a subset of points, and (3) the model output to in situ measurements of carbon14 uptake. We present here the results of Part 1, in which the primary production fields for six months of 1998 allow us to evaluate the differences between models throughout the annual cycle and for different regions. Preliminary results indicate that although primary production fields are similar for different models, regardless of model complexity, point values or regional means can differ by a factor of two or more. Differences in primary production are greater for extreme values in temperature.

OS12J-11 1620h

Comparisons of Satellite and In Situ Chlorophyll-a Measurements in Coastal Upwelled Waters

Michael F Crowley[1] (732-932-6555 x543; crowley@atlantic.rutgers.edu); L. Alex Kahl[2] (805-571-7680; alex@icess.ucsb.edu); Oscar Schofield[1] (732-932-6555 x548; oscar@imcs.rutgers.edu); Kota Prasad[3] (858-746-1100; kota@seaspace.com); Cristina Orrico[4] (805-756-2948; corrico@calpoly.edu); Scott Glenn[1] (732-932-6555 x544; glenn@caribbean.rutgers.edu)

[1]Rutgers University, Institute of Marine and Coastal Sciences 71 Dudley Road, New Brunswick, NJ 08901, United States

[2]UCSB ICESS, 6515 El Nido Ln. Suite A, Goleta, CA 93117, United States

[3]SeaSpace Corporation, 12120 Kear Place, Poway, CA 92064, United States

[4]California Polytechnic State University, Biological Sciences Dept. Fisher Hall, Bldg. 33, San Luis Obispo, CA 93407, United States

Off the southern coast of New Jersey, upwelled water evolves into an alongshore line of three recurrent upwelling centers that are co-located with historical regions of low dissolved oxygen (DO). The upwelling eddies have been clearly visible in AVHRR imagery over the last decade, and other than the annual seasonal warming cycle, represent the second most significant factor influencing sea surface temperatures. Associated with the upwelling are high concentrations of phytoplankton which are visible in ocean color remote sensing. The optical features of the upwelled waters are dominated by particulate organic carbon (POC) with C:N ratios of healthy phytoplankton. A robust relationship between POC and in-water optical parameters has allowed POC patterns to be defined in space and time. Using ocean color imagery, POC loads were estimated in response to the recurrent upwelling events. These maps are strongly dependent on the accuracy of the ocean color estimates of the inherent optical properties. Given this, the in situ database collected during the HyCODE/COMOP research effort, was used to validate currently available ocean color products for these optically complex coastal waters. The estimated in water respiration from the POC export is estimated to deplete bottom water oxygen concentrations by at least 10 percent. One major advantage of the upwellings is that they provide strong optical gradients, which have allowed us to cross-calibrate the international constellation of satellites against each other and in situ data. During summer 2001 we cross-calibrated SeaWIFS, MODIS, Oceansat, and FY1-C ocean color satellites. For the Chinese FY1-C ocean color satellite, launched in 1999 has no post launch calibration coefficients, a local overpass time of 9:00AM which dictates a low sun angle, and has bands which average a width of 0.6 microns in the visible spectrum. Through darkest pixel and sun angle corrections, we have been able to achieve estimates of surface chlorophyll-a values similar to SeaWIFS and Oceansat. By tapping the full constellation of international ocean color satellites, we were able to adaptively sample episodic features on the scales of hours, not days, which has never before been possible.

URL: http://marine.rutgers.edu/cool

OS12J-12 1635h

Comparisons of SeaWiFs derived Inherent Optical Properties to In Situ Coastal Measurements at LEO

L. Alex Kahl[1] (805-571-7680; alex@icess.ucsb.edu); Michael F Crowley[2] (732-932-6555 x543; crowley@atlantic.rutgers.edu); Oscar Rock Schofield[2] (732-932-6555 x548; oscar@imcs.rutgers.edu); Robert Arnone[3] (228-688-5268; arnone@nrlssc.navy.mil); Trish X Bergmann[2] (732-932-6555 x332; bergmann@imcs.rutgers.edu); Cristina Orrico[4] (corrico@calpoly.edu)

[1]UCSB-ICESS, 6515 El Nido Lane Suite A, Goleta, CA 93117, United States

[2]Rutgers University, Institute of Marine and Coastal Sciences 71 Dudley Road, New Brunswick, NJ 08901, United States

