VERtical Transport In the Global Ocean (VERTIGO) – *Here We Go!*

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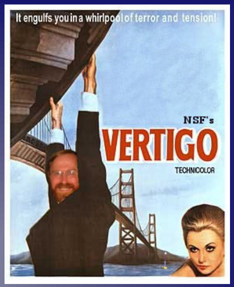


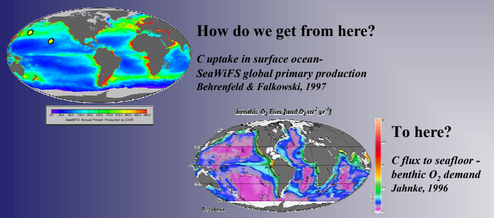


Figure 1 Left panel- Behrenfeld & Falkowski 1997 annual surface ocean carbon uptake (g m^{-2} y^{-1}) estimated using a primary productivity model and SeaWiFS average annual chlorophyll field. Right panel, Jahnke 1996 annual estimates of deep carbon flux (mol m^{-2} y^{-1}) at 1000m estimated from sediment composition and benthic flux correlation.

ABSTRACT

VERtical Transport in the Global Ocean (VERTIGO) is a new mid-size research project designed to address: what are the fates of sinking particles leaving the upper ocean? and what factors influence remineralization length scales for different sinking particle classes? The basic approach is to examine changes in particle composition and flux between the surface and 500-1000m within a given particle source region using a combination of approaches, many of which are new to the field. These include neutrally buoyant sediment traps, particle pumps, settling columns and respiration chambers, along with the development of new biological and geochemical tools for an integrated biogeochemical assessment and improved modeling of the biological pump. Two cruises will be conducted comparing the Hawaii Ocean Time-series site (HOT) and a new moored time-series site in the subarctic NW Pacific (Japanese site K2; 47ºN 160ºE). The first major VERTIGO field work will begin in the summer of 2004, so this poster is intended as a preview of coming attractions, with the intent to stimulate ideas and more general discussion regarding oceanic studies of the "twilight zone".

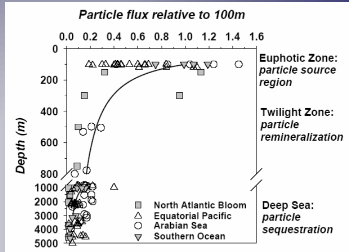
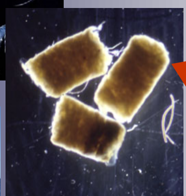
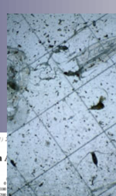
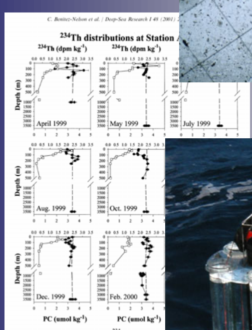


Figure 2. A compilation of all particle flux vs. depth data available from the last decade of JGOFS studies shows a significant data void between the upper ocean (fluxes at 100m derived from shallow traps or ^{234}Th methods) and fluxes >500m derived from deep ocean traps (redrawn from Berelson, 2001; not all shallow data plotted). Solid line is Martin curve for POC with b=-0.858. These data are plotted as fluxes relative to 100m to facilitate comparisons between basins.

