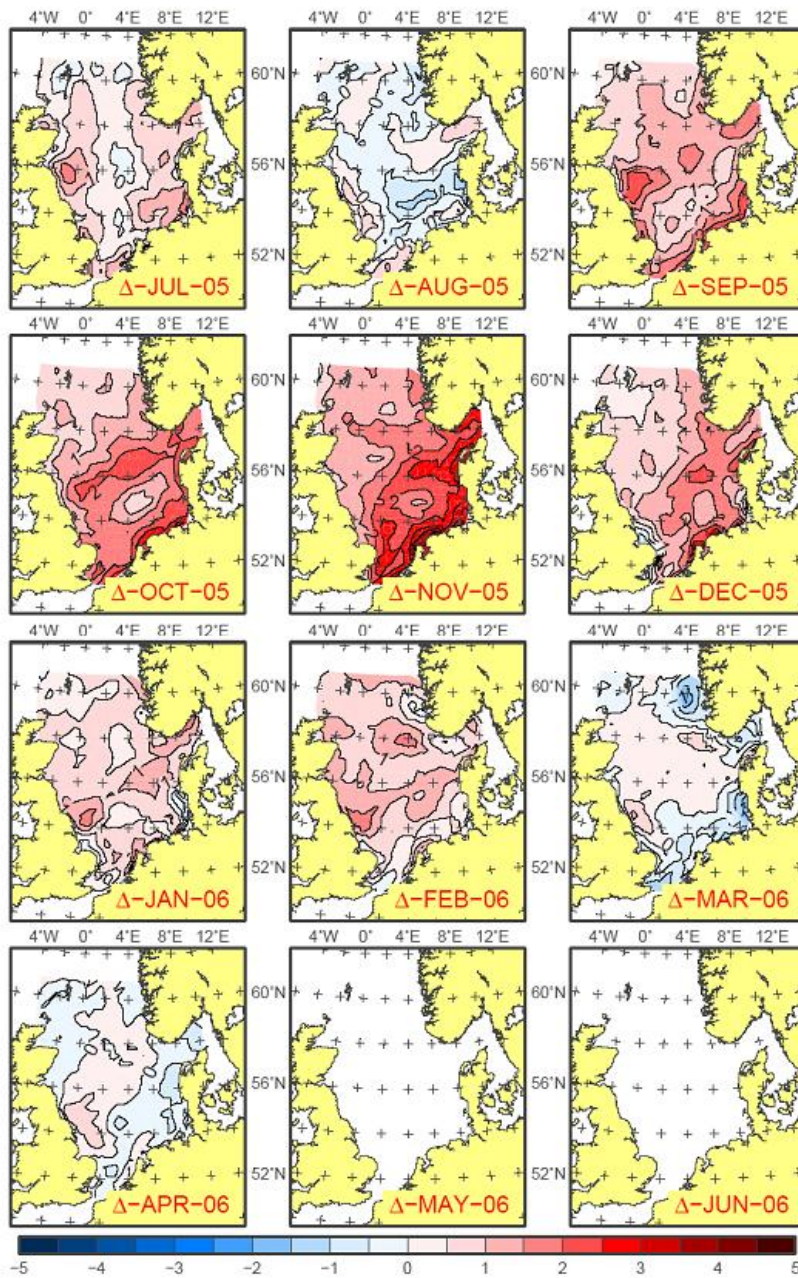


Fig. 10. Anomalies for monthly mean sea surface temperature for July 2005 - April 2006. Data from BSH.

The North Sea cooled through January to March when the sea surface temperature was 5-7°C over most of the North Sea, except for the eastern areas where the temperature was <5°C (Fig. 9). Last autumn, the North Sea was warmer than usual, with temperature anomalies about 2°C higher than average in November. The temperature anomalies remained above average in January and

February. In March they had changed to be on the cold side in the eastern areas, while remaining slightly above average in the central areas of the North Sea (Fig. 10).