[3]Naval Research Lab, Ocean Optics Code 7333, Stennis Space Center, MS 39529

[4]California Polytechnic Institute, Biological Sciences Dept Fisher Hall, Bldg. 33, San Luis Obispo, CA 93407, United States

A large data base of in situ bio-optical measurements were collected at the LEO-15 (Long-term Ecosystem Observatory) off the southern coast of New Jersey (USA) as part of the HyCODE/COMOP experiment. The data was used to quantify the impact of coastal upwelling on nearshore bulk apparent and inherent optical properties. There was good qualitative agreement between the AOPs and IOPs in space and time. The measured IOPs were used as inputs to the Hydrolight radiative transfer model (RTE). Estimated spectral AOPs from the RTE were strongly correlated (generally R2 > 0.80) to measured AOPs. The RTE was then used to construct the spectral remote sensing reflectance. Spectral signatures of Hydrolight-derived in situ and SeaWiFs derived Rrs values compared favorably pooling all data. Generally, the R2 between the measured and modeled was above 0.7 using all available imagery; however just using the days with ideal satellite geometry and clear atmospheric conditions the R2 was greater than 0.92. However, within each spectral band the R2 Rrs values were compared directly, the results were far less encouraging. Direct comparison of SeaWiFs to modeled in situ Rrs as a function of wavelength was less encouraging. The R2 between measured and modeled varied with wavelengths and between days. Generally the correlations were greatest in the red and green wavelengths with poor correlations in the blue wavelengths. The R2 varied by on average by a factor of 4 across the spectral bands with values ranging from 0.9 in the red to 0.2 in the blue wavelengths on certain days. The relative impact of solar and satellite geometries and the corresponding impact on the correlation to the in situ data is discussed.

URL: http://marine.rutgers.edu/cool

OS12K HC: 316 C Monday 1330h

Coupled Biophysical Processes, Fisheries Resources, and Climate Variability in Coastal Ecosystems of the Northeast Pacific Ocean II

Presiding: **H P Batchelder,** College of Oceanic and Atmospheric Administration**; L Washburn,** ICESS/Dept. of Geography

OS12K-01 1330h

Effect of Ocean Conditions on the Cross-Shelf Distribution of Walleye Pollock (Theragra chalcogramma) and Capelin (Mallotus villosus).

Anne Babcock Hollowed[1] (206-526-4223; anne.hollowed@noaa.gov)

Phyllis J. Stabeno[2] (206-526-6453; stabeno@pmel.noaa.gov)

Sigrid Salo[3] (206-526-6802)

Chris D. Wilson[1] (206-526-6435; chris.wilson@noaa.gov)

[1]Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115, United States

[2]Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, United States

[3]JISAO, University of Washington, Seattle, WA 98195, United States

This study explores the role of oceanographic forcing on fish distributions with focus on the processes influencing the cross-shelf distribution of walleye pollock and capelin. We present results from process oriented field studies and retrospective analysis of sea surface temperature, water column properties, and summer trawl surveys.

Field observations were obtained during the first two years (2000 and 2001) of a multi-disciplinary experiment on the southern coast of Kodiak Island in the Gulf of Alaska. Fish distributions and school structure were monitored with acoustics. The acoustic survey was augmented with a comprehensive oceanographic program consisting of: five ocean moorings, satellite tracked drifters, and shipboard measurements.

The study site consisted of two submarine troughs (Barnabas and Chiniak) on the east side of Kodiak Island, Alaska. The Alaskan Stream, and the Alaska Coastal Current influence flow through the region. The geostrophic flow through the troughs is cyclonic. Mooring data and water column profiles collected reveal a sharp-shelf-break front in Chiniak and a mid-trough front in Barnabas.

Acoustic survey data identified three acoustic sign types: age-1 pollock, adult pollock and capelin. The spatial relationship of these sign types to real time current, water column structure, and temperature was examined. Pollock aggregated on the coastal side of the frontal systems in both troughs. The persistence of the fronts and the role of fronts in determining pollock distribution are examined using retrospective analysis of fish and oceanographic surveys for the years 1984 to present. The implications of these research findings to fisheries assessment and ecosystem management is discussed.

