for new approaches for updating coast-wide information on marsh condition, especially in light of forecasts predicting a significant increase in the rate of global sea level rise. Conventional aerial photographic techniques can be expensive and, more importantly, do not lend themselves to timely regional assessments of changes in coastal marshes. Landsat Thematic Mapper, with its relatively high spatial resolution, satisfactory spectral characteristics, and frequency of observations, provides a potentially useful tool for making regional appraisals of changes in marsh surface condition. We have developed a three-component spectral mixing model that classifies marsh substrates into one of four categories, ranging from substrates that lack of any evidence of degradation to those where complete deterioration heralds imminent loss. Using this methodology in Chesapeake Bay and Delaware Bay, we documented large scale marsh degradation (70% of mapped marshes) between 1984-1993, a period corresponding to exceptionally high rates of sea level rise along the US middle Atlantic Coast. The model has since been applied to the whole Atlantic Coast as well as the Gulf Coast. Though extensive validation has confirmed the accuracy of model results for microtidal coasts like Chesapeake Bay, mesotidal and macrotidal areas present problems that reflect the influence of higher tidal ranges on the model characterization of marsh substrate condition. Mesocosm experiments with a spectroradiometer show that, although the shapes of spectral curves largely remain the same as the marsh surface is more completely inundated at high tide in higher tidal ranges, spectral response from 680 to 720 nm is considerably dampened. This dampening tends to bias classification toward greater levels of substrate degradation than may be present. Multi-temporal analyses across the tidal cycle for these coasts are planned to determine the impact of higher tidal ranges on the model.

URL: http://www.glcf.umiacs.umd.edu

OS42U-05 1450h

Selecting Hyperspectral and Multispectral Image Processing Routines for Coral Reef Substrate Discrimination

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The Great Barrier Reef (GBR) is the worlds largest living structure, yet its sheer magnitude renders it virtually impossible to conduct fieldwork over the entire region, and many reefs are fragile and difficult to access. Therefore, remote sensing remains the only way to obtain synoptic data about many coral reef ecosystems. Subsequent to image acquisition, the multitude of processing techniques often makes selection of the most appropriate method unclear, and standard procedures are yet to be developed for reef environments. In coral reef ecosystems, substrate complexity, water column attenuation and georectification difficulties make field campaigns for accuracy assessment challenging. Thus assessing image processing routines for their own merits becomes difficult if knowledge of true pixel content is uncertain. Hence, the aim of this project was to develop an approach using synthetic images to identify optimal processing routines to discriminate coral reef substrate types. Preliminary results were obtained from synthetically generated images, whereby each pixel in the synthetic image contains hyperspectral reflectance data obtained in situ on Heron Reef ($23^{\circ}27'$S, $151^{\circ}55'$E) southern GBR, Australia from three types of target substrates: corals (n=167); algae (n=42); and sediment (n=34). Additional pixels were synthesized to contain the average spectral profile of these features and simulated linear mixtures. The resultant synthetic "reference-image" contains a series of pixels with a gradation from 100% of one target substrate to 100% of the next, with 10% increments of each target substrate. Synthetic image generation allows visual analysis of colour composites, where variations in reflectance between image pixels (with known sub-pixel scale composition of target features) are easier to visually interpret than standard spectral profiles. By using this approach, standard image processing techniques can be applied and classification techniques assessed with 100% confidence of the pixel content. Using the synthetic reference-image (including reflectance and first and second derivative information), several image enhancement and classification routines were assessed for their substrate discrimination accuracy. The spectra were also resampled to simulate the multispectral response of Landsat ETM and IKONOS sensors to determine the optimal processing techniques for both hyperspectral and multispectral data at this scale. Our results have proved promising for substrate discrimination and analysis of field spectra and will now be applied to data over larger spatial scales. Through this research we highlight the relative strengths and weaknesses of image processing procedures for coral reef substrate discrimination, enabling selection of the most appropriate routine for individual applications. This procedure for image processing evaluation is applicable not only for coral reef ecosystems, but in all environments where remote sensing image analysis is performed.