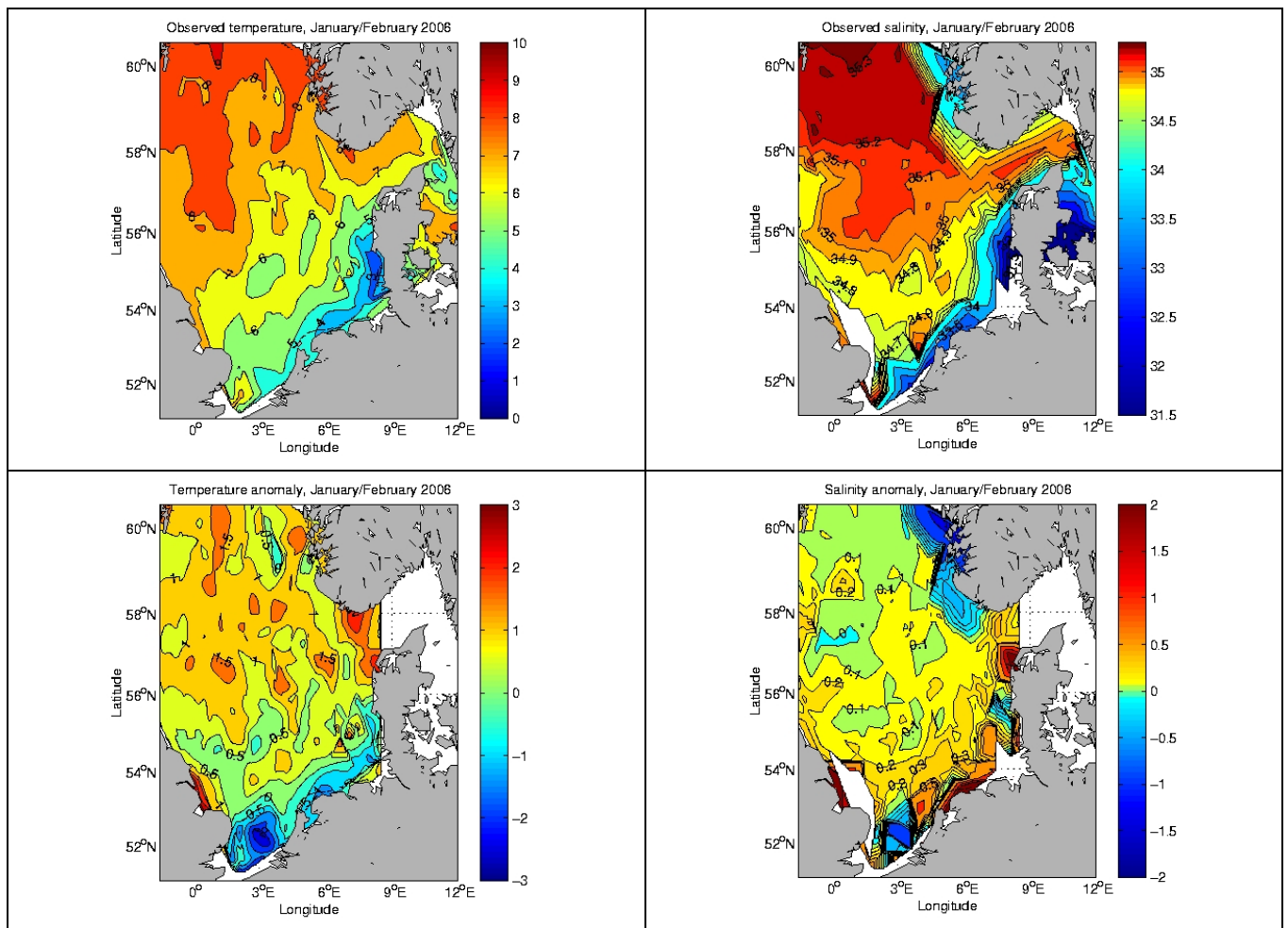


Fig. 11. Horizontal distributions of bottom temperatures and salinities (upper panels) and their anomalies compared to the climatological mean conditions for the 1976-2000 period (lower panels). Data from the 1st Q 2006 ICES IBTS.

The distributions of temperature and salinity at the bottom, as measured during the ICES 1st quarter IBTS (International Bottom Trawl Survey) in late January and February, are shown in Fig. 11. The temperature generally decreased from 8-9°C in the northwest to 5°C or less along the continent in the southeastern area. The temperature anomalies were positive by 0.5-1.5°C above the climatology over most of the North Sea except for the southeastern coastal areas (Fig. 11, left panels).

The salinities decreased from about 35.3 in the north to 34.8-35.0 over most of the southern North Sea. The anomalies were positive, with values about 0.1 unit above the climatology for most of the North Sea (Fig. 11, right panels).

Monthly mean modelled seabed temperature for January, February and March 2006 have been obtained from the MRCS (Medium-Resolution Continental Shelf) model run by the UK Met Office (Fig. 12). This model is based on the POLCOMS shelf seas modelling system developed by Proudman Oceanographic Laboratory. Further details of the MRCS model, including plots of near real time conditions, updated weekly, and a summary of model verification, are available from: <http://www.metoffice.gov.uk/research/ncof/mrcs/browser.html>. More information on the model is also given in Annex 1.

