Editorial - Progress in Oceanography

The Canary Islands coastal transition zone – upwelling, eddies and filaments

The marine science and technology (MAST) III program of the European Union funded the Canary Is
lands Azores Gibraltar Observations (CANIGO) project from 1996 to 1999 with the overarching objective of a better understanding of the physics, biogeochemistry and paleoceanography of the eastern subtropical North Atlantic. Parrilla, Neuer, Le Traon, and Fernandez-Suarez (2002) edited two volumes of papers detailing many results of the project. The present compilation of papers complements those volumes by reporting observational work carried out in the last months of the project, too late for inclusion there.

The component of CANIGO reported here, which focussed on the transition zone of the NW African coastal upwelling downstream of the Canary Islands, was an interdisciplinary effort involving researchers from ten institutes and universities in Spain, UK and France. The work contributed to the specific goals of CANIGO. These included obtaining an improved knowledge of physical processes controlling mesoscale circulation related to the North Atlantic subtropical gyre, studying the carbon cycle in nutrient limited (oligotrophic) and nutrient-rich (productive) waters and, to a lesser extent, quantifying the influence of coastal upwelling on the magnitude and composition of particle flux in the Canary region. Our work was based on a single month long cruise carried out during the height of the annual upwelling to determine the circulation and physical, biogeochemical and biological processes related to the upwelling filament system that appears repeatedly immediately south of the Canaries archipelago.

Since the comprehensive observational program on California Current filaments (Brink & Cowles,
1991), other upwelling systems have revealed their idiosyncratic filament structures to concerted efforts, e.g. Joint and Wassman (2001). Filaments are considered to be narrow ($10–30 km), long (100–500 km) and relatively shallow (50–100 m) surface features that locally transport relatively cool and biologically active waters from coastal upwelling regions towards the open sea. Because they originate in areas of high productivity, they often exhibit high chlorophyll content, characteristic distributions of phyto-, zoo- and icthyoplankton, and significant concentrations of dissolved and particulate organic matter, but their overall significance in export to the oligotrophic ocean is still poorly determined (e.g., Alvarez-Salgado et al., 2001).

Much effort was devoted to working in a coherent inter-disciplinary, rather than fragmented multi-
disciplinary, manner. Such an approach of necessity entails compromise by all participants, but yields benefits and insights unavailable to single discipline approaches. The basic strategy was to define the overall structure of the transition zone through an initial survey and remote sensing, and then to sample a wide range of properties across the expected filament at different distances from shore to determine the evolving conditions in filament waters as they progressed offshore. Rapid physical surveying determined where to locate the biogeochemical and biological sampling most effectively. The situation in situ revealed itself to be more complex, of course, than the hypothesised scenario, as is evident in the papers.

In this volume Barton, Arıstegui, Tett, and Navarro Perez (2004) document the series of interacting current jets and eddies that make up the complex system. Cyclonic and anticyclonic eddies, trapped behind or shed from individual islands, entrained or distorted the meandering path of the two filaments that arose during the study. The whole filament system circulated about a large cyclone anchored over the trough south of the archipelago. With distance offshore, there was a shift from large to small phytoplankton cells (Arıstegui et al., 2004) and from higher to lower autotrophic biomass. However, both particulate and dissolved organic carbon measures were higher midway along the filament system. These authors argue that recirculation about the trapped eddy constrained the export capacity of the filament and resulted in lower sedimentation rates and higher respiration/production ratios. Chlorophyll a decreased along filament but microplankton respiratory activity was higher in the filaments than in the shelf upwelling (Garcıa-Munoz, Arıstegui, Montero, & Barton, 2004a). The two filaments differed in detailed properties but their combined offshore transport of excess total organic carbon amounted to 97.1 kg s^{-1}, similar to other north Atlantic systems. Sebastian, Arıstegui, Montero, Escanez, and Niell (2004) studied the enzymatic alkaline phosphatase activity (APA) across the coastal transition zone. They observe that filament waters presented basal APA activity not induced by inorganic phosphorus (Pi) deficiency, and interpret this as a consequence of an effective Pi transport into the open ocean by filaments. The distributions of two calanoid copepod species showed a clear dependence on the hydrographic structure (Yebra, Hernandez-Leon, Almeida, Becognee, & Rodrıguez, 2004). Feeding and respiration rates of Scolecithrix danae differed greatly between anticyclonic eddies and filaments. Scottocalanus sp. were found only in the upwelling and filament waters.

Rodrıguez, Barton, Hernandez-Leon, and Arıstegui (2004) show that horizontal distributions of fish larvae depended strongly on the mesoscale oceanography. Larvae concentrated in cyclonic eddies, but were displaced offshore in the filaments. Indeed, neritic larvae proved a good indicator of the filaments, and recirculation around the trapped eddy could return sardine and anchovy larvae to the shelf region. Comparison with other years suggests that the dominance of sardine over anchovy, or vice versa, relates to changes in average temperature.

Upwelling filaments have still been little studied, in spite of their potential bio-geochemical implications. Filaments may contribute largely to the export of coastal primary production to the open ocean, either in particulate or dissolved form (Alvarez-Salgado et al., 2001; Garcıa-Munoz et al., 2004b). At a global scale, they may influence the marine carbon cycle through shelf-ocean transport of organic matter. This could enhance microbial remineralization in the mesopelagic zone of eastern boundary currents, and lead to plankton metabolic imbalances in these regions. However, limited knowledge of the dynamics and variability of upwelling filaments renders it difficult at present to draw any global conclusions in this respect. Their effectiveness in seaward transport of organic matter will depend on the seasonality and strength of upwelling events, as well as in the interactions of filaments with eddies. Paradoxically, eddy interactions may play a dual role in the offshore carbon flux, either increasing water and organic matter exchange by inducing filament generation, or decreasing the transport of labile organic matter by eddy re-circulation. Similarly, neritic fish larvae may be dispersed seawards (here possibly to renew island populations) or retained near the shelf by recirculations, depending on the filament-eddy interactions. Further studies of system variability linked to high resolution modelling are required to resolve these issues.

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Editor's Note: Review and final editing of these papers from the CANIGO project was directed by me, since Drs. Barton and Aristegui, the only potential guest editors for this issue, are coauthors of most of the papers. I thank the substantial battery of reviewers who have considered the papers. However, much of the coordination of preparation and revision was handled by Barton and Aristegui.

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