VERTIGO Components

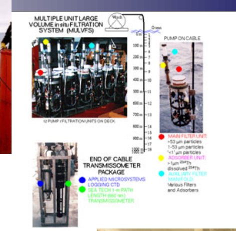


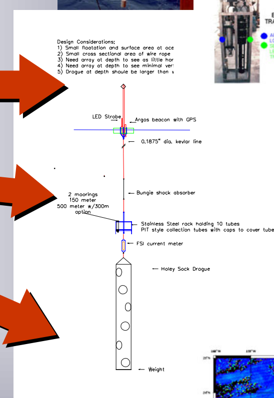


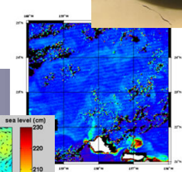


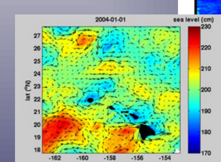
Approach & Analyses	Lead PI
Status of Algal Community	
size composition, physiological status- size-fractionated FRRF	Boyd
Algal community structure- microscopic analyses and identification, stains	Boyd/Silver/ Steinberg
Primary production- ^{14}C	Boyd
New production- ^{15}N	Dehairs
Export production- ^{234}Th	Buesseler
Characterization of the Building Blocks	
Sinking/ascent rates- polyacrylamide gels settling columns	Trull Boyd
Ballast properties- bSi, $CaCO_3$	Trull
Isotopes- C/N isotopes ^{234}Th	Trull Buesseler
Direct Measurement of Flux vs. Depth	
Neutrally Buoyant Sediment Traps geochemistry, SEM-EDS, brine C/N isotopes ID, microscopy, swimmers	Valdes Buesseler Trull Steinberg/Silver
Drogued traps- Same as NBST & polyacrylamide gels	Buesseler Same as NBST Trull

Suspended/Sinking Particle Interactions	
Deck pump- size fractionation- CHN, major elements microscopic ID; stains/TEP	Trull Buesseler/Trull Steinberg/Silver
Large volume pumps-(0-1000m) geochemistry microscopy	Bishop Bishop/Buesseler Steinberg/Silver
C-ARGO floats	Bishop
Abundances- transmissometer	Bishop
Marine "snow-catcher"- geochemistry	Dehairs Dehairs/Buesseler
Mid-Water Processes	
Bacteria- Abundance, communities	Silver
Zooplankton- Biomass, composition, repack., remin.	Steinberg
Remineralization Rates	
In-situ trap cup experiments	Trull
Bacterial respirometers	Boyd
Geochemical proxies- Barium, ^{234}Th	Dehairs Buesseler
Modeling components	
Food-web/particle processes	Boyd
1-D production/export model	Matear
Particle source regions	Siegel









What controls the efficiency of particle transport between the surface and deep ocean?

More specifically, what is the fate of sinking particles leaving the upper ocean and what factors influence remineralization length scales for different sinking particle classes? The null hypothesis is that remineralization rates do not change in response to either changes in particle source characteristics or mid-water processing. This would result in a single, global relationship between particle flux and depth. This is implies a particle flux profile described by the "Martin" curve:

$$F_z = F_{100}(z/100)^{-b}$$

where F_z is the particle flux profile, F_{100}, the flux at 100m, z is depth in meters and b is an empirically determined constant (Martin et al., 1987). An "Open Ocean Composite" (OOC) is commonly used to model vertical transport in global 3-D ocean carbon cycle models and is the basis for predictions of C sequestration and export from surface production ($F_z = 1.53(z/100)^{-0.858}$ mol of OC m^{-2} y^{-1}; e.g. Suess, 1980; Pace et al. 1987; Berger et al., 1988; Sarmiento et al. 1993).

There are, however, many reasons to reject the null hypothesis. Variations in b, the remineralization term, are not uncommon. Looking from below at the deep trap flux relative to shallow export and/or production, there is strong evidence for variability in mid-water transport efficiency (Fisher et al., 2000; Berelson, 2001; Antia et al., 2001; Lutz et al., 2002; Francois et al., 2002). In addition, seasonal, regional and global ocean models achieve improved fits to observed nutrient distributions when remineralization length scales are allowed to vary regionally, and to differ for different nutrient elements (Schlitzer, 2002; Usbeck, 2002; Wang et al., 2001). Finally, the obvious mismatch between spatial patterns in primary production and the export of carbon to the deep ocean (Fig. 1) indicates that a complex suite of transformations must occur in the "twilight zone", the region below the surface euphotic zone and the deep ocean. For example, high surface production in the N. Atlantic and N. Pacific does not necessarily lead to high C sequestration and burial in the deep sea (Fig. 1).

We are thus at a juncture in ocean biogeochemistry, where we know from field data and models that significant variability exists in flux vs. depth patterns. However, the depth region where the most marked attenuation of the particle flux occurs (100-500m) has a striking gap in flux data (Fig. 2). This region has been under-sampled for a variety of reasons, including problems associated with surface-tethered free-drifting sediment traps, such as hydrodynamic bias, resolubilization in traps, and swimmers (see Gardner, 2000). This proposal sets out to fill this gap and test two basic hypotheses regarding remineralization control, namely: 1. particle source characteristics are the dominant control on the efficiency of particle transport; and/or that 2. mid-water processing, either by zooplankton or bacteria, controls transport efficiency.

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