Real-Time Assessment of a Developing Eddy Dipole in the Iceland Basin

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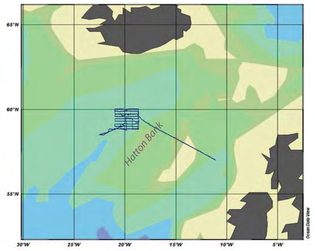
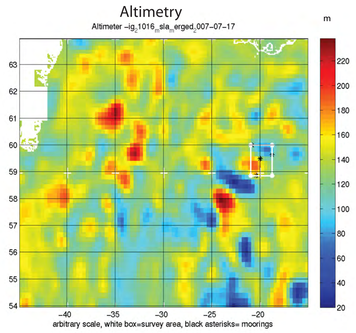
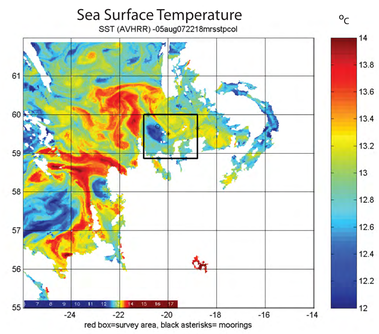


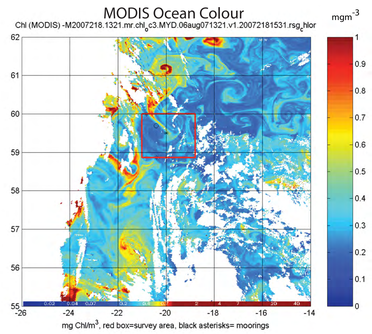
Cruise D321
RRS Discovery
24th July - 23rd August 2007

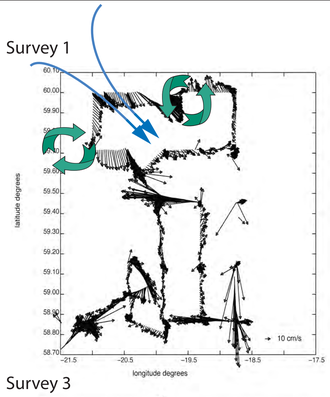
Satellite Imagery

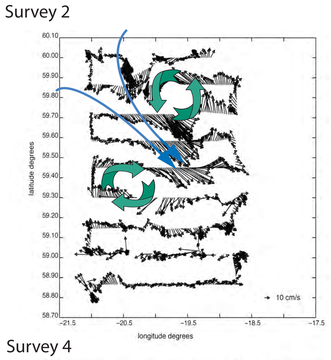
Early in the cruise, sea surface temperature, sea surface height anomalies and inferred chlorophyll concentration from daily ocean colour images for a large area of the North Atlantic showed the appearance of an eddy dipole structure within our survey site. Near real-time satellite data together with VM-ADCP data to over 500m were then used to determine the movement of the eddy centres and the central jet as the system developed and propagated eastward through our survey area.

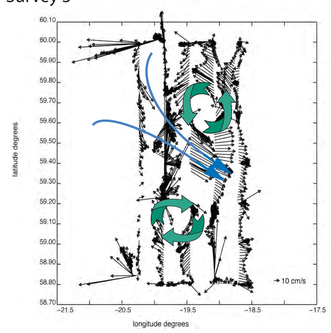


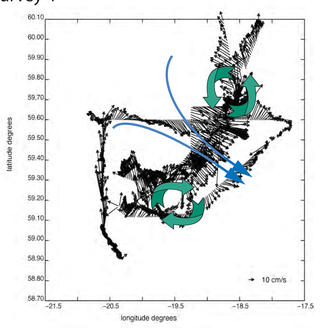












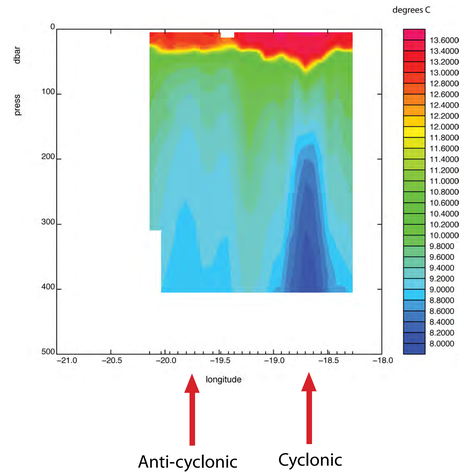
Both the intense jet associated with the dipole structure and the eddies themselves moved eastwards into and through our survey area until they reached the shoaling topography of the Hatton Bank. Here the southern, anti-cyclonic eddy appeared to stagnate; whilst, by the time of the fourth survey, the northern, cyclonic eddy appeared to become detached from the dipole jet and began to interact more strongly with eddy structures to the north and east.

VM-ADCP Current Data

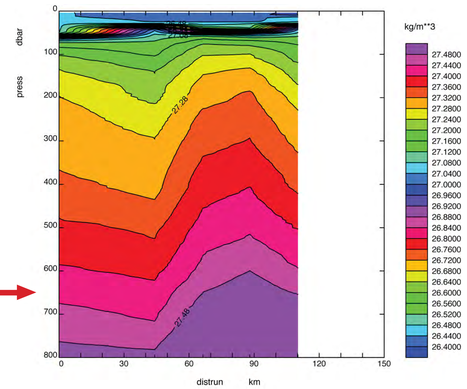
Current vectors from vessel-mounted ADCPs (150 and 75 kHz) revealed a south-easterly flowing central jet with contra-rotating eddies on either side. Both eddy components persisted down to over 650m, the maximum depth of the ADCP data. The jet was fast and deep-reaching with velocities of over 65cms^{-1} persisting down to the maximum depth of the ADCP data. The intensification of the flow between the eddies is an indication of their interaction due to their proximity. The centres of the vortices lay approximately 90km apart.

