13:45h Tuesday – HCC 323C – OS23E-04

TI: Biologically Produced Oxygen in the Subtropical North Pacific: a 4-D Seaglider Survey of Oxygen, Temperature and Salinity

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AU: Emerson, S
AU: Eriksen, C C
AU: Stump, C

AB: Carbon export has been quantified at several locations corresponding to the primary time series stations in the ocean using the oxygen mass balance approach. This method is based on quantifying the biological component of a surface ocean oxygen mass balance. A limitation of the one-dimensional approach used to make these estimates has been an inability to constrain mixing at the base of the permanent thermocline, and thus the flux of oxygen across this boundary. A better defined spatial and temporal data set is needed to define the physical processes controlling the flux of oxygen across the thermocline. A Seaglider based method of measuring export production provides a 4-D (space and time) budget of oxygen, salinity and heat for the study area. With this technique we hope to decrease the errors involved in carbon export measurements as well as open the possibility for determining carbon export in a wide range of locations. An autonomous Seaglider was deployed from February through December 2005 in the vicinity of the Hawaii Ocean Time Series Station Aloha in the subtropical North Pacific. During deployment, the Seaglider traversed a 50 km by 50 km square region following a `bowtie' pattern centered on Station Aloha, repeatedly diving to 1000 meters. Each dive cycle lasts several hours and each `bowtie' circuit was completed in 15-20 days. The Seagliders were equipped with temperature salinity and pressure sensors as well as both an Aanderaa optode oxygen sensor and a Seabird 43 oxygen sensor. Upwelling rate, and depth averaged currents are calculated from GPS fixes and the glider flight dynamics. The optode sensor was shown to be stable with regard to sensor drift, while accuracy was obtained by calibration to in situ winkler titrations. Sensor drift as well as flow dependencies was observed over the course of the deployments for the Seabird sensor. The Seabird however has a faster response time and thus has potential to measure smaller scale variability if properly calibrated. During 2005 the Seaglider oxygen data quantifies a seasonal build up of oxygen in the euphotic zone and the development of a summer subsurface oxygen supersaturation maximum that reached approximately five percent. Integrated over the the upper 100 m, the biggest change in oxygen inventory was a two percent increase in from mid February to the end of April. The evolution of the oxygen supersaturation field will be shown in a series of 3-D plots and/or animation.

14:15h Tuesday – HCC 323C - OS23E-06

TI: Multi-Month Seaglider Surveys of Eddies in the Gulf of Alaska: How Eddy Dynamical Structure Evolves Temporally and Influences Phytoplankton Growth

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AU: Eriksen, C C

AB: The continental shelf of the Gulf of Alaska (GoA) has a highly productive ecosystem at many trophic levels. One process potentially contributing to high productivity is nutrient transport from the GoA's open basin onto the shelf. Anticyclonic eddies in the GoA have been preliminarily identified as important contributors to this transport, bringing nutrient-rich water in contact with shelf species. Autonomous buoyancy-driven gliders (Seagliders) crossed two GoA anticyclonic eddies a total of 18 times during 2004-5 as part of the GLOBEC Northeast Pacific Program. Surveying an eddy continuously for several months is a novel application of glider technology. The gliders were equipped with CTD, dissolved oxygen, and fluorescence sensors and dove to 1000 m about 3.5 times per day. Satellite altimetry data were used to guide the glider across the eddies and indicate the eddies originated in the eastern GoA near the Alaska Current. The Seaglider observations are being used to improve understanding of how the eddies' subsurface dynamical structure varies over several month timescales and how the eddies influence phytoplankton growth. Anticyclonic eddy properties including depressed isopycnals, depth-averaged currents consistent with clockwise rotation, and positive sea level anomalies are observed repeatedly. Geostrophic velocities are largest in the upper 200 m outside the eddy

core. Eddy waters exhibit elevated chlorophyll fluorescence, especially near eddy edges. While the 2004 eddy was over the continental slope after the springtime onset of stratification in the upper 100 m, fluorescence was enhanced where eddy currents were directed on-shelf. A hypothesis is eddy currents bring phytoplankton on the shelf in contact with nutrient-rich basin water, creating a bloom. In the 2005 eddy the subsurface chlorophyll maximum is displaced with the isopycnals. We report on estimates of the eddies' transports, diameters, and rotation periods. The depth-radial structure of the eddies is discussed in the context of mesoscale eddy dynamics.