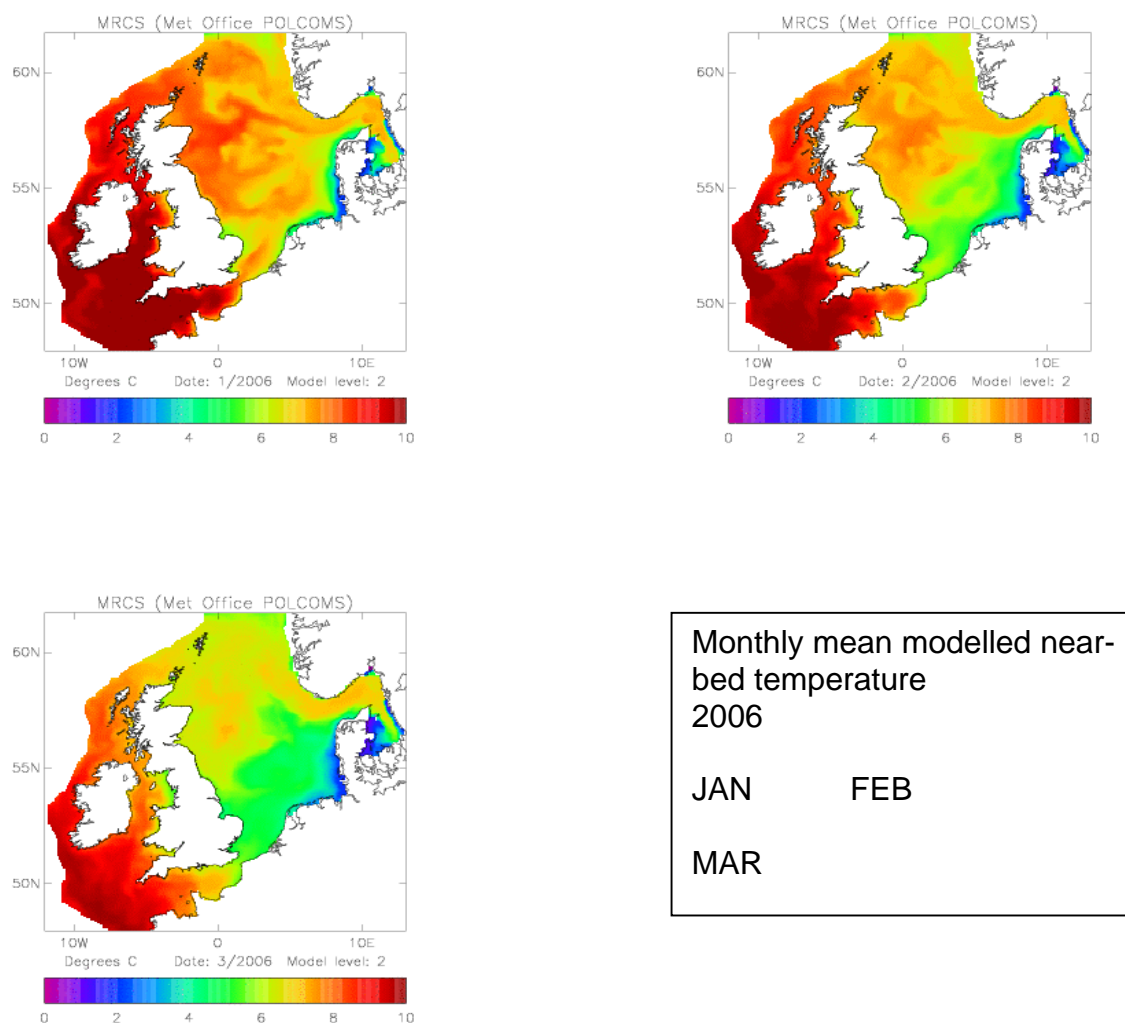
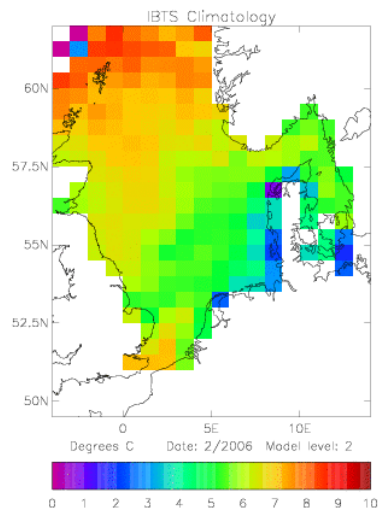


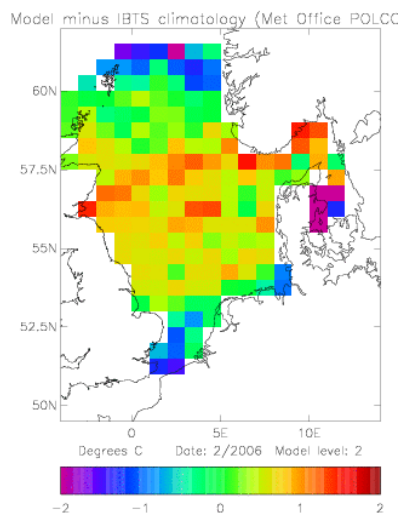
Fig. 12. Monthly mean modelled seabed temperature for each of January, February and March 2006. Model results from the MRCS model run by the UK Met Office. The Met Office is a partner in the UK National Centre for Ocean Forecasting. Gridded datasets of the model output are available on request from: enquiries@ncof.gov.uk