OS12K-02 1345h

Analysis of Hydrographic Data Collected by the Pollock Conservation Cooperative Research Center in the Bering Sea

Hank Statscewich[1] ((907) 474 - 7834; stats@ims.uaf.edu)

Dave Musgrave[1] (musgrave@ims.uaf.edu)

[1]University of Alaska, Fairbanks, Institute of Marine Science, O'Neill Building, Fairbanks, AK 99775, United States

The Bering Sea is a semi-enclosed marginal sea of the North Pacific Ocean whose circulation is characterized by a cyclonic gyre driven by the inflow of the Alaskan Stream through deep passes in the Aleutian Islands. At present, the Southeastern Bering Sea shelf supports the Walleye Pollock fishery, the largest single species fishery in the world as well as the salmon run along the Alaska Peninsula, also the worlds largest. This study aims to show that the seasonal and interannual variability of water masses may aid in identifying regions of high catch and bycatch for the Bering Sea Pollock fishery. It makes use of records of salinity, temperature and depth collected on Pollock fishing vessels during normal fishing operations in the Southeast Bering Sea during the fishing seasons of 2000 and 2001. Regions were divided in terms of concentration of fishing activity and proximity to bathymetric features conducive to shelf-slope exchange. Levels of catch per unit effort were highest for the region defined by a shoaled bank located west of the Pribilof Islands. Consistently high bycatch of Chinook salmon is observed in the Bering and Pribilof Canyons. Higher temperatures associated with increased solar activity and decreased turbulent mixing led to greater Chinook bycatch in the spring of 2001 for areas to the Southeast of the Pribilof Islands.

OS12K-03 1400h

Using inner shelf oceanography to understand larval recruitment on the central Oregon coast.

Brian A Grantham[1] (541-737-8293; granthab@bcc.orst.edu)

Bruce A Menge[1] (541-737-5358; mengeb@bcc.orst.edu)

Jane Lubchenco[1]

[1]Partnership for Interdisciplinary Studies of Coastal Oceans, Department of Zoology Oregon State University 3029 Cordley Hall, Corvallis, OR 97331-2914, United States

The mechanistic links between nearshore oceanographic processes and larval recruitment are poorly understood. Since 1998 we have been using a shallow (15-40 m deep) mooring array and associated intertidal sites to examine the relationships between inner shelf oceanography, larval transport, and the recruitment of intertidal invertebrates. Our talk summarizes the results of this ongoing study.

In 1998-99 moorings measuring temperature, salinity, currents, larval recruitment and larval flux were deployed in 15-40 meters of water off central Oregon. Recruitment rates of barnacles and mussels were measured concurrently at intertidal sites inshore of the moorings. All larval collectors was sampled weekly to biweekly. In each year we observed several major upwelling relaxations. During relaxations temperature and salinity changes were usually, but not always, accompanied by reversals in the otherwise predominantly equatorward near-shore flows. Maximum barnacle recruitment occurred during these relaxations, but only at sites experiencing current reversals. Maximum mussel recruitment did not coincide with these events. These observations led us to conclude 1. that barnacle and mussel larvae depend on different physical processes for onshore transport, and 2. that wind and density-driven current reversals are the primary mechanisms responsible for generating barnacle recruitment events along the central Oregon coast.

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To better understand the mechanisms controlling barnacle and mussel recruitment, high-density mooring arrays were combined with periods of daily recruitment measurement in 2000 and 2001. Once again barnacle recruitment corresponded with current reversals, but there was considerable among-site variation in the timing and magnitude of these events. These results suggest that modifications to large-scale oceanographic processes, caused by local variation in coastal morphology, may generate spatial variation in recruitment even along relatively straight coastlines.

OS12K-04 1415h

Linking Phytoplankton Fluorescence Patterns in the Nearshore and Inner Shelf off Oregon

Amanda L Ashe[1] (541-737-6625; aashe@coas.oregonstate.edu)

Mark R Abbott[1] (541-737-5195; mabbott@coas.oregonstate.edu)

Michael P Kosro[1] (541-737-3079; kosro@coas.oregonstate.edu)

Brian A Grantham[2] (541-737-8293; granthab@bcc.orst.edu)

Ricardo M Letelier[1] (541-737-3890)

[1]College of Oceanic and Atmospheric Sciences, Oregon State University 104 Ocean. Admin. Bldg., Corvallis, OR 97331-5503, United States

[2]Department of Zoology, Oregon State University, Corvallis, OR 97331-2914, United States