1630h Tuesday – POSTER - OS25N-04

TI: Resolving Seasonal and Interannual Circulation Over the Washington Continental Slope With Seagliders

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AU: Perry, M J

AB: Continuous hydrographic surveys extending 220-240 km seaward from the continental shelf edge off Washington since August 2003 reveal seasonal and interannual patterns of circulation and upper ocean structure. Seaglider long-range autonomous underwater vehicles have been used to collect fortnightly ~5 km resolution sections to 1 km depth covering more than 10,000 km of survey track to date. Measurements include profiles of temperature, salinity, dissolved oxygen, chlorophyll fluorescence, and optical backscatter as well as independent estimates of depth-averaged current. Isopycnal tilts delineating the equatorward California Current offshore and the poleward inshore countercurrent reverse seasonally. Seasonal alongshore current fluctuations tend to propagate offshore near the speed of a gravest baroclinic mode long Rossby wave. Interannual transport differences of several Sverdrups in the upper 1 km are apparent between autumn 2003 and 2004. Differences in water type are also evident interannually, apparently linked to differences in advection over the continental slope. These changes constitute an appreciable fraction of the regional changes observed previously by others in the 1997-98 El Nino and summer 2002 subarctic water intrusion events.

1630h Tuesday – POSTER - OS25N-05

TI: Seaglider Observations of a Phytoplankton Thin Sheet in Waters off the Washington Coast, USA

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AU: Sackmann, B S
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AB: Seaglider - an autonomous, long-range, underwater glider - has been operating almost continuously in waters off the coast of Washington, USA, since autumn 2003. Seaglider occupies repeat surveys along a V-shaped transect that extends 200-km seaward from the continental shelf break into deep oceanic waters. During the June 2004 deployments a series of optical thin layers, detected with measurements of phytoplankton chlorophyll fluorescence and optical backscattering, were observed along the northern arm of the transect. These thin layers were present for almost 100 km, suggesting that this feature was actually a thin "sheet" of phytoplankton, albeit with some holes. The phytoplankton thin layers were located at the pycnocline and typically were on the order of one-to-several meters thick with an amplitude of three-to-ten (or more) times greater than ambient concentrations. Characterizing the spatial and temporal evolution of thin sheets using traditional sampling techniques is difficult; satellite ocean color imagery cannot always detect subsurface structure unless it is very close to the surface and ship-based sampling is often too sparse and/or labor intensive. This extensive mesoscale feature, observed on two repeat Seaglider transects, persisted for more than two weeks.

10:15h Wednesday – HCC 315 - OS32G-02

TI: The Labrador Sea low-salinity cap and Its control over deep convection and biological productivity, as investigated by Seagliders

