### OS31C-39 0830h POSTER

#### Short-term variability of bacterial production and consumption of dimethylsulfide (DMS)

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Biological transformation rates of dimethylsulfide (DMS) and dimethylsulfoniopropionate (DMSP) were determined during 48 hours in the St. Lawrence estuary in July 2000. A drifting buoy was used to follow a water mass in which concentrations of DMS, dissolved DMSP (DMSPd) and particulate DMSP (DMSPp) were measured every 2 hours at the surface and at the depth of fluorescence maximum (2-6 m). DMS production and consumption rates were determined every 4 hours during onboard incubations. Dinoflagellates, mostly *Alexandrium tamarense* and *Scrippsiella* sp., dominated the phytoplankton community. During the course of the experiment, DMSPp and DMSPd concentrations varied from 20 to 120 nM and from 2 to 22 nM, respectively, and DMS concentrations increased from 0.2 nM to 6.0 nM. The DMS accumulation can be explained by an excess of DMS production over DMS consumption. Gross DMS production rates ranged from 0 to 2.0 nM $h^{-1}$, with the highest rate observed following a pulse of DMSPd. In general, DMS production rates exhibited large short-term variability in phase with the semi-diurnal tidal cycle. DMS consumption rates varied between 0 and 0.6 nM $h^{-1}$, with highest rates (> 0.3 nM $h^{-1}$) measured when DMS concentrations exceeded 3.0 nM. Elevated levels of DMSPd and DMS seem to rapidly trigger bacterial DMSPd cleavage and DMS consumption. During this experiment, processes of the DMS cycle show significant short-term variability and respond very rapidly to changes in the physical environment. This needs to be taken into consideration in the development of DMS production models.

### OS31C-40 0830h POSTER

#### Fluid Flow as a Controller of Methane Oxidation Rates in Marine Sediments

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Methane oxidation activity within marine sediments associated with cold seeps of the San Clemente Escarpment during an Alvin cruise in 2000 was measured at various locations. The Navy Fan, a 100 to 200 m section that overlies older San Clemente strata, is characterized by the presence of distinct sand layers ranging from 3 to 5 cm in thickness that provide discrete pathways for migration of fluids at high lateral advective rates. The San Clemente fault cuts through the Navy Fan deposits and exposes migration pathways on a 60 m high scarp wall with fluid discharge sites along the escarpment zone demarked by chemosynthetic communities and barite deposits. Sediments collected at seep sites on the scarp exhibited elevated methane turnover times ranging from 2 to 45 days within the upper 10 cm. Methane oxidation rate maxima within the sediment were observed at depths corresponding to porewater anomalies of dissolved metabolites indicative of lateral flow of methane-rich fluids within the sediment. Seep sites located at the base of the scarp are characterized by vertical fluid flow along high permeability conduits of the San Clemente fault. Sediments collected at these sites exhibited methane turnover times of 8 days to 27 years in the upper 10 cm with the majority of oxidative activity confined to the upper 0.5 cm. Nearby background (non-seep) sediments had relatively longer methane turnover times of 42 days in surface sediments and greater than 300 years below 2 cm depth. Methane turnover times for San Clemente seep sediments supplied by lateral flow of methane-enriched fluids were significantly higher than those observed elsewhere in methane-saturated sediments characterized by disruptive gas bubble flows driven by decomposing methane hydrates. Fluid flow characteristics appeared to be a more important controlling parameter of methane turnover times in marine sediments than methane porewater concentrations except in surficial sediments directly in contact with bottom seawater.

## OS31D HC: Hall III Wednesday 0830h

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

*Presiding:* **H P Batchelder,** College of Oceanic and Atmospheric Administration**; P T Strub,** College of Oceanic and Atmospheric Sciences**; W T Peterson,** National Marine Fisheries Service

### OS31D-41 0830h POSTER

#### Ocean Climate Variability off Oregon?

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A line of stations along 44.6 N extending 150 km from the Oregon coast is being sampled 5 times per year for 6 years beginning in July 1997. Temperature and salinity along this line were also measured regularly from 1961 to 1971; averages and standard deviations from the 1961-71 data provide a standard of comparison for the present sampling program.

We calculate temperature anomalies between recent observations and the corresponding seasonal average values from 1961-71, and normalize the anomalies by the seasonal standard deviation to indicate statistical significance (a value >2 corresponds to a probability >0.95). El Niño strongly affected the temperature of Oregon coastal waters between July 1997 and Sept 1998: upper ocean waters were significantly warmer than the corresponding 1961-71 averages. The positive anomalies off Oregon lingered several months past the end of El Niño in the equatorial Pacific Ocean. El Niño also affected the currents: the northward geostrophic flow observed in Nov 1997 and Feb 1998 was stronger than the 1961-71 fall and winter averages. Since Nov 1998, water temperatures off Oregon have not been significantly different from the corresponding 1961-71 seasonal averages. Sections usually show both positive and negative anomalies that are small (<2) in most locations. The main exception is a slight midsummer warming of a zone centered at a depth of about 150 m over the outer continental slope, about 100 km west of Newport. The location and distribution of this slight summer warming suggests that poleward advection by the California Undercurrent may be stronger or more persistent now than it was during the 1961-71 reference period. The recent summer sections of geostrophic velocity do not show an obvious increase in the strength of the Undercurrent, but do indicate that a larger portion of the cross-section is subject to northward flow. The higher resolution ADCP data indicates the core of the Undercurrent is flowing about 10 cm/s northward in summer.