At the time of preparation of this model output, the IBTS Q1 data were not available, so we were not able to present model-observation collocation here. It is hoped to be able to include more validation in future updates. The IBTS ~20 year climatology of Quarter 1 seabed temperature consists of the Q1 near-bed temperatures averaged into ½ degree grid boxes. The climatology is plotted in Fig. 13a. Fig. 13 b shows the difference between the IBTS

climatology and the February 2006 MRCS model near-bed temperatures extracted onto this coarse grid.



a) the IBTS ~20 year climatology of near bed temperature ($^{\circ}\text{C}$)



b) Difference: Modelled monthly mean for February minus climatology ($^{\circ}\text{C}$)

Fig. 13. a) ICES IBTS climatology of near-bottom temperature (average for about 20 years). b) Difference between modelled monthly mean near-bottom temperature for February (from the MRCS model; Fig. 12, upper right panel) and the IBTS climatology.

The difference between model and climatology show positive values around $0.5\text{-}1^{\circ}\text{C}$ for the central parts of the North Sea. This is in fair agreement with the IBTS 2006 observations (Fig. 11). At the present time it is known that the heat transport along the shelf break is underestimated in the model that provides boundary forcing to MRCS, so the cold conditions in the north produced by the model are probably unrealistic. Work is in hand to improve this. Elsewhere, in central and southern North Sea the MRCS model shows good comparison with available sea surface temperature observations, so there can be more confidence in the model results in these waters. The model shows cooler than average waters around the Dover Straits, which is in agreement with the observed IBTS anomalies (Fig. 11).

Modelled bottom temperature distributions for January, February and March obtained with the Optos_nos model run by MUMM, are included as Annex 2.

A seasonal time series as monthly means of salinity at a station in the Southern Bight (south of the Dogger Bank at 52°N) is shown in Fig. 14, along with 30-years average climatology (1971-2000).

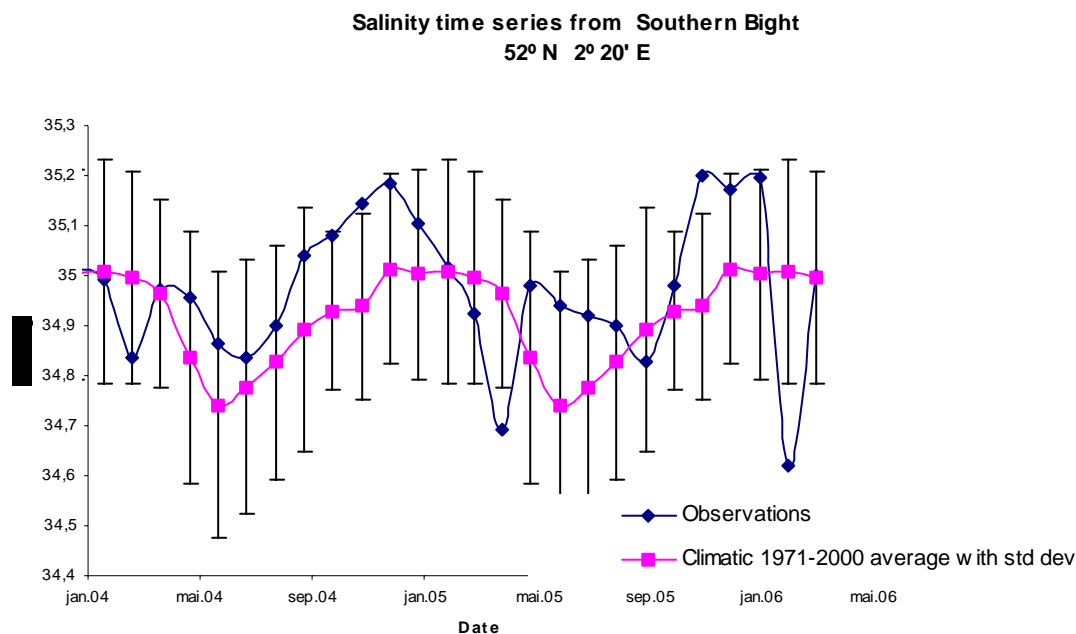


Fig. 14. Salinity data from one station, mid route, from the Harwich – Rotterdam ferry. The ship borne observations as monthly mean values from January 2004 to March 2006 (blue) are shown along with the climatic monthly mean (pink) and standard deviation (error bars). (From Liam Fernand, Cefas).