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AB: Advection of low-salinity surface water over the top of the Labrador Sea exerts strong control over deep convection and Labrador Sea Water production, and produces one of the most intense spring blooms of primary productivity in the northern Atlantic. During the two winters 2003-2005 and one spring (2005) Seagliders (autonomous undersea vehicles) probed the Labrador Sea with extensive sections which show unequivocal evidence of the dominant source of this layer, the west Greenland boundary current and continental shelf. Both eddy shedding, and the separating boundary current which is forced offshore by the 3000m isobath, are involved in this process, which is enhanced in late winter. Two Seagliders probed a strong anticyclonic eddy, with Topex/Poseidon altimetry mapping the surface geostrophic current field. The eddy simultaneously carried a low-salinity cap and a large bolus of warm, saline Irminger Sea water beneath, both of which contribute to restratification of the central Labrador Sea and resistance to deep convection. This synoptic study supports Lilly et al. description (Prog. in Oceanogr. 2003) of anticyclonic eddies populating and restratifying the Labrador Sea, as seen at the Bravo mooring site (56.75N, 52.5W). The control by this upper ocean layer is expressed through the `buoyancy barrier', the downward integral of dynamic height, which is a measure of the buoyancy that must be removed by air/sea interaction in order to drive deep convection. It is shown here that the salinity contribution to upper-ocean buoyancy dominates the temperature contribution across most of the Labrador Sea in most seasons, with respect to convection to 1000m depth; deeper convection is typically limited by thermal stratification as well. Water-mass transformation analysis of numerical models (Bailey, Rhines and Hakkinen, Clim. Dynamics 2005) illustrates how influential this effect is on the global meridional overturning circulation, as represented in the model. Climate models' response to atmospheric forcing (and the North Atlantic Oscillation, global warming) can depend upon the supply of this low-salinity cap to the subpolar convection sites. The spring bloom of primary planktonic productivity exhibits a strong maximum in the Labrador Sea southwest of Greenland. Seaglider profiles show that, in spring of 2005, this production occurs in close conjunction with the low-salinity water advected from Greenland. As in marginal ice zones, the buoyant stability of the upper 100m helps to retain phytoplankton in the euphotic zone. The difference here is that this stable layer is advected and wind-blown to spread far across the Sea, stimulating a large zone of growth.

15:30h – Wednesday – HCC 316A – OS34N-03

TI: Water Transport and Freshwater Fluxes through Davis Strait: Initial Results from a new Measurement Program

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AU: Petrie, B
AU: Gobat, J I
AU: Moritz, R
AU: Soukhovtsev, V

AB: Davis Strait is a critical site for investigating freshwater exchange between the Arctic and North Atlantic Oceans and an ideal location for monitoring temporal and spatial variability of the critical upstream boundary condition for Labrador Sea convection. Fluxes through the Strait represent the net integrated Canadian Archipelago throughflow, modified by terrestrial inputs and oceanic processes during its southward transit through Baffin Bay. By the time they reach Davis Strait, Arctic waters already embody most of the transformations they undergo prior to exerting their influence on the deepwater formation sites in the Labrador Sea. Hydrographic sections occupied during ship-based surveys and by an autonomous underwater glider supplement year-round current, temperature and salinity measurements collected by an extensive moored array that characterize watermass variability, currents and transport(already have year-round). Sections occupied in autumn 2004 and 2005 reveal a southward-flowing, surface-intensified layer of Arctic water (S ~ 31) that

stretches from the Baffin coast to the Greenland shelfbreak. The West Greenland current carries fresh Arctic waters northward in a 50 m thick layer over the Greenland shelf. Deeper (200-600 m), a core of high salinity Irminger water moves northward along the Greenland shelfbreak. High-resolution sections occupied by an autonomous Seaglider capture deformation scale variability, resolving small-scale recirculation to provide volume and freshwater transport estimates between the Strait's 400 m isobaths. Between the Baffin and Greenland shelves, velocity records from 6 subsurface moorings with separations ranging from 16 to 62 km show only weak lateral correlation. Southward flow persisted year-round at all sites except the two situated over the Greenland slope, which captured the northward West Greenland current punctuated by periods of southward flow. Bottom-mounted instruments and a prototype shallow float collected the first year-round measurements over the narrow Baffin and broad West Greenland shelves. Instruments mounted on four bottom landers and a 20 m float recorded variability at short lateral scales over the Baffin shelf, revealing a narrow, fresh jet flowing within a kilometer of the coast. During the ice-free period, a surface-intensified Arctic water layer moved southward over the Baffin shelf. The salinity profile reverses during ice-covered months (freshest waters near the bottom), perhaps due to brine rejection. Four landers deployed over the West Greenland shelf suggest that variability at larger lateral scales dominates this broad region.
UR: http://iop.apl.washington.edu