Our present sampling program resumed at onset of El Niño 1997-98 during a warm phase of Pacific Decadal Oscillation. A cold phase of PDO began in 1998 and has persisted since. The equatorial Pacific has been in a cold (La Niña) regime for the last three years but waters off Oregon are not significantly cooler than during the 1961-71 period, which was also a cool phase of PDO. Will this cool phase of PDO and near-normal temperatures off Oregon persist through the next El Niño?

### OS31D-42 0830h POSTER

#### Altimeter SSH and Alongshore Transport Anomalies in the NE Pacific During 1999-2000

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Along the U.S. west coast and British Columbia, there have been reports of zooplankton species changes following the 1997-1998 El Niño. Cooler coastal water and more abundant zooplankton and baitfish have also been reported. Replacement of warm-water species with species associated with colder water (as reported off southern California, Oregon and Vancouver Island) could be explained by either advection from farther north or by stronger upwelling,leading to cooler water that favors the growth of cool-water species.

Using over 8 years of TOPEX/POSEIDON and ERS altimeter data, we investigate changes in Sea Surface Height (SSH) and alongshore geostrophic transport along the margin of the NE Pacific Ocean, from 20°N to Kodiak Island. Comparisons are made to Coastal Upwelling Index time series and NCEP winds. The period prior to the El Niño is represented by data from October 1992 through September 1996. Data from October 1998 through September 2000 represent the period following the El Niño. SSH values show a descrease of 5-10 cm during 1999-2000 in the 100 km next to the coast from Baja California to Southern Alaska. Initial calculations of alongshore transport are not as conclusive. After an initial period of equatorward transport along much of the coast during spring of 1998, alongshore transport anomalies during 1999-2000 are only consistently equatorward off California, but not at other latitudes. A more thorough analysis of SSH, transports and winds will be presented in the poster.

### OS31D-43 0830h POSTER

#### Satellite Data Analysis of the Influence of El Nino 19971998 on the Pelagic Ecosystem off California

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The influence of El Nino event 19971998 was evaluated off central and southern California via multidisciplinary analysis of remote-sensed data. The EOF statistical method was applied to sea surface temperature anomalies (SSTA) measured by AVHRR radiometers, anomalies of water circulation derived from sea surface height anomalies (SSHA) measured by TOPEX/Poseidon radar altimeter, and meteorological information. EOF statistics demonstrated that an El Nino event occurred during the second half of 1997 and the first half of 1998, with sea level elevated along the coast and with SSHA gradients indicating retarding of both the equatorward California Current and the alongshore poleward Southern California Countercurrent. The positive SST anomaly developed first in the Southern California Bight and then in the zone of upwelling to the north of Point Conception. The anomalies of upwelling index and the wind stress curl pattern also changed during the El Nino event, but these changes were observed later than hydrological variations and were too weak to explain the observed changes in SSTA and SSHA. Seasonal summer minima of remote-sensed (CZCS and SeaWiFS) chlorophyll concentration were observed in all zones of the region under study during the entire period of observations (19781986 and 19972000), suggesting that nutrient limitation is regulated by strength and depth of seasonal pycnocline. Seasonal maxima were observed during summer in zones of upwelling, during spring in the regions adjacent to upwelling zones, and during winter in the southern area, far from upwelling zones due to winter cooling. The main factors stimulating the growth of phytoplankton biomass were the intensity of coastal upwelling and wind stress. In 19971998 the remote-sensed phytoplankton biomass significantly decreased during the summer chlorophyll minimum. SSTA increased first in the Southern California Bight and then in the more northern upwelling zones without significant changes of wind pattern. All these variations during the El Nino event were consistent with deepening of pycnocline resulting from Kelvin waves propagating northward along the coast. We conclude that oceanic teleconnection,

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i. e., the consequences of propagation northward of coastally trapped downwelling Kelvin waves, were responsible for the 19971998 El Nino event.