High frequency temperature, salinity, and chlorophyll fluorescence records collected nearshore at the 15 m isobath off the Oregon Coast at Fogarty Creek (FC; 44.84°N, 124.06°W), Whales Cove (WC; 44.79°N, 124.16°W), Yachats Beach (YB; 44.32°N, 124.12°W), and Strawberry Hill (SH; 44.25°N, 124.13°W) during summer 2000 were analyzed and compared to similar data recorded in the inner shelf at the 81 m isobath off Newport (NH; 44.64°N, 124.31°W). Moored instruments in the nearshore sites consisted of fluorometers and Seacats placed at 7 m depth. The inner shelf mooring had similar instruments deployed at 5 m depth. Preliminary cross-correlation analyses indicate that while the fluorescence signal in the southern nearshore sites (YB and SH) displays a significant positive correlation with the inner shelf signal with lag time of 0 days, the northern stations (FC and WC) display only a weak but statistically significant negative correlation with NH with a 4 day lag. Further analyses of chlorophyll fluorescence in the temperature-salinity domain indicate that fluorescence increases with increasing temperature and a slight decrease in salinity. This pattern suggests that chlorophyll concentration in the nearshore sites increases during relaxation periods following upwelling events, probably as a result of the advection of surface waters in which phytoplankton populations have been growing. However, the northern nearshore sites display a strong decrease in salinity during some relaxation events. These water masses with high temperature and low salinity have relatively low values in chlorophyll fluorescence. We suggest that this fresh water intrusion in the northern nearshore stations holds back the increase in chlorophyll concentration during relaxation events and represents a key difference between these stations and inner shelf and southern nearshore sites. This hypothesis is being tested with an extended dataset collected between March and October 2001.

URL: http://picasso.coas.oregonstate.edu/ORSOO/data.html

OS12K-05 1430h

Transport of Eggs and Larvae of English Sole on the Oregon-Washington Shelf

Christopher N Rooper[1] (1-206-221-6884; rooper@u.washington.edu)

Donald R Gunderson[1] (1-206-543-7878; dgun@u.washington.edu)

Barbara M Hickey[2] (1-206-543-4737; bhickey@u.washington.edu)

[1]School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195-5020, United States

[2]School of Oceanography, University of Washington, Box 357940, Seattle, WA 98195, United States

For English sole (*Pleuronectes vetulus*) processes in the coastal ocean are thought to be important to determining the fate of pelagic egg and larval stages. English sole spawning is highly protracted and spawning activity can occur from September to April, exposing the 8-10 week egg and larval stages to a variety of oceanographic conditions. Young-of-the-year sole settle in shallow nearshore waters and estuaries in the spring. The purpose of this study is to examine the processes that influence transport of egg and larval stages from spawning grounds to nursery estuaries. A model was constructed using coastal wind, sea level, and current data to predict egg and larval transport. English sole spawn timing was back-calculated for 15 cohorts of English sole captured from 1998-2000 during trawl surveys of Oregon and Washington estuaries. English sole spawning generally occurred in February and March of each year, with some additional spawning in previous months. Eggs were generally carried onshore prior to hatch. Assuming passive transport mechanisms, larval stages were not retained within the nearshore system for the duration of their development. This suggests that English sole may utilize local features such as estuarine or upwelling fronts, or behavioral mechanisms such as selective tidal stream transport for retention in nearshore areas.

OS12K-06 1505h

Lagrangian Observations of Circulation and Chlorophyll in the Oregon Upwellng System

Rick A. Reynolds[1] (206.221.5755; reynolds@ocean.washington.edu)

Eric A D'Asaro[2] (206 685 2982; dasaro@apl.washingtom.edu)

[1]School of Oceanography, Box 357940 University of Washington, Seattle, WA 98195-7940, United States

[2]Applied Physics Laboratory and School of Oceanography University of Washington, 1013 NE 40th Str, Seattle, WA 98105, United States

Neutrally buoyant, isopycnal floats were deployed in the Oregon upwelling system in the summers of 2000 and 20001. On the northern part of the shelf the floats upwelled from mid-depth to the coast and returned offshore in southward-going jets and eddies. South of this, the strong upwelling and downwelling occurred in fronts and in the lee of capes. Some floats were trapped for many weeks in localized areas. High frequency measurements on the floats showed strong internal tides, relatively weak diapycnal mixing and strong horizontal mixing.