In-Situ Hydrographic Sections

Using the near real-time satellite images and ADCP data, short targeted surveys were made of the developing eddy dipole structure, alternating between the use of the CTD frame and the towed SeaSoar undulating recorder as vehicles for in-situ instruments. A SeaSoar section through both the cyclonic and anticyclonic elements of the dipole demonstrates their distinct hydrographic properties. Isopycnals are vertically stretched in the centre of the anti-cyclonic eddy and squeezed in the cyclonic eddy. The expression of potential vorticity anomaly (here inferred from the minimum and maximum in vertical stratification) is significantly deeper in the anti-cyclonic eddy, indicating strong baroclinicity in the dipole. The anti-cyclonic structure appears to be a winter mode water eddy with a remnant signal of deep water mixing to over 800m.

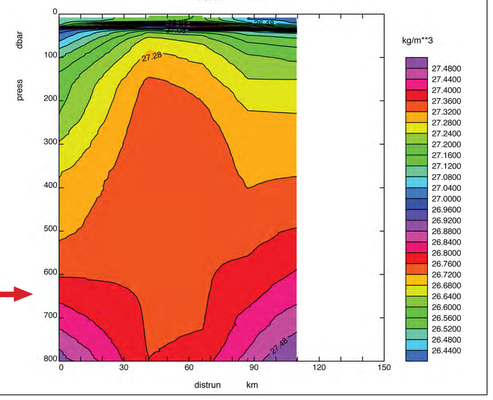


Cyclonic



The cyclonic eddy has a warm surface expression possibly as a result of increased stability in the water column leading to greater summer heating. The anticyclone has a cold surface signature as isopycnals were uplifted above the weakly stratified eddy core.

Anti-cyclonic

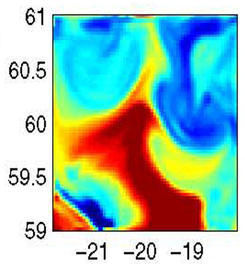


Forecast Model

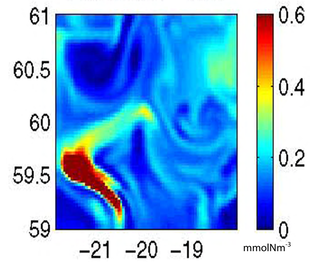
The Harvard Ocean Prediction (HOPS) model with 3km horizontal resolution for a limited geographic area was used to provide a forecast model for the duration of the time at sea. The HOPS model was initialised with homogeneously low values for all biological parameters except nutrients, which were set at Levitus January values. The physical model was atmospherically forced using NCEP meteorological data. Boundary conditions were updated every 5 days from the Met Office 1/9° Forecast Ocean Assessment Model (FOAM).

The physical model was run with a 10 compartment biological model including concentrations of diatom and non-diatom phytoplankton, small and meso-zooplankton, silicate, nitrate and ammonium. Physical and biological data relayed back to NOCS during the cruise in near real time were used to adjust the model to better represent the survey environment. Forecasts for physical and biological parameters were then made for selected days during the cruise.

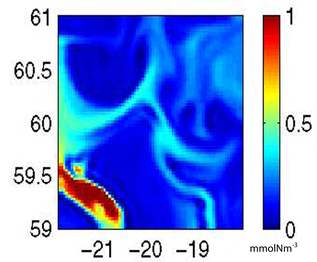
The images to the right are forecast model snapshots of surface temperature, diatom, meso-zooplankton and ammonium concentrations for the 8th August 2007. High ammonium concentrations in association with high standing stocks of meso-zooplankton represents the effect of grazing pressure on diatoms.



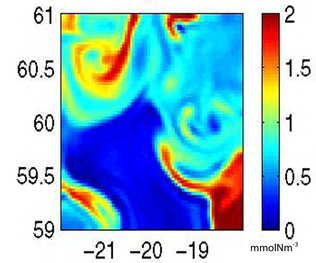
Temperature



Diatoms



Meso-zooplankton



Ammonium

Biogeochemical Impact and Discussion

Targeted net hauls and water collection for on-deck incubations within each component of the eddy dipole enabled the assessment of their biogeochemical impacts. There were significant differences in phytoplankton and zooplankton communities between the eddies and within the central dipole jet, although quantitatively much of this data is still to be worked up. The forecast modelling successfully represented most of the spatial patterns in terms of the domination of the physical regime by the development of an eddy dipole from mid-July until the end of August. Adjusted biological parameters began to show similar patterns to observations, particularly in a grazing pressure relationship between larger zooplankton and ammonium concentration in the mixed layer. We are however, just one month back from sea - considerable analysis and synthesis of the observations is planned for the forthcoming months, during which time we expect to understand these and other relationships through, for example, examination of the observations made of the microbial loop.

Thank you to the Captain, officers, crew and all the scientists aboard RRS Discovery during D321