### OS31D-44 0830h POSTER

## Contrasting Causes of Surface and Thermocline changes in Temperature and Salinity Anomalies in the CalCOFI Region

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The long-term variability observed in temperature and salinity data in the 52-year CalCOFI (California Cooperative Fisheries Investigations) time series off Southern California has been difficult to attribute to particular physical causes. Consequently, it is difficult to understand the changes in physical processes (such as isopycnal shoaling and advection) that affect marine populations. High salinity anomalies can result from either isopycnal shoaling or intrusion of more saline tropical waters from the south or west. Low salinity anomalies result from an increase in the flow of the California Current or the depression of isopycnals. In this presentation, CalCOFI data are analyzed by both sub-regions and depth. Averaged temperature and salinity anomalies at 10 meters exhibit no correlation throughout the 52-year time period, although a positive relationship was found for the period from 1950-1979. There is a negative relationship between temperature and salinity within the thermocline depths due to the shoaling and relaxation of isopycnals across annual to multi-annual time scales. The contribution of isopycnal movements throughout the water column confounds near-surface signals that would result from advection. Salinity anomalies at 10 m can be either high or low during El Niño events, depending on the intrusion of tropical waters occurs along the coast or in the offshore region. In contrast, I found that El Niño conditions were consistently associated with anomalously low salinities within the thermocline due to a depression of isopycnals throughout the water column. Although a decadal shift occurred in near-surface temperatures after 1977, there is no clear decadal shift in salinity values within the thermocline. Distinguishing which physical processes dominate the physical environment of the CalCOFI region will help determine whether changes in populations of marine organisms are caused by advection into the region or by growth in favorable hydrographic conditions.

### OS31D-45 0830h POSTER

## The Seasonal Cycle of Upper Ocean Temperatures of the West Coast: Local Atmospheric Forcing and Rossby Wave Propagation

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Wind stress and wind stress curl (WSC) strongly shape upper ocean conditions in the North Pacific on a full range of time scales. Prior work by Bakun and Nelson (1991) has shown that cyclonic wind stress in coastal regions coupled with alongshore equatorward flow can affect local upwelling and therefore coastal temperatures, stratification, and productivity. This relationship may be complicated by the signal of westward propagating Rossby waves, which may be generated by local wind forcing and/or remotely forced by coastal Kelvin waves. By comparing the evolution of WSC to ocean temperature, we are able to investigate the impact of local Ekman processes and Rossby waves on the seasonal cycle of ocean conditions. The NCEP reanalysis daily surface winds and WODB98 upper ocean temperatures at standard depths are analyzed to define climatologies, monthly values, and anomalies of WSC (1968-96) and sea temperature at 150m depth (150m ST, 1946-96) for the north Pacific Ocean, and their spatial and temporal relationships. The seasonal evolution of 150m ST and local (overlying) WSC are negatively correlated at the coast. However 150m ST and local WSC are not correlated at offshore locations. Coastal WSC has a significant negative correlation with offshore 150m ST, with an increasing lag with distance offshore. Coastal subsurface temperature is well correlated with subsurface temperature offshore with lags that suggest an offshore propagation of the seasonal depth of the thermocline consistent with theoretical Rossby wave propagation. At $32^{o}$N, the phase speed computed from the observed 150m ST was 3.0 cm/s, compared to the theoretical speeds of 3.3 cm/s (Killworth et al. 1997). The seasonal evolution of thermocline temperatures at the coast appears to be forced by local WSC. There is intriguing evidence of coastal isotherm displacements propagating offshore at speeds consistent with internal Rossby wave theory.

### OS31D-46 0830h POSTER

## Climate-scale Variability of Pelagic Fish Abundance on the British Columbia Shelf During the Late Holocene

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The western North American Coastal Upwelling Domain, extending from Baja, California to the northern tip of Vancouver Island, B.C., is a region of major summer upwelling. The domain is home to several pelagic fish stocks that depend on the seasonal productivity that upwelling provides. In addition to their considerable commercial value, these stocks are critical to higher trophic levels as forage species. Recent studies suggest that marine conditions in the region undergo climate-scale variability that can adversely affect trophic productivity.

Effingham Inlet, in Barkley Sound on the southern British Columbia shelf, is a narrow 17 km inlet with a series of silled basins that support the formation of anoxic bottom water. A total of thirteen oceanographic surveys and several coring cruises were conducted from December 1995 to October 2000. The overall goals were to: characterize the present-day water property structure and the dynamics of water renewal in relation to outer coastal oceanographic processes; and to determine the effects of climate variability on the dynamics of fish populations on the continental shelf.

Present-day oceanographic data confirm the dysoxic/anoxic nature of Effingham Inlet basins. Brief periods of bottom-water oxygenation are surprisingly frequent. Sediments in the "inner" and "outer" basins were deposited in annual lamella couplets with intermittent interruptions due to both small debris flows, and the resuspension of unconsolidated sediments during oxygenation of the bottom waters. These sediments archive a high-resolution late Holocene (last 5000 years) record of climate cycles and paleoproductivity in the Coastal Upwelling Domain reflected in the lithology and through paleontological proxy signals, including fish remains (e.g. scales and bones), preserved in the sedimentary record.

Results presented will integrate present-day oceanographic time series data with the sedimentological and stratigraphic record from the inner basin of Effingham Inlet, revealing how the record of pelagic fish remains relate to climate variability on the west coast of North America. Lithological characteristics and an analysis of the fish remains independently indicate three broad climate regimes during the late Holocene. Spectral and continuous wavelet transform analysis was carried out on the laminated sediments, and the well-preserved fish-scale remains of Pacific herring and northern anchovy. Analyses show overall population cyclicity of these species at several decadal to centennial scales, particularly the ∼88 year Gleissberg solar cycle.

Using such a multi-disciplinary