Several floats, one equipped with a fluorometer, traversed the persistent region of high chlorophyll found over Heceta Bank. These floats provide no evidence that water is trapped in this region; instead they suggest rapid flushing. The high productivity over Heceta Bank may be modelled as a spatially trapped bloom located downstream of the upwelling on the northern Oregon shelf. The fluorometer data support this with chlorophyll increasing initially in the surface layer and then decaying (with doubling times of a few days) followed by a similar pattern in the thermocline.

OS12K-07 1520h

Near-Shore Small-Scale Processes During Upwelling Relaxations Along Northern California and Oregon and Their Implications on Larvae Settlement: a Remote Sensing Approach.

Jan Svejkovsky[1] ((858) 792-8529; jan@oceani.com)

Steve Schroeter[2] ((760) 438-5953; schroete@lifesci.ucsb.edu)

John Dixon[2] (jdixon@coastal.ca.gov)

Tom Ebert[2] (tebert@sunstroke.sdsu.edu)

[1]Ocean Imaging Corp., 201 Lomas Santa Fe Dr., Suite 370, Solana Beach, CA 92075, United States

[2]UCSB, Marine Sciences Institute, Santa Barbara, CA 93106, United States

Previous studies have shown a link between upwelling relaxations in the California Current System (CCS) and increased near-shore settlement of various invertebrate larvae. It has also been postulated that the frequency and timing of the relaxation episodes play a dominant role in regional recruitment of the species stocks. We utilized data series from AVHRR thermal and Synthetic Aperture Radar (SAR) satellite sensors over the past decade to detect changes within 20km of the coast associated with spring and summer upwelling relaxations in the northern CCS region.

Our findings indicate that two different regimes are encountered north and south of Cape Blanco. South of C. Blanco a dominant coastal effect in many summertime relaxation episodes is the nearshore retainment of river runoff which rapidly increases surface temperatures, decreases salinity and most likely increases vertical stratification within 5 km of the coast. This is especially prominent in a large upwelling shadow region south of C. Mendocino, but commonly affects coastal sections north of the Cape as well. Although the expected flow reversal to shoreward and/or poleward is usually observed in satellite image series during extended relaxations, the offshore waters do not commonly reach the very nearshore habitats. Instead, many regions offering adequately shallow larvae settlement habitats are mainly influenced by the runoff mixture which spreads longshore with the reversed currents. SAR data revealed that this runoff-affected inner zone is often characterized by greatly increased concentrations of surfactants forming large surface slicks. The region north of C. Blanco exhibits much reduced retention of river runoff during relaxations. An upwelling relaxation in the northern region is primarily characterized by inshore movement of the main upwelling front. SAR data reveal high aggregations of surfactants inshore of the advancing front.

Past studies have shown surface slicks to be associated with increased aggregations of fish and invertebrate larvae, and to possibly act as shoreward transport mechanisms in conjunction with internal waves. We examined a decade of bi-weekly purple urchin (S. purpuratus) larval settlement records at Ft. Bragg and Pt. Cabrillo in relation to the occurrence of the satellite-sensed runoff and surfactant patterns in that region. A strong correlation was found between the formation of those upwelling relaxation characteristics and larval settlement rates. In addition, the ENSO years of 1992 -1993, and 1997 - 1998 corresponded to especially strong periods of the inshore warm, surfactant-laden runoff retainment zone, as well as unusually high larval settlement rates.

Our results suggest that retained river runoff spread by nearshore poleward currents during upwelling relaxations along northern California forms and important component of the very-nearshore zone that contains shallow habitats. Satellite data show that during most events offshore waters do not reach into this zone and are thus unlikely to significantly contribute to the increase of available settling larvae populations. The close temporal and spatial correspondence of surfactant accumulations with high urchin larvae settlement rates at Ft. Bragg/Pt. Cabrillo suggests that SAR-sensed distributions of surface slicks may be useful in studying both regional recruitment patterns and shoreward transport mechanisms of the pelagic larva stages of various organisms.