1630h Thursday – POSTER - OS45D-17
TI: The MOSEAN HALE-ALOHA Mooring Program: Recent Developments
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AB: The HALE-ALOHA (H-A) mooring program is sited adjacent to the Hawaii Ocean Time-series (HOT) site, approximately 100 km north of Oahu. The HALE-ALOHA mooring, which was first deployed in 1997 and is presently funded by NOPP as part of MOSEAN (Multi-disciplinary Ocean Sensors for Environmental Analyses and Networks), has four major objectives: 1) to develop and test new interdisciplinary sensors and telemetry systems, 2) to facilitate scientific studies requiring high frequency, long-term interdisciplinary data, 3) to provide data for developing and testing interdisciplinary models, and 4) to calibrate and validate satellite-based ocean observations. Examples of instrumentation tested using the H-A mooring include: several different multi-wavelength optical sensors, fluorometers, backscatter sensors, and chemical samplers and sensors (i.e., for macro- and micro-nutrients, carbon dioxide, oxygen, nitrogen, and noble gases). New data telemetry systems and a new interdisciplinary surface buoy have also been tested using H-A. Complementary ship-based (Hawaii Ocean Time-series, HOT), sediment trap mooring (HOT), glider (UW Seaglider), and satellite data sets have been used along with H-A data to expand the utility of the collective Hawaiian regional scientific research efforts. Several processes with time scales ranging from minutes to several years have been studied using H-A data sets. HALE-ALOHA has been used to detect and observe processes that cannot be captured with ship- or satellite-based sampling. In particular, data have been collected during passages of tropical storms, mesoscale eddies, and Rossby waves. The unique data have been used to further our understanding and to develop improved models of upper ocean processes during and in the wakes of extreme forcing events and nutrient injections and plankton blooms associated with eddies and Rossby waves. It is anticipated HALE-ALOHA will continue to provide the community with a deep-sea platform that can be utilized within the framework of the NSF ORION OOI, ONR, OceanSITES, and GOOS programs among others. Areas of expanded capabilities are expected to include testing of emerging sensors and systems, expanded use of gliders, AUVs, and profiling floats in the vicinity of H-A to provide 4-D data sets, interdisciplinary data assimilative models for real-time predictions and adaptive sampling, and data links for educational outreach through programs such as the JASON Project.

13:00h Friday – HCC 317B –OS53C-01 - INVITED

TI: Analysis of a Cyclonic Eddy off the Washington Coast Using Merged Seaglider Optical Data and Ocean Color Satellite Imagery

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AB: Seaglider - a long-range autonomous glider - has conducted repeat surveys off the Washington coast since 2003, along a V-shaped transect that extends 200 km seaward from the continental shelf break into deep oceanic waters. Highly resolved (~5 km horizontal spacing, ~1 m vertical resolution) sections across the northern California Current system provide measurements of temperature, salinity and dissolved oxygen to 1000 m, and chlorophyll a fluorescence (proxy for phytoplankton concentration) and optical backscattering (proxy for particle concentration) to 150 m. The standard V-shaped transect occupied by Seaglider spans a dynamic transitional region that links a highly productive shelf environment with the open ocean. In late summer and autumn, large scale meanders [O(150 km)] of the California Current system off Washington, USA, and Vancouver Island, Canada, have been observed to shed large, persistent, cyclonic eddies over the slope. One of these detached eddies was observed in September and October 2004 with both satellite ocean color imagery and Seaglider optical observations. Surface chlorophyll estimates from satellite imagery were ~3-4X greater in the eddy, compared to adjacent offshore waters. However, satellite assessment of total water column biomass within the eddy is problematic because subsurface phytoplankton distributions and deep chlorophyll maxima are hidden from satellite view. By merging surface ocean color satellite imagery and subsurface Seaglider measurement of chlorophyll fluorescence, we were able to obtain a quasi-4-dimensional representation of phytoplankton distributions within and outside the eddy, and better determine integrated phytoplankton biomass in each water mass. Glider observations provide a particularly efficient and cost-effective way of providing a vertical context to satellite data, and are unique in their ability to revisit features of interest once they have been detected.
UR: http://optics.dmc.maine.edu/sackmann/wash_coast/