The salinity at the station in the Southern Bight was above the average from October 2005 to January 2006. The salinity decreased markedly in February, corresponding to the reversal of the flow through the Channel, as indicated by the NORWECOM and **Optos_nos models (Figs 7, lower left panel, and 8)**.

A detailed time series of water temperatures for the period from January to May 2006 in the German Bight is shown in Fig. 15. The data were measured at different water depths at station 'German Bight' of the Marine Environmental Monitoring Network of BSH (MARNET, <http://www.bsh.de/en/Marine%20data/Observations/MARNET%20monitoring%20network/index.jsp>). The temperature decreased to its minimum of about 3°C in mid March, followed by a steady increase to about 4°C by the end of March and about 8°C by early May. Onset of stratification started around 20 April, as indicated by higher temperature in the surface layer at this station.

The sea surface temperature at Arendal on the Norwegian Skagerrak coast remained above the long-term average for the entire period of the 3rd and 4th quarters of 2005. This situation changed during January 2006, when the temperature started to decrease to close to average for February and to below average for March (Fig. 16).

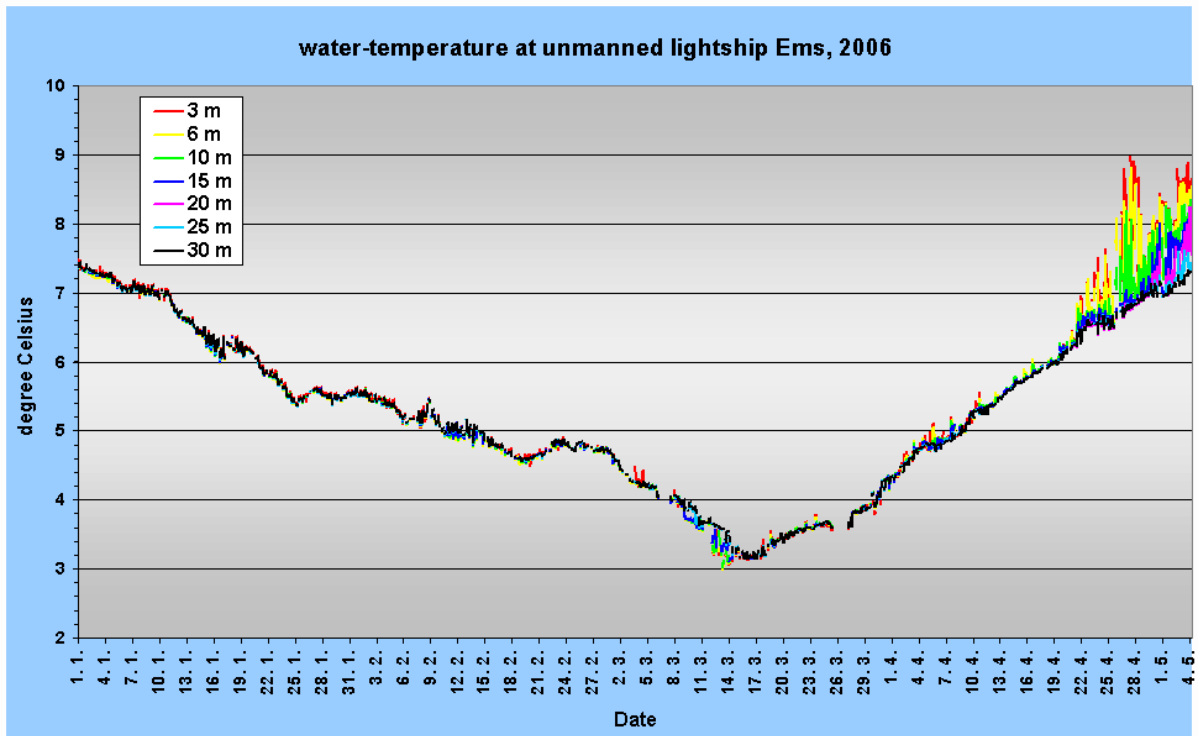


Fig. 15. Water temperatures measured at different depths at MARNET station 'German Bight' from January to May 2006. Data from BSH.