URL: http://www.geosp.uq.edu.au/brg

OS42U-06 1505h

Transmissometer POC – Bottles versus Pumps

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The distribution of particulate organic carbon (POC) can be quantified rapidly from transmissometer profiles of beam attenuation if accurate measurements of POC in the water can be obtained for calibration. The two standard means of determining POC concentrations are to filter samples from water bottles or by in-situ filtration with later anlysis of the filtrate. However, the concentrations measured by these two methods can differ by a factor of 2 to 200. A third, independent method of determining POC is to calculate the difference between total organic carbon in filtered and unfiltered water using high temperature combustion (HTC) methods. In the Ross Sea the ratio of bottle POC to HTC POC was 1.44 during cruise NBP 96-4A and 1.87 during cruise NBP 97-1, but the ratios are upper estimates because of undersampling of large particles in samples of 0.1 ml for HTC. The ratio of bottle POC to pump POC ranged between 20 and 200 on NBP 96-4A and between 5 and 50 on NBP 97-1. In the Antarctic Polar Front the ratio ranged between 2 and 25 on cruise RR Kiwi 7. The bottle POC values are closest to the independent method of measuring POC (i.e. by HTC), whereas pump POC values are low. Other evidence suggests that at POC concentrations below 2 μM/l, bottle POC may be high due to adsorption of DOC onto filters. After considering possible reasons for the bottle/pump differences for POC>2μM/l, and based on filtration tests and correlations, we conclude that the most likely cause for the low in-situ pump POC values results from high pressure differentials across the filter during in-situ filtration, resulting in carbon being sucked through the fibers. Obviously this has important ramifications for any program based on POC measurements.

OS42U-07 1520h

Physical Dynamics and Optical Character of the Hudson River Outflow Plume

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Under pressure and density forcing, river outflow plumes turn in an anticyclonic path and become trapped by Coriolis and topographic constraints against adjacent coastlines. The resulting freshwater plumes can extend for along-coast distances of over 100 km from their sources, with an offshore scale of 5-15 km. Downwelling favorable winds confine the plumes and amplify the alongshore currents within them. When winds turn to an upwelling favorable state, the plumes are rapidly mixed into the interior of the continental shelf. The plumes are biologically and optically important contributors to interior shelf waters due to high loads of CDOM, chlorophyll particulates and sediments. In this study, we examine the results of a mooring array and shipboard survey along the coast of New Jersey during July, 2001. Using ac-9 (wetlabs) and other optical instruments, calibrated against filter pad measurements, we describe the distribution of optically important materials in the plume and adjacent waters, and relate the dynamics of the plume (adcp and temperature/salinity arrays) to the inherent optical property distribution, an important foundation for interpretation of color satellite images.

OS51A HC: 318 B Friday 0830h

Physics and Biology of Antarctic Continental Shelf Waters III

Presiding: **K L Daly,** University of South Florida, College of Marine Science**; D P Costa,** Ecology Evolunary Biology

OS51A-01 0830h

Feeding and energy budget of Antarctic krill Euphausia superba at the onset of winter in the Lazarev Sea (juveniles, adults, furcilia III larvae)

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Overwintering success of Euphausia superba is a key factor dictating population size, but there is uncertainty over how they cope with the scarcity of pelagic food. Both non-feeding strategies (reduced metabolism, lipid utilisation or shrinkage in size) or switching to other foods (carnivory, ice algae or detritus) have been suggested for adult krill, while for larvae it is assumed that they have to feed during winter, because of their low lipid reserves and continuous development in the field. We examined these strategies in the SW Lazarev Sea in autumn (April 1999), when sea ice was forming and phytoplankton was at winter concentrations (0.6-0.9 microgram Chla L-1). Both juveniles and adults had very high lipid content (36% and 44% of dry mass respectively). However their low O:N ratios suggested that these reserves were not being utilised. Results from gut contents analysis and large volume incubations agreed that juveniles fed mainly on phytoplankton and adults fed on small copepods (smaller than 3mm). The feeding methods also concurred that feeding rates were low compared to summer. Even when acclimated to high food concentrations, clearance and ingestion rates were lower than 30% of summer rates. Respiration and ammonium excretion rates of freshly caught krill were 60-80% of those in summer. These findings suggest both switch feeding and energy conservation strategies, with a trend of reduced and more carnivorous feeding with ontogeny. In contrast to juveniles and adults, the most abundant furcilia III larvae, showed low lipid content (12% of dry mass) and their high O:N ratio of 72 suggest a high lipid turnover. Gut content analyses of freshly caught larvae demonstrated that they fed exclusively on phytoplankton. The larvae did not reduce their metabolism and were able to utilise high food concentration when it was available. The study shows that during periods of low food supply in the water column, larvae have to exploit ice algae to cover their metabolic demands.