OS12K-08 1535h

Patterns of Larval Crab Abundance in a Pacific Northwest Estuary as Determined by Light Traps

Curtis Roegner[1] (501-861-1818; curtis.roegner@noaa.gov)

David Armstrong[2] (davearm@u.washington.edu)

Barbara Hickey[3] (bhickey@u.washington.edu)

Alan Shanks[4] (ashanks@oimb.uoregon.edu)

[1]NOAA/NMFS, Pt.Adams Field Station, Hammond, OR 97121, United States

[2]School of Fisheries and Aquatic Sciences, University of Washington, Seattle, WA 98195, United States

[3]Shcool of Oceanography, University of Washington, Seattle, WA 98195, United States

[4]Oregon Institute of Marine Biology, University of Oregon, Charleston, OR 97420, United States

Determining the factors influencing the larval dispersal of estuarine and nearshore crabs has long been of interest, but the causes of variation in larval supply remain elusive because of difficulties sampling larvae and physical parameters with adequate spatio-temporal resolution. In particular, physical mechanisms influencing the cross-shelf transport of crab megalopae to coastal sites require clarification. We are using light traps and instrument mooring to examine correlations between larval abundance and oceanographic events in 3 Pacific Northwest estuaries. Light traps provide a simple and effective method for collecting daily samples of brachyuran crab larvae. The frequency of sampling allows events down to the wind-band of variation to be resolved. This presentation will focus on patterns of larval supply for several crab species in Coos Bay, OR during 1998-2000. Concurrent time series of physical measurements were acquired for meteorological stations plus instrument moorings located within the estuary and along the continental shelf. These time series demonstrate links between plankton abundance and oceanographic processes.

OS12K-09 1550h

Temporal and Spatial Variations of Hydrography in Monterey Bay: Implications for Larval Transport and Recruitment

Margaret M Dekshenieks[1] (831-459-4632; margaret@es.ucsc.edu)

Curt D Storlazzi[1] (831-459-2403; manta@es.ucsc.edu)

Mark H Carr[2] (831-459-3958; carr@biology.ucsc.edu)

Pete T Raimondi[2] (831-459-5674; raimondi@biology.ucsc.edu)

Jared D Figurski[2] (831-459-3958; jared_figurski@yahoo.com)

[1]University of California Santa Cruz, Ocean Sciences Department 1156 High Street, Santa Cruz, CA 95064, United States

[2]University of California Santa Cruz , Long Marine Laboratory 100 Shaffer Road, Santa Cruz, CA 95060, United States

Thermistor chains and acoustic Doppler current profilers (ADCPs) were deployed at the northern and southern ends of Monterey Bay to examine the thermal and hydrodynamic structure of the inner (h 20 m) shelf of central California. The thermistor chains and ADCPs sampled temperature and current velocity at two-minute intervals over a 13-month period (06/2000-07/2001). These instruments were deployed as part of the Partnership for Interdisciplinary Studies of the Coastal Oceans (PISCO). PISCO is a marine science research program that focuses on understanding nearshore ecosystems of the U.S. West Coast. Time series of temperature and current velocity, in conjunction with data from Advanced Very High Resolution Radiometer (AVHRR) and Coastal Ocean Dynamics Applications Radar (CODAR), help to establish the basic hydrography for Monterey Bay. Analyses of time series data reveal that semi-diurnal and diurnal tidal motions dominated the temperature and current records. The transitions from ebb to flood tide were rapid, often exhibiting characteristics of tidal bores. Analyses also show that when thermal stratification was high, during the spring and summer months, more than 2000 high frequency (Tp 4 to 20 min) internal wave events in packets of 8-10 occurred. Typically, these internal wave packets followed the transition from ebb to flood tide. Previous studies along the west coast of the U.S. have concluded that internal waves and tidal bores may play a significant role in the onshore transport of larvae. The implications for larval transport and recruitment in Monterey Bay will be discussed.

URL: http://www.piscoweb.org/what/index.html

OS12K-10 1605h

Inner-Shelf Circulation Near Point Conception, California

Cynthia Cudaback[1] (805-893-5145; cudaback@lifesci.ucsb.edu)

Libe Washburn[2] (805-893-7367; washburn@icess.ucsb.edu)

[1]Marine Science Institute, University of California, Santa Barbara, CA 93106, United States

[2]Institute for Computational Earth Systems Science, University of California, Santa Barbara, CA 93106, United States

