Final Report for R/V Falkor cruise FK003a,b

In compliance with U. S. State Department clearance applications:
F2012-019**,** FK003 Atlantic Crossing Sampling and Testing (UK, Faroes, Greenland, Canada)
F2012-045**,** FK003 Atlantic Crossing Sampling and Testing (Iceland)

Authorizations for Coastal States:
United Kingdom
Iceland
Faroes & Greenland (Denmark)
Canada

Project Title: High-resolution sampling of plankton taxa, marine snow, and environmental variables across the north Atlantic subpolar gyre

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Background - The North Atlantic subpolar basin and adjoining shelf seas are critically important to the ecological and socio-economic health of North America and Europe. This region feeds the global ocean circulation and is subject to freshening due to polar ice melt. It also is a major source of the dominant transatlantic copepod species, Calanus finmarchicus, and includes shelf and oceanic ecosystems that support large fisheries. This region is the focus area of the recent EU-North American BASIN program, whose goal is to better understand the north Atlantic subpolar system, including both shelf and basin and their connections. Prior to this study, there were no existing high-resolution data on the vertical-horizontal distribution of zooplankton across the entire region. Furthermore, traditional sampling methods are typically destructive and do not provide data on important delicate taxa and marine snow. Data on the relationship of plankton taxa to their environment across a continuum of scales from the individual organism to the basin scale is needed for better insight into the underlying processes controlling their populations.

In July 2012, the Schmidt Ocean Institute's new ship R/V *Falkor* crossed the Atlantic on its maiden voyage. This cruise provided a unique opportunity to tow the VPRII across the North Atlantic subpolar basin to collect multi-scale high-resolution data on plankton and hydrography.

Fig. 1. VPRII towfish, winch, and faired tow cable

The Video Plankton Recorder – The VPRII (Fig. 2) is an underwater video microscope that images mesoplankton and marine snow and collects data on environmental variables. The tow body was carefully designed to avoid disturbing the imaged volume prior to sampling it, minimizing avoidance by zooplankton and destruction of delicate plankton and marine snow (Davis et al. 2005). The VPRII includes a digital video camera and strobe mounted on a fast, 5m/s (10-knot) towfish that undulates automatically between the surface and 130m (and deeper with more cable fairing) and steers to starboard when surfacing to avoid the ship's wake (Davis et al. 2005). The VPRII environmental sensors include a CTD, fluorometer, OBS, PAR, and dissolved oxygen. The image analysis and plotting software automatically identifies plankton and marine snow in the size range of 50 microns to cm (with present lens setting) (Davis et al. 2004, 2005; Hu and Davis 2006), providing

quantitative abundance estimates of plankton that agree closely with traditional net sampling (Benfield et al. 1996; Broughton and Lough 2006). The VPRII has been used for high resolution mapping of abundance and biomass of plankton taxa across tropical ocean basins and in regional seas (Davis and McGillicuddy 2006), but had never been towed in the North Atlantic subpolar gyre

Project Goals

The main goal of this project was to collect high resolution data on plankton and hydrography across the North Atlantic subpolar basin using the second generation Video Plankton Recorder (VPRII) on a cruise of opportunity. Specifically the goal was to towyo the VPRII at 5 m/s (10 knots) in the upper water column on the Schmidt Ocean Institute (SOI) ship R/V *Falkor* during its maiden voyage across the Atlantic in July 2012. SOI funded the ship time and an NSF award supported scientific participation in this cruise to collect the VPRII data. The secondary goals were to collect underway acoustic data for testing these systems (EK60, ADCP, EM302, EM710) as well as station data on along the transect using the CTD rosette and plankton net tows. In addition, the cruise was used to test the VPRII, which had been upgraded to include a color camera and nitrate sensor (funding from the Marine Science and Technology Foundation).

Project Outcomes

During the maiden science voyage of the new Schmidt Ocean Institute (SOI) ship, R/V *Falkor*, (July 2-28, 2012, FK003a,b), the VPRII was towyoed across the North Atlantic (Fig. 2) on a continuous transect from the northern UK shelf to the southern Greenland shelf (Leg 1, FK003a) followed by a second continuous transect from Nuuk, Greenland to the North Atlantic Slope Water south of Nova Scotia (Leg 2, FK003b).

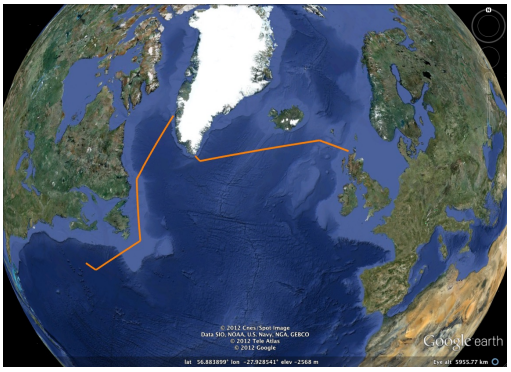

Fig. 2. FK003 VPRII track

The VPRII successfully sampled a combined 5382-kilometer (2906 nautical mile) transatlantic transect (Fig. 2), providing high quality images of plankton (Fig. 3) together with environmental data (Fig. 4).