OS51A-02 0845h

Winter Growth and Condition of Ice Krill (Euphausia crystallorophias) off East Antarctica

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In Austral winter (July/August) 1999 we conducted a study into krill growth rates in the Mertz Glacier

polynya off the coast of East Antarctica. Antarctic krill (Euphausia superba) were absent, however, several catches of the coastal ice krill (Euphausia crystallarophias) were made and a range of experiments and measurements were conducted to assess their winter condition. Krill collected were very large and appeared in active, healthy condition in the top 200m of the water column. Echosounder measurements indicated the presence of large dense aggregations similar to those seen during summer. The disgestive glands of the krill were light green indicating some recent feeding activity, however, the size of the digestive glands was small relative to the size of glands of krill of the same size caught in summer. This indicates that feeding had been occurring only at low levels during the collection period. Growth rates, measured using the instantaneous growth rate methodology on live animals, were just positive indicating that food had been available in sufficient quantities to allow growth over the period of the moult cycle. The mean length of the moult cycle was was significantly greater than the measured intermoult period in summer. Lipid levels were low, less than 5% of body weight compared to summer levels measured off East Antarctica of 15% and summer and autumn levels of up to 45% measured in the Weddell Sea. The winter krill were richer in wax esters and poorer in polar lipids than specimens collected in summer. Krill from the polynya were lacking in C16 PUFAs that are markers of a phytoplankton diet which are common in summer. The eyeball diameter to bony length ratio of winter-collected krill was compared to that of summer collected krill to examine whether shrinkage might have occurred. These studies have indicated the utility of utilising a variety of techniques to examine the condition of krill during winter and have applications to the SO-GLOBEC Program.

OS51A-03 0900h

Biochemical Determination of Age Structure and Diet History in the Antarctic Krill, Euphausia superba, During Austral Winter

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Antarctic krill is the keystone species supporting the southern ocean ecosystem. Yet information on demographic structure of krill populations has been limited due to its highly variable growth rates and possible shrinkage during winter periods of low food. We examined the population age structure and dietary history of E. superba using cellular peroxidation products (collectively termed lipofuscins)and lipid biomarkers as part of the Southern - GLOBEC program. Sub-adult and adult krill (size (total length) ranging from 21.4 - 60.4 mm; (41.3 +- 10.7 mm, n=537) were collected from the open water areas near Adelaide Island using multiple opening/closing nets and environmental sensing system (MOCNESS). Lipofuscins were extracted from neural tissues (eye and eye-stalk), quantified, and normalized to protein content on board to allow comparisons across animal sizes. Multiple fluorescent components were observed, with the major product having a maximum fluorescence at excitation of 355nm and emission of 510nm. Lipofuscin levels of field-collected krill were highly variable, but significantly correlated with body size ($r>0.4$ at $p=0.05$). Further examination will compare field collections to reared animals of known age to calibrate the demographic structure observed in overwintering populations. Lipid markers (fatty acids, sterols, etc.) are being applied as tracers of their dietary history and linked to age information to understand feeding history. These results suggest that lipofuscin can be measured among individual krill, and can be combined with lipid markers to understand age and overwintering strategies.

OS51A-04 0915h

SO GLOBEC: Winter metabolism of krill, Euphausia superba, on the western Antarctic continental shelf

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Overwintering Euphausia superba are faced with an energy shortfall due to the loss of their phytoplankton food source, a result of the vanishingly low chlorophyll biomass typical of the Antarctic water column during the fall and winter. Two strategies that are widely exploited to overcome food deprivation in overwintering species are the use of an energy depot as a source of fuel and a reduction in the need for fuel by reducing metabolic demand. The present study was designed to test the hypothesis that Euphausia superba reduces its metabolic demand as part of its overwintering strategy. Krill were captured in a Tucker trawl designed for gentle handling of specimens on two GLOBEC cruises to the Western Antarctic Peninsula (WAP) shelf, one in the austral fall (April-May) and the other in the austral winter (July-August). Specimens were rapidly sorted into cold (-1.0^{o}C) filtered seawater and allowed to adjust to laboratory conditions for a minimum of 4 h. They were then placed in sealed, water-jacketed vessels filled with filtered (0.45u) seawater and allowed to deplete the oxygen to intermediate levels of dissolved oxygen (80 mm Hg) at a temperature of -1.0^{o}C. Oxygen consumption was continuously recorded with Clark polarographic electrodes. No differences were observed in oxygen consumption between the fall and winter seasons. The equation for the line describing metabolism vs mass in fall-winter WAP shelf animals was Y (ul O2 individual $^{-1}$ h $^{-1}$) = 0.310 X (mass (mg))$^{0.772}$, r ^{2}=0.754. WAP shelf fall-winter krill had a metabolic rate about 60 % of that of summer animals captured in the Weddell Sea (Y (ul O2 individual $^{-1}$ h $^{-1}$)= 0.514 X (mass (mg))$^{0.792}$, r^{2}=0.9650) suggesting a profound drop in metabolic rate during the winter. Despite the observed dramatically reduced metabolism in fall-winter, WAP shelf krill showed a higher rate than E. superba captured in the Weddell Sea during winter (Y= 0.213 X $^{0.802}$, r^{2}=0.970).