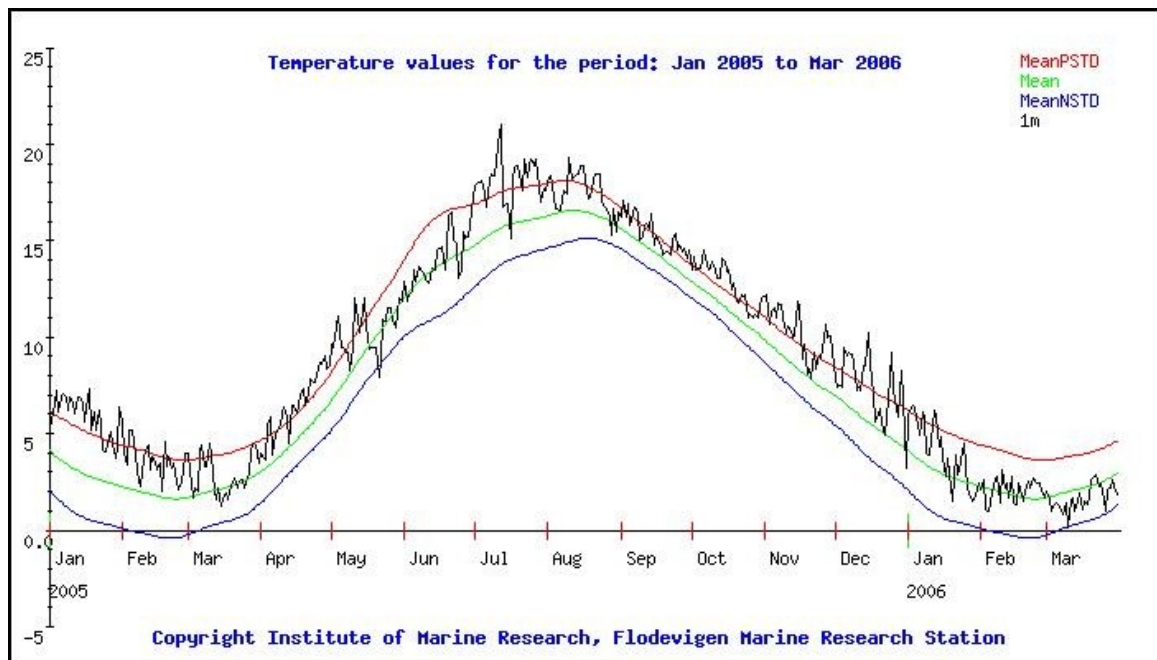


Fig. 16. Daily sea surface temperature recordings at Arendal on the Norwegian Skagerrak coast from January 2005 to March 2006. Also shown is the long-term average temperature ± 1 SD (standard deviation). Data from Institute of Marine Research (IMR).

Seasonal phytoplankton development

Fig. 17 shows the satellite-derived monthly mean chlorophyll *a* concentration for the Southern Bight and the Channel for March 2006 as compared to March 2005. When interpreting these maps it is important to bear in mind the quality of this data, which varies with location. For some turbid coastal regions the detection limit for satellite chlorophyll *a* may be rather high (e.g. $\sim 5 \mu\text{g/l}$ for the Thames Estuary region) and the constant “background” concentrations found within a few kilometres from the shore are less reliable. However, for these regions satellite data can still be used for detection of the high biomass algal blooms and, in particular, for assessing year-to-year differences or anomalies in the high biomass blooms. Thus, comparing the data between March 2005 and March 2006, the most important differences are that concentrations are generally higher in the Southern Bight of the North Sea in 2006 and especially in the Eastern Channel for the coastal region of Boulogne (1.5°E , 50.25°N) where local rivers provide nutrients. It seems that the spring phytoplankton bloom is occurring earlier (or stronger) in 2006 for this region. Work is in progress to clarify the cause of this interannual difference (light or temperature-driven?) and to provide better than monthly temporal resolution for the bloom timing.

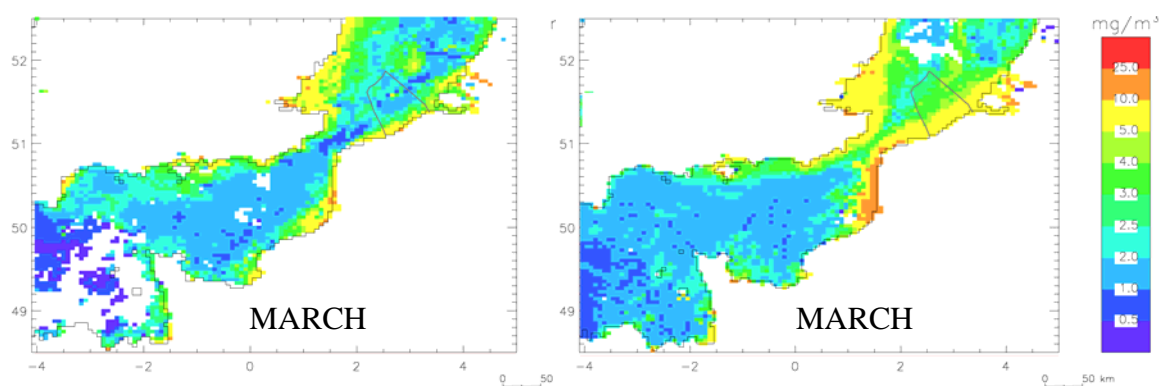


Figure 17. Monthly mean chlorophyll *a* concentration in March 2005 (left) and March 2006 (right) derived from ENVISAT-MERIS for the Southern Bight of the North Sea and the Channel. White areas denote land and pixels where no acceptable satellite data was available (because of clouds or failure of quality control checks). Belgian waters are delineated by the thin grey lines. Data provided by the European Space Agency in the framework of Envisat AOID 698, processed by MUMM (BELCOLOUR project).