Some nearshore fish and invertebrate species have widely dispersing larvae that must cross the inner shelf twice, first to enter the coastal currents and later to settle in their adult habitat. Transport across the inner shelf may thus significantly affect coastal marine ecosystems. We examined the flow over the inner shelf at three contrasting sites near Point Conception, California. We found that coastal and inner-shelf currents follow similar seasonal patterns, but currents over the inner-shelf (15 m isobath) are slower than currents over the mid-shelf (100 m isobath) by a factor of 4-5. North of the Point, strong along-shore winds drive temporal variations in currents and water temperature. Cross-shore currents are vertically sheared, suggesting wind-driven upwelling, and along-shore currents have a profile consistent with a balance between direct wind forcing and bottom friction. As Lentz (1994) observed in Northern California, classical Ekman theory over-estimates inner-shelf transport by a factor of four. East of the Point, classical wind-driven upwelling is not observed. At one location, the dominant cross-shore winds drive the cross-shore component of circulation. Along-shore currents at this location are correlated with winds only during winter storms; prior studies have indicated that along-shore currents are due to non-local forcing. At the third location, also East of the Point, winds near the shore are generally weak and variable, and along-shore winds are correlated with along-shore currents only during winter storms, suggesting direct wind forcing. Inner shelf temperatures measured at six locations (three on either side of the Point) show remarkable along-shelf coherence in meteorologic and seasonal-scale variability. Strong thermal gradients are observed only in late summer, when coastal currents converge at Point Conception.

OS12L HC: 319 A Monday 1330h

The Cycle of Carbon in the Southern Ocean (S.O.) II

Presiding: **U Bathmann,** Alfred Wegener Institute**; D A Hutchins,** College of Marine Studies,University of Delaware**; I Peeken,** Intitut of Marine Research**; J Tremblay,** McGill University**; M J Lutz,** Stanford University

OS12L-01 1330h INVITED

Satellite-based Primary Production Estimates in the Southern Ocean: a Comparative Study

Mary-Elena Carr[1] (818-354-5097; mec@pacific.jpl.nasa.gov)

Marjorie Friedrichs[2] (757-683-5560; marjy@ccpo.odu.edu)

J. Keith Moore[3] (303 497-1692; jkmoore@ucar.edu)

Richard Barber[4] (252 504 7578; rbarber@duke.edu)

[1]Jet Propulsion Laboratory, California Institute of Technology; MS 300-323, 4800 Oak Grove Dr., California Institute of Technology;, Pasadena, Ca 91101-8099, United States

[2]Old Dominion University, Crittenton Hall, 768 52nd Street, Norfolk, VA 23529, United States

[3] National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 8035, United States

[4]Duke University, 135 Duke Marine Lab Road, Beaufort, NC 28516, United States

Ocean color sensors and the suite of models that derive primary production from satellite data provide global maps of marine photosynthesis at unprecedented temporal resolution. This satellite approach is particularly attractive for the Southern Ocean where field campaigns are costly and labor intensive. However the Southern Ocean presents a challenge for space-based primary production models, as temperature dependent functions for the global ocean may fail at extreme values, macronutrient distributions do not always determine photosynthetic performance, and high growth rates are not necessarily accompanied by high biomass. Likewise, most models are not parameterised for the Southern Ocean due to data constraints. In fact satellite-based estimates tend to be smaller than recent in situ carbon uptake measurements. Here we present early results from a comparison study of space-based primary production models, the third Primary production Algorithm Round Robin (PPARR3), focussing on model behaviour in the Southern Ocean. In this exercise we compare the output of several primary production models among themselves, and with a limited set of in situ carbon uptake measurements. We find that although the spatial patterns and basin-wide averages are very similar for the tested models, point values and regional means can vary by a factor of two or more. The models diverged most in regions of very cold temperatures. A direct comparison between carbon uptake measurements made along 170W in early March 1998 and different models using the monthly satellite-derived mean chlorophyll along the transect led to generally similar distributions. However, the modeled values were consistently smaller than those measured in situ (30-50%). One simulation was run using the cruise-measured value of a key model parameter instead of the globally-tuned derivation; this run yielded a higher estimate of primary production than was measured. The goal of PPARR3 is to provide a forum for model improvement by providing identical input fields, systematic intercomparison of model output, and a quality-controlled in situ database to refine parameterization. We anticipate that this exercise will enable the next generation of satellite-based primary production models for the Southern Ocean.