OS51A-05 0930h

Overwintering Strategies of Antarctic Krill

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As part of the ongoing U.S. Southern Ocean GLOBEC program, the overwintering behavioral strategies of different life history stages of Antarctic krill (*Euphausia superba*) are being investigated to better understand the effects of environmental variability on krill survivorship. Larval krill were abundant throughout the study area during autumn 2001 and individuals occurred in many stages of development (Calyptopis III to Furcilia 6), suggesting that the previous summer was a strong year for krill reproduction, reproduction extended over a relatively long period, and that circulation was favorable for retaining larvae on the shelf. In contrast, juveniles were generally absent. Adult krill were rare in the open waters of Marguerite Bay, but were relatively abundant in adjacent coastal fjords and embayments.

During winter when the study area was covered with sea ice, most larvae had developed to Furcilia 6. Chlorophyll concentrations in the water column (0.03-0.06 $\mu g\ l^{-1}$) and under sea ice (0.01-0.5 $\mu g\ l^{-1}$) indicated that autotrophic food availability was extremely low. Experimental results suggested that larvae likely fed on microzooplankton (see Gallager et al., this issue) and detritus and adults fed on copepods. Winter molting rates were similar to those during autumn, but growth rates were negligible for all stages. Although larval krill were observed under sea ice, preliminary results suggest that sea ice formed late in the year in this region may not allow sufficient growth of sea ice communities to provide a significant food source for overwintering krill. Several alternative food sources may have supported the population at a maintenance level.

OS51A-06 0945h

Lipid Biochemistry of *Euphausia superba* — an Ontogenetic and Trophodynamic Perspective on Overwintering

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Energy stores are crucial to ensure survival of early developmental stages of *Euphausia superba* during the long Antarctic winter without significant primary production. Here, we present a comprehensive data set on the lipid content and composition of various ontogenetic stages of *E. superba* with special emphasis on furciliae: total lipid contents gradually increase from 8% of dry mass in Calyptopis I to about 25% in Furcilia VI. Decreasing levels of short-chain fatty acids reflect utilization of storage lipids during the first non-feeding larval stages. In contrast, the diatom marker fatty acids 16:1(n-7), 18:1(n-7) and 20:5(n-3) gain importance when growth and lipid accumulation is fuelled by external resources. Between-year comparisons illustrate differences in krill fitness that can be related to environmental conditions and hence food availability. In addition, feeding experiments were performed to assess the applicability of specific marker fatty acids to determine trophic relationships in furciliae which invest dietary energy primarily in somatic growth. While adults and juveniles hardly altered their fatty acid composition with varying food sources in autumn, the furciliae utilized dietary lipids as indicated by their fatty acid compositions. Typical diatom fatty acids fed to furciliae were compared with the fatty acid composition of excreted faecal strings. It revealed the preferential uptake of long-chain polyunsaturated fatty acids as well as 16:1(n-7), while the portion of short-chain saturates was larger in the faeces. This combination of field and laboratory studies improves our understanding of ontogenetically varying adaptive strategies of *E. superba* to survive the extreme Antarctic winter.

OS51A-07 1020h

Krill Flux in Southern Ocean Food-Webs

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That krill are transported in the current systems of the Southern Ocean is well established but there has been little quantification or assessment of the significance of such a horizontal flux. At South Georgia the local stock of krill is probably maintained by the input of krill from further south. Model studies have suggested that the Southern Antarctic Circumpolar Front (SACCF) may have a role in transporting krill into the region. Here we report an interdisciplinary study of the ocean to the north of South Georgia where the SACCF retroflects around the island. There was a strong jet associated with the westward flow SACCF and a weaker return flow to the east further offshore. There was an enhanced biomass of krill associated with the westward flow of the SACCF. Using vertically resolved estimates of water volume transport and krill biomass we have derived an estimate of krill flux in the region. Comparison of the integrated flux of krill with some of the estimated food-web fluxes in the region indicates that the flux component will have dominated the food-webs flows at this time. Using model studies and analyses of the development of the biological community we are considering the origin of the krill observed in the SACCF during the summer at South Georgia.