More information relevant to the seasonal plankton development will be provided in the NORSEPP report for the 2nd quarter 2006.

Annex 1. Modelled monthly mean sea bed temperature

The UK Met Office runs the POLCOMS shelf seas modelling system developed by Proudman Oceanographic Laboratory, POL (www.pol.ac.uk), for a variety of configurations for the NW European shelf and adjacent waters.

Surface forcing is taken from the available Met Office numerical weather prediction (NWP) models, either the 40 km global NWP model, or for the NW European shelf, the 12 km mesoscale (to be replaced by 12 km North Atlantic European) NWP model. Surface fluxes of heat and moisture from the mesoscale model are used as three-hourly averages, and hourly values of 10 m wind and surface pressure forcing are used.

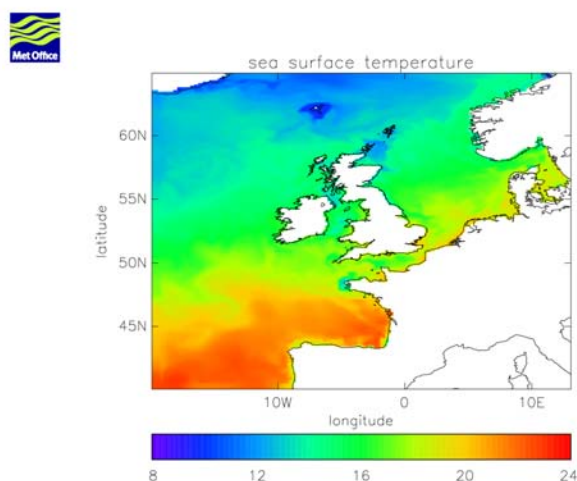
The results presented below are taken from the 7 km Medium Resolution Continental Shelf (MRCS) POLCOMS model, which is nested within the ~12 km Atlantic Margin POLCOMS model. In turn the AMM model is nested into the Atlantic FOAM model at the open ocean boundaries.

A summary of the model configurations is given below, and further information on the shelf seas models can be found on: <http://www.metoffice.com/research/ncof/shelf/index.html>

(i) Atlantic Margin model (AMM)

The AMM model is a ~12 km resolution physical model, extending from approximately 40°N to 65°N and 20°W to 13°E, nested into 1/9° Atlantic FOAM. The model has 32 vertical levels and is run operationally on a daily basis. Information about the model domain can be found at <http://www.metoffice.com/research/ncof/shelf/amm.html>.

Figure 1. The area covered by the POLCOMS Atlantic Margin Model.



(ii) MRCS (Medium-Resolution Continental Shelf) model

The MRCS (Medium-Resolution Continental Shelf) model is a coupled hydrodynamic-ecosystem model, where the hydrodynamics are supplied by the Proudman Oceanographic Laboratory Coastal Ocean Modelling System (POLCOMS) developed at Proudman Oceanographic Laboratory (POL), and the ecosystem component is supplied by the European

Regional Seas Ecosystem Model (ERSEM), developed at Plymouth Marine Laboratory (PML).

The model area is located on the north-west European continental shelf, ranging from 12°W to 13°E and 48°N to 62°N, as shown in Fig. 12. It has an open boundary which follows the 200 m depth contour around most of the domain. The resolution is approximately 7 km in the horizontal and in the vertical there are 18 *s*-coordinate levels.

Annex 2. Modelled temperature distributions in the central and southern North Sea and eastern Channel

Monthly mean bottom temperature distributions for January, February and March 2006 have been obtained as model results from the Optos_nos model run by MUMM (Fig. 1). A comparison between the model results and observations of temperature taken on the track of the R/V Belgica in the Belgian coastal zone is shown in Fig. 2. There is a general good agreement between the modelled and observed temperature results. However, at the end of March quite great differences were observed. The reasons for this difference remain to be explained.