OS12L-02 1400h

Chlorophyll Variability in the Agulhas Current System: a Wavelet Analysis on Modelled and SeaWIFS Chlorophyll Fields

Jerome LLIDO[1] (+33 561332785; jerome.llido@cnes.fr)

Eric MACHU[2] (+33 561193012; eric.machu@cerfacs.fr)

Isabelle DADOU[1] (+33 561332954; isabelle.dadou@cnes.fr)

Veronique GARCON[1] (+33 561332957; veronique.garcon@cnes.fr)

[1]LEGOS/CNRS, 18 Ave Edouard Belin, TOULOUSE 31401, France

[2]CERFACS, 42 Ave Gaspard Coriolis, TOULOUSE 31057, France

The frontal system formed by the Agulhas Return Current (ARC) and the Subtropical Convergence (STC) is a region of intense mesoscale activity presenting enhanced levels of biological production and chlorophyll a. The ARC is a meandering Rossby wave initiated in the Agulhas Retroflection area clearly identified in the ocean color signal.

A wavelet analysis is performed on the 4-years (October 1997- September 2001) time series of SeaWIFS chlorophyll a data in the Agulhas Current system to determine the range of the dominant wavelengths of the Rossby wave associated to the meanders of the ARC. A similar analysis is carried out on modelled chlorophyll distributions. Two versions of a three dimensional coupled physical/biological model are examined : a coarse (1.2 degree) and an eddy-permitting version (1/3 of a degree). The range of wavelengths associated to the Rossby wave varies between 380 and 760 km. The meridional average of the power Hovmoller, which gives a measure of the global 380-760 km wavelength variance in the selected 15-45 E band, is compared between SeaWIFS chlorophyll data and modelled chlorophyll. Similarities and discrepancies are discussed in the light of other physical signals (Sea Surface Temperature, Sea Level Anomalies).

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Chlorophyll-a Ocean Color Algorithms for the Southern Ocean and their Influence on Satellite Estimates of Primary Production

B. Greg Mitchell[1] (858-534-2687; gmitchell@ucsd.edu); Mati Kahru[1] (858-534-8947; mkahru@ucsd.edu); Rick Reynolds[1] (206-634-9046); John Wieland[1] (858-534-8947; wieland@ucsd.edu); Dariusz Stramski[1] (dstramski@ucsd.edu); Christopher Hewes[1] (858-534-8525; chewes@ucsd.edu); Osmund Holm-Hansen[1] (858-534-2339; oholmhansen@ucsd.edu)

[1]Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, Dept 0218, La Jolla, CA 92093-0218, United States

An ocean color chlorophyll-a (chl-a) algorithm for the Southern Ocean (SPGANT) has been developed by combining in situ spectral reflectance and chl-a data obtained during recent cruises to the region. Monthly composites of global Southern Ocean primary production 1997-2001 are calculated from SeaWiFS ocean color data by using either NASAs standard OC4 or our new SPGANT chlorophyll algorithm in the productivity model. Our results are compared to previously published global and Southern Ocean chl-a algorithms and primary production estimates. We used ship-based in situ match-up data for both chl-a and normalized water-leaving radiances (Lwn) to evaluate the efficacy of different algorithms. The SPGANT algorithm minimizes the bias of NASAs OC4 algorithm that underestimates near-surface chl-a for the Southern Ocean by up tot 30-40%. The largest underestimates are in the range of 0.8 3 mg chl m^{-3}. At low chl-a (<0.2) the OC4 algorithm tends to overestimate relative to in situ observations. Evaluation of spectra of Lwn, absorption and backscattering coefficients indicates that differences in Southern Ocean chl-a algorithms compared to low latitude data (e.g. the NASA global data set used for OC4) are attributed to changes in both absorption and backscattering relative to chl-a. SeaWiFS underestimates of chl-a for large regions in the Southern Ocean result in lower estimates of satellite-derived primary production.

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Air-Sea CO2 Fluxes Inferred From in Situ and Remotely Sensed Parameters in the Southern Ocean

Jacqueline Boutin[1] (33144274971; boutin @ lodyc.jussieu.fr); Yvan Rangama[1] (33144274971; rangama@lodyc.jussieu.fr); Jacqueline Etcheto[1] (33144277071; etcheto@lodyc.jussieu.fr); Liliane Merlivat[1] (33144277072; merlivat@lodyc.jussieu.fr); Taro Takahashi[2] (taka@ldeo.columbia.edu); Bruno Delille[3] (Bruno.Delille@ulg.ac.be); Michel Frankignoulle[3] (Michel.frankignoulle@ulg.ac.be)