OS51A-08 1035h

Modeling studies of Antarctic krill survival during transport across the Scotia Sea

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A dynamical circulation model, the Harvard Ocean Prediction System (HOPS), was used to calculate the flow in Drake Passage and the Scotia Sea which was then used to assess transport of Antarctic krill (*Euphausia superba*) from the western Antarctic Peninsula to South Georgia. Drifter simulations show the multiple trajectories that can be followed by particles released on the west Antarctic Peninsula shelf as they move across the Scotia Sea towards South Georgia. In addition a time-dependent, size-structured, physiologically-based krill growth model was used to assess the food resources that are needed to sustain Antarctic krill during such a transport across the Scotia Sea. The results of the drifter and krill growth simulations show that pelagic phytoplankton concentrations are not sufficient to support continuous growth of Antarctic krill during the 200 to 250 days needed for transport to South

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Georgia. The inclusion of a supplemental food source during part of the transport time, such as sea ice algae (up to 80 mg Chl a m^{-3}), does not significantly alter this result. Survival and growth of larval krill during modeled transport is, however, enhanced by encounters with mesoscale patches of high chlorophyll concentrations (1 mg m^{-3}), while subadults and adults benefit less from these conditions. Further simulations show the importance of an additional food source, such as heterotrophic food, for the survival of subadult and adult Antarctic krill. These simulations also suggest the possibility of alternative transport scenarios, such as Antarctic krill beginning transport at the Antarctic Peninsula in austral summer overwinter under the sea ice that extends northward from the Weddell Sea into the Scotia Sea.

OS51A-09 1050h

Acoustic Distribution of Antarctic Krill during SO-GLOBEC 2001 - POLARTSTERN expedition.

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Better understanding of the physical and biological factors that influence Antarctic krill (Euphausia superba), its growth, reproduction, recruitment, survival and distribution, is the primary goal of the Southern Ocean Global Ocean Ecosystem Dynamic (SO-GLOBEC) program. The investigation of all of these factors were objectives of POLARSTERN cruise ANT XVIII 5b, conducted April-May 2001 in the eastern Bellingshausen Sea. Here we will focus on the distributional aspect of krill and zooplankton in this area. We present species distributions along transects perpendicular to the coast of Adelaide Island in the upper 300m open water and contrast those with distribution patterns recorded under newly formed closed sea-ice fields near Alexander Island. The results are interpreted in terms of physical influences characterized by patterns of water column structure and flow fields, biological conditions of potential food items, and effects of sea-ice biology. Krill behavior and zooplankton-krill interaction will also be discussed.

URL: http://www.awi-bremerhaven.de/Biomeer/ANT_XVIII_5.pdf

OS51A-10 1105h

Broad-scale Distribution of Zooplankton Acoustic Backscattering in Continental Shelf Waters of the Western Antarctic Peninsula During Austral Fall and Winter 2001

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Two surveys were conducted in austral fall (May-June) and winter (July-September) of 2001 to investigate the distribution of zooplankton in relation to hydrographic regimes of the continental shelf in and around Marguerite Bay, as part of the Southern Ocean GLOBEC program. Acoustic and environmental data were collected with the Bio-Optical Multi-frequency Acoustical and Physical Environmental Recorder (BIOMAPER-II) along transect lines running across the shelf and perpendicular to the Western Peninsula coastline, between 65 and 70S. The BIOMAPER-II was also equipped with a Video Plankton Recorder (VPR) to describe the distributions of planktonic taxa. In fall, acoustic backscattering at 120 kHz was greatest in regions of abrupt topography close to shore, where scattering was concentrated in dense patches between 50 and 120m. The middle to outer portion of the shelf was characterized by less dense layers of scattering extending from 100m depth to the bottom, and a general along-shelf, North-South increasing gradient in scattering intensity. A persistent shallow layer was also present across most of the shelf, generally situated near the top of the pycnocline. By winter, in contrast, backscattering had decreased substantially in magnitude throughout the survey area. The shallow layer was still present, but those few areas of high scattering were characterized by a dense layer in immediate proximity to the bottom. There were few large and distinct patches of the sort observed in the fall. The observed distributions of backscattering were associated with concomitantly measured water column properties (e.g., temperature, salinity, and topography).

It is often assumed that krill are the dominant contributors to backscattering in Antarctic waters, and indeed, our net samples (MOCNESS) and VPR data indicate a high abundance of adult krill in the high-scattering coastal regions observed in the fall survey. In other regions of the shelf, however, direct observations and predictions of expected backscattering based on net catches and taxon-specific models of acoustic target strength suggest that other organisms such as pteropods and copepods can dominate backscattering.

OS51A-11 1120h

Distribution of Larval Krill and Zooplankton on the Continental Shelf of Marguerite Bay, Antarctic Peninsula: Preliminary Results from Southern Ocean GLOBEC Cruises