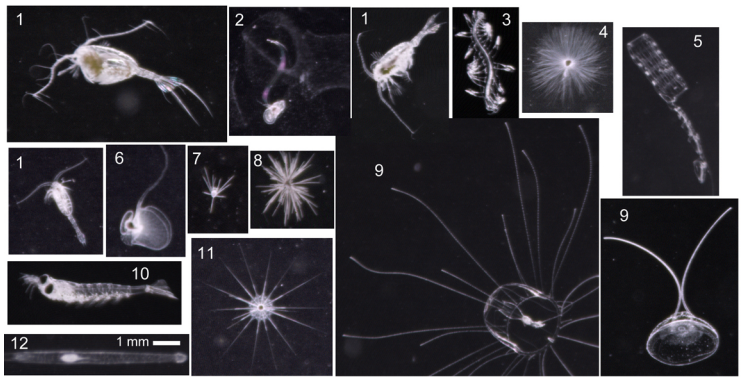

Fig. 3. Example images collected by the VPRII on FK003. The 1 mm scalebar in lower left applies to all images. 1=copepod, 2=larvacean, 3=polchaete, 4=foraminiferan, 5=doliolid, 6=pteropod, 7=echinoderm larva, 8=*Trichodesmium* colony, 9=medusa, 10=euphausiid, 11=radiolarian, 12= chaetognath (with copepod prey in gut).

Unprecedented numbers of plankton images were recorded during leg 1 due to an extensive bloom of chain-forming diatoms and other plankton (Fig. 4). This bloom was unexpected given the time of year (July) and large spatial extent (>1000 km). The VPRII data were collected simultaneously with underway acoustic-backscatter data (Simrad EK60 and hull mounted

ADCP) that measured larger zooplankton and nekton (e.g., fish, squid, shrimp). Data collected during the R/V *Falkor* cruise from the VPRII also were supplemented with along-track multi-beam acoustic test data (EM302, EM710). During the testing of the EM710 multi-beam echo-sounder off the S coast of Greenland, the wreck of the *Terra Nova* was discovered.

In addition to acoustic data, a series of deep CTD casts and plankton net tows were made at daily stations along the transect. Satellite data on temperature, chlorophyll, and sea level height are being used to identify oceanographic features sampled along the transect and relate them to the in situ data.

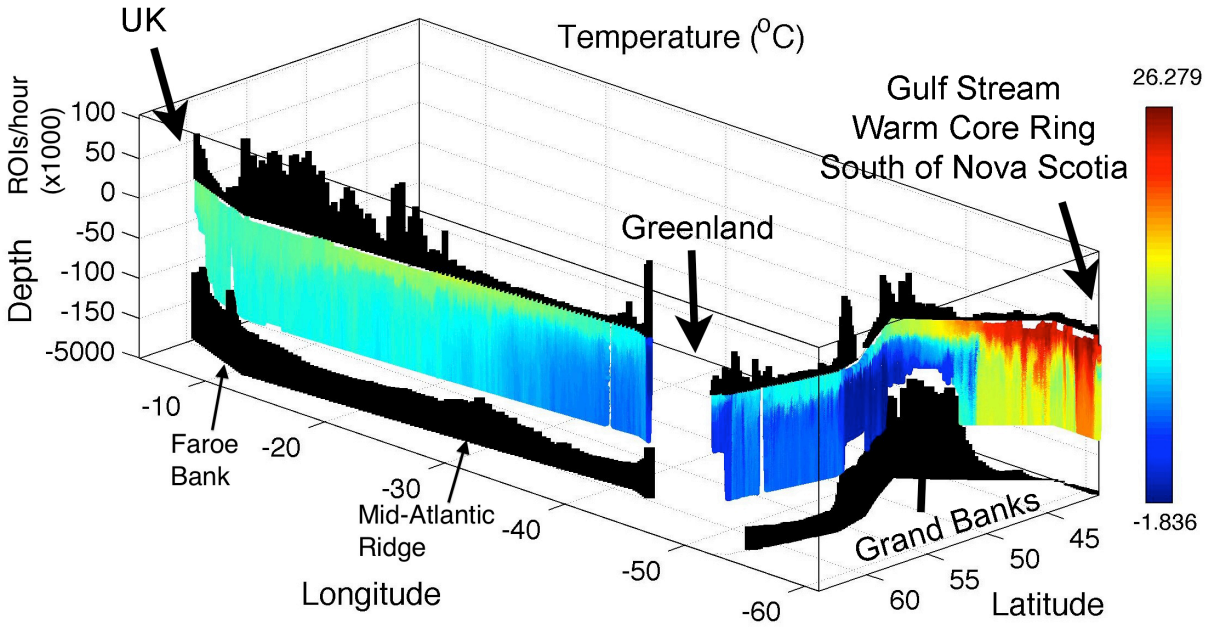

Fig. 4 VPRII data collected during the R/V *Falkor* cruise. Temperature data (color curtain plot) collected using the CTD mounted on the VPRII during the transatlantic sampling. The number of plankton images (regions of interest, ROIs) captured per hour (in thousands) is displayed in the upper bar plot (black). Bottom bar plot is seafloor depth (scaled).

The continuous high-resolution vertical section of data, across a wide diversity of habitats, oceanographic features, and water masses, is currently being processed using other funding and is part of a PhD thesis. Two PhD students participated in this cruise. These students are using optical, acoustical, and net sampling to study marine zooplankton distributions in their thesis work. The experiences and training during the proposed cruise provided them an excellent opportunity to learn these sampling systems and the North Atlantic subpolar gyre ecosystem. The completed survey demonstrates the capability for trans-ocean surveys using digital imaging, which can be incorporated into future sampling programs using ship's of opportunity. Data have been made publicly available via the Biological-Chemical Oceanography Data Management Office at Woods Hole (see below).

VPRII Upgrade – The cruise also was used to test the upgraded VPRII system. Prior to the cruise the VPRII was upgraded to include a color video camera, a ring strobe illuminator, a nitrate sensor, and a new electronics interface. (note: the nitrate sensor failed after 6 hours or use). The upgraded system was co-developed and built by Seascan Inc. and included both underwater and topside components.

Data Publically Available – The data collected during this cruise are publicly available. The BCO-DMO webpage for this project is:
http://osprey.bco-dmo.org/project.cfm?flag=view&id=272&sortby=project

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