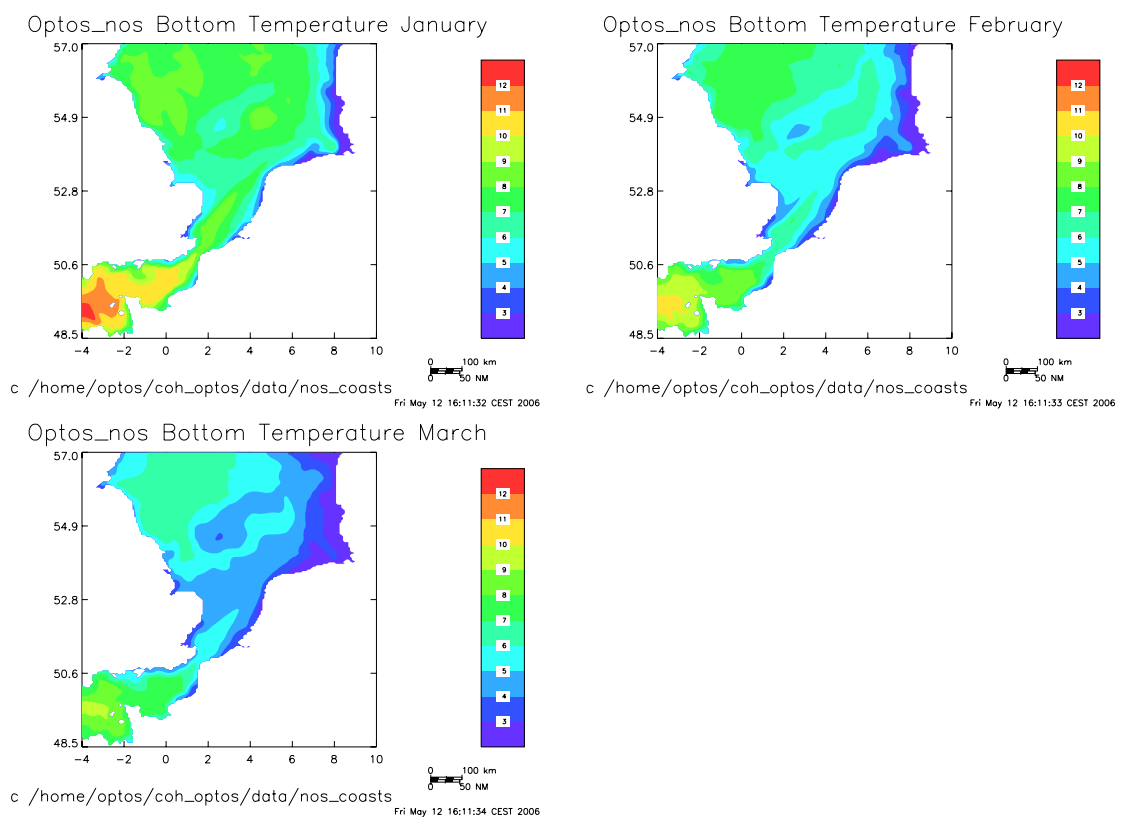


Fig. 1. Monthly bottom temperature computed with the Optos_nos model for January, February and March 2006. MUMM, Belgium.

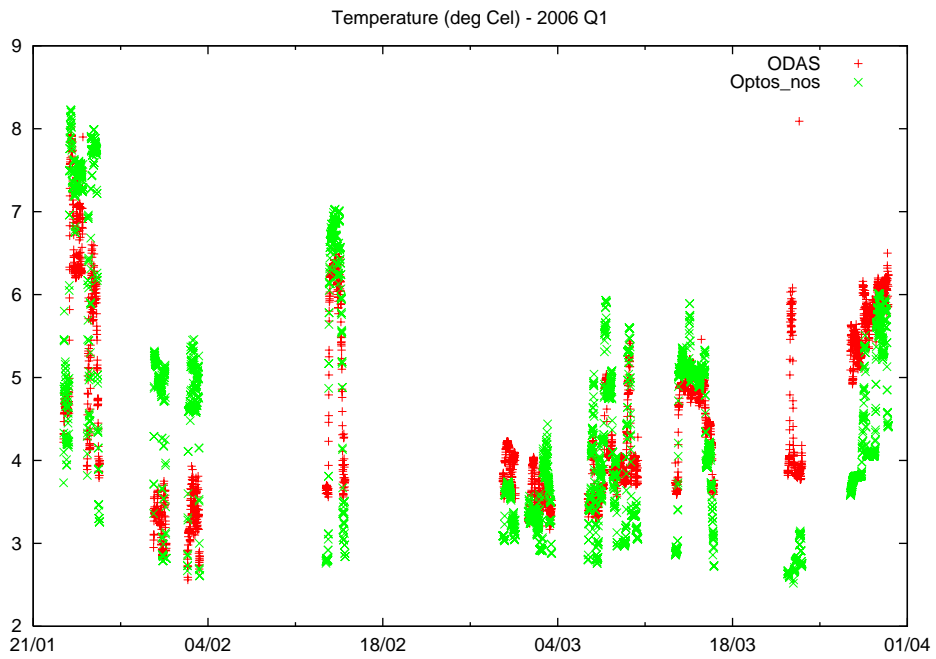


Fig. 2. Comparison between temperature observations from R/V Belgica (in red) and Optos_nos model (MUMM) results of surface temperature (in green).