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Marguerite Bay is known to be a region where persistent populations of krill are found, even throughout the Antarctic winter. The Southern Ocean GLOBEC program seeks to describe how circulation and hydrography influence the distribution of krill on the shelf and how this contributes to successful overwintering by populations of krill in the region. The distribution of plankton, including larval krill, and hydrography were described during two cruises to Marguerite Bay, Antarctic Peninsula, in April-May (fall) and July-August (winter), 2001. The taxonomic and size composition of the zooplankton community and coincident hydrography were quantified using a Video Plankton Recorder and environmental sensors mounted on the BIOMAPER-II oceanographic surveying instrument and a 1 m^2 MOCNESS. Broad-scale surveys of the Marguerite Bay region, including the continental shelf and slope, were conducted by towyoing the BIOMAPER-II from near-surface to near-bottom or 250 m. Larval and adult euphausiids, copepods, pteropods, polychaetes, and marine snow were observed with the video cameras. Abundances of all plankton were much reduced during the winter cruise, when the region was nearly completely ice covered, relative to during the fall cruise. The most striking and surprising finding of the fall cruise was that larval krill were distributed across the entire shelf from the offshore edge adjacent to the Antarctic Circumpolar Current to the coast. Greatest abundances of larval krill were observed subsurface in association with the pycnocline. Elevated abundances of adult krill were observed at depth within Marguerite Bay and in coastal waters west of Alexander Island. It is clear from the distributions of larval krill that they had spread across the shelf prior to the onset of winter.

OS51A-12 1135h

Trophic Relationships Among Antarctic Zooplankton - Some Uses and Limits of the Stable Isotope Approach

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The use of stable isotopes to study food webs has increased rapidly in popularity, but there are still some uncertainties in the application of this method. In this study, the isotopic composition of Antarctic euphausiids and copepods were examined against their foodweb baseline Particulate Organic Matter (POM) signals. Interpretations of food web interactions and timescales of isotopic change were helped by calibration experiments with Euphausia superba furcilia, juveniles and adults fed a variety of known diets. The delta 15N and delta 13C isotope signals of POM varied regionally (Polar Front, Weddell Gyre, Lazarev Sea) and seasonally (i.e. between high and low primary productivity), and these changes were reflected in the zooplankton. While isotope signatures of copepods and larval euphausiids corresponded well with concurrent and literature findings of their diets, this was not always the case for adults. Their lower rates of growth and tissue turnover, combined with advection or migration, might lead to a mis-match with a temporally or regionally changed baseline isotopic composition. This interpretation is supported by the experiments with postlarval E. superba, which showed that the isotope signal of the whole body did not reach isotopic equilibrium with its food within 30 days, although fecal pellets and molts changed much faster. Differences in isotope signals were found between reproductively active male and female E. superba, which suggest that a specific biochemical composition can obscure the influence of the feeding history on stable isotope signals. Isotopic analysis may be a valuable tool to help interpret remote food webs, but in the Southern Ocean, slow growth and large scale transport are potential problems.

OS51A-13 1150h

Seasonal Changes in the Association of Larval Krill with its Potential Microplankton Food Resource Along the Western Antarctic Peninsula

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An objective of the Southern Ocean GLOBEC program is to understand physical and biological processes contributing to the overwintering success of larval krill (furcilia) along the Western Antarctic peninsula. On two cruises to the Western Antarctic peninsula, May-June (austral fall) and July-September (austral winter), the under ice distribution of furcilia and water column microplankton populations were assessed. In addition, on the winter cruise, feeding experiments were conducted to assess the potential utilization of microplankton as a food resource by furcilia. Under ice furcilia populations were quantified using stereo video cameras mounted on a Remotely Controlled Vehicle (ROV). Microplankton were enumerated microscopically after Lugols and DAPI staining, in addition to observing motion characteristics on live samples taken with Niskin bottles across a 200 nm square grid. Diver-collected furcilia were exposed to natural assemblages of microplankton collected from various depths in time-course particle depletion experiments. During the fall cruise, ice cover was sparse and furcilia were found in dense layers within the pycnocline. The ciliate Mesodinium sp. was a prominent member of the microplankton community in the surface mixed layer particularly where salinity was relatively low. Large centric diatoms, tintinnids and oligotrichous ciliates were abundant at the top of the pycnocline, while heterotrophic dinoflagellates dominated at depth. During the winter cruise, ice cover was heavy and reasonably continuous both in and off shore. Furcilia were found scattered throughout the grid in direct association with the under ice surface. Extremely dense patches were common where under ice surface roughness was great, but no inshore-offshore gradient or other spatial pattern was detected. Compared with the fall cruise, microplankton in the water column during the winter were sparse with greatest concentrations at both the ice/water interface and immediately above the pycnocline. Particle depletion feeding experiments showed furcilia were capable of clearing up to 98% of available particles between 50 and 150 um. Ingestion of microplankton by furcilia was confirmed by both DAPI and AO staining of gut contents and by conducting feeding experiments with fluorescently labeled prey. Together these results suggest furcilia spend the winter months associated with the under ice surface feeding on microplankton, a strategy which may play a major role in the overwintering of larval krill.

OS51B HC: 315 Friday 0830h

Equatorial Oceanography V

Presiding: **D Moore,** NOAA /PMEL**; G C Johnson,** NOAA/PMEL

OS51B-01 0830h INVITED

Temporal and Spatial Structure of the Equatorial Deep Jets in the Pacific Ocean

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The spatial and temporal structure of the equatorial deep jets (EDJs) in the Pacific Ocean is investigated using CTD station data taken on the equator from 1979 through 2001. The EDJs are clearly revealed using vertical strain estimated from the CTD data in a stretched vertical coordinate system. There are 32 meridional sections available, with 27 of these west of the dateline. The meridional sections show the expected equatorial trapping, but yield little new detailed information about meridional structure. Long equatorial time series can be created at a few other longitudes, most notably 110°W and 140°W. Analysis of the equatorial data yields several results. There is a clear vertical wavelength near 400 sdbar (with $N_o = 1.555 \times 10^{-3}$ s^{-1}) associated with the EDJs. This signature is more easily seen in the eastern Pacific (at and east of 140°W), perhaps because there the EDJs are isolated from the influence of relatively short period Rossby waves generated by surface forcing. The EDJ vertical propagation in this region, 4×10^{-7} sdbar s^{-1} (14 sdbar year^{-1}), is remarkably slow and downward, suggesting a period of around three decades. Given this time scale, it is no surprise that previous observational analyses of these jets, limited to two years or less, had difficulty finding any significant vertical propagation. The EDJs show some coherence from 95°W to 140°W. However, the zonal scales of the EDJs are apparently so long that they defy quantification over this longitude range. Significant difficulties exist for interepreting the EDJs as linear equatorial waves, but given the EDJ vertical wavelength and propagation, Kelvin and Rossby waves would also have very long zonal wavelengths.

OS51B-02 0855h

Upper and Intermediate Circulation in the Western Equatorial Pacific Ocean in November 1999 and April 2000

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Direct velocity measurements were carried out with a Lowered Acoustic Doppler Current Profiler (LADCP) in the western equatorial Pacific Ocean during 6-month apart cruises in November 1999 and April 2000. The measurements were made from the surface down to 1200 m depth, between 20°S and the equator along 165°E and 180°, as well as along the equator between those two longitudes. The zonal velocity along the 165°E and 180° meridional sections was found in general agreement with the mean section of zonal current constructed from the 41 sections of the Pacific Equatorial Ocean Dynamics (PEQUOD) program at 159°W [Firing, J. Mar. Res., 45, 791-812, 1987]. Yet, an eastward flow near 6°S and 400 m depth was measured at both longitudes for the two cruises, consistent with the observations of Rowe et al. [J. Phys. Oceanogr., 30, 1172-1187,2000]. The upper core of this eastward flow was linked to a deeper core centered near 5°S-1000 m, the resulting pattern could be named the South Equatorial Intermediate Countercurrent (SEICC). The upper core of the SEICC was found at the poleward edge of a region of low vertical gradient of potential density. Along the equator and below the Equatorial Undercurrent (EUC) the zonal current was clearly westward in November 1999 and eastward in April 2000. Such a reversal of the equatorial intermediate currents was already observed in June 1983 at 159°W and in December 1989 at 155°W [Firing et al., J. Geophys. Res., 103, 21413-21423, 1998]. Here the reversal was coherent over 15° of longitude, from 165°E to 180°E. In November 1999, a strong northward flow was observed near 175°W from the surface to 1200 m depth. At that time, the Deep Equatorial Jets (DEJ) broke into smaller vertical scales. Coincidentally, this event seemed to affect the EUC which lost energy and was then formed of two superimposed velocity cores. As the ship steamed eastward along the equator, LADCP data evidenced that the DEJ and the EUC progressively retrieved their 'usual' vertical scales. Processes responsible for our observations remain unclear. The possible role of tropical instability waves and local topography will be discussed.

OS51B-03 0910h

Deep Equatorial Current Structure in the JAMSTEC Model Compared to Observations

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One of the unsolved challenges of numerical modelling is a realistic simulation of the equatorial current structure below the thermocline. Although spatial and temporal coverage are poor, observations from all three oceans show complex patterns of deep zonal currents near the equator. Within a degree of the equator, a stack of eastward and westard relative maxima with a vertical wavelength of several hundred meters is typically found; these are the equatorial deep jets. They are embedded in narrow, meridionally-reversing, zonal flows with much larger vertical extent. There is neither a generally accepted theory for these deep equatorial currents nor an accurate ocean general circulation model (GCM) simulation of them.

With 55 levels, the 1/4-degree JAMSTEC GCM has greater potential to resolve deep equatorial current structure than most comparable models. In the Pacific it produces structures resembling the Equatorial Intermediate Current on the equator and the Equatorial Intermediate Countercurrents off the equator. It also produces equatorial deep jets that appear to be realistic in many respects, with one major exception: their vertical scale is about twice the observed scale. The JAMSTEC deep jets in the Pacific do not propagate in the vertical or undergo temporal reversals, but they vary in amplitude with seasonal changes in the larger-scale currents. In the Indian and Atlantic oceans the JAMSTEC deep jets are weaker than in the Pacific, and highly variable in time; they do not appear in the annual mean. Temporal variability of the observed as well as the modelled currents, together with the lack of current profile time series, make model-data comparison more difficult than in the Pacific.

OS51B-04 0925h

Seasonal Variability of Deep Currents in the Equatorial Atlantic: a Model Study

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A suite of high-resolution models of the Atlantic Ocean is used to study the seasonal variability and spatial structure of the deep current field in the equatorial regime. The model behavior confirms previous suggestions based on solutions of the WOCE "Community Modelling Effort" and the "DYNAMO" model intercomparison project, of the presence of a system of baroclinic zonal currents in the deep water, spanning the zonal extent of the basin, and oscillating at annual and semi-annual period. The host of model experiments demonstrates that in contrast to annual mean fields, there is relatively little sensitivity of the seasonal flow patterns to model factors such as grid choices and mixing parameterizations. A particular manifestation of the seasonal variability concerns the Deep Western Boundary Current (DWBC). Amplitude and phase of the simulated seasonal cycle are in quantitative agreement with observational results. The simulations indicate that the interaction of the deep equatorial current bands with the DWBC gives rise to a complex patterns of seasonal recirculation cells. This suggests that DWBC measurements not extending across these cells may not be representative of low-fequency variations of the net meridional transport near the western boundary.

OS51B-05 0940h

Thermocline Processes in the Tropical Pacific and Their Role in Decadal Climate Variability

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The thermocline is the layer of the ocean that is characterized by large vertical temperature gradients. Thermocline variability can arise through subduction processes as well as baroclinic Rossby wave propagation, processes that have been invoked in several recent theories of decadal climate variability. In the Pacific, the thermocline exhibits two tropical centers of variability, at approximately 10°S and 13°N. A large fraction of the variance in these areas is characterized by long timescales, in the decadal range. In this study we investigate the origin of the centers of variability at 10°S and 13°N using the output from a numerical simulation performed with the National Center for Atmospheric Research ocean general circulation model (OGCM) forced with observed fluxes of momentum, heat, and freshwater over the period 1958-1997. Both centers of variability are associated with first mode baroclinic Rossby waves forced by anomalous Ekman pumping. The waves propagate to the western boundary, and continue equatorward along the boundary. After reaching the equator, they propagate eastward along the equator, where they appear to produce a low-frequency modulation of the thermocline depth. A simple Rossby wave model is used to examine which aspects of the forcing (amplitude, spatial and/or temporal coherency) are responsible for creating the large thermocline signals at 10°S and 13°N. At those latitudes, the thermocline deepens poleward in both hemispheres, so that meridional excursions of the thermocline can also give rise to large local changes in thermocline depth and temperature. The contribution of this process to the thermocline variability at 10°S and 13°N is also examined.

URL: http://www.cdc.noaa.gov/~mac/publications.shtml

OS51B-06 0955h

Coupled ocean-atmosphere response to the equatorial emergence of spiciness anomalies.

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The response of the atmosphere-ocean system to the surfacing of temperature anomalies from the oceanic thermocline is a key processes in deterministic low-frequency climate variability. Of interest here is the appearance of salinity compensated temperature anomalies (spiciness anomalies) in the upwelling region of the equatorial Pacific. This coupled adjustment is investigated by forcing a sophisticated, coupled ocean- atmosphere model with prescribed spiciness fluxes in the upper thermocline of the western Pacific. Two experiments, one associated with an increase the other with a decrease of temperature and salinity on isopycnal surfaces were conducted. Each experiment was run for ten years and repeated three times.

Results indicate that the emergence of warm spiciness anomalies in the central equatorial Pacific is reflected at the ocean surface as warm and salty anomalies. The atmospheric response includes increases in easterlies in the eastern Pacific, and westerly wind anomalies in the western Pacific. These winds and associated Ekman pumping depress the thermocline in the central tropical Pacific. This leads to a weak nonlinear response in that the equatorial isopycnal outcrops east of the data line are located further west in the run with warm spiciness forcing compared to the cold spiciness forcing.

These changes in the tropics result in a eastward shift of the centers of deep atmospheric convection and force teleconnected changes in the atmosphere. During northern winter the emergence of warm spiciness anomalies is accompanied by westerly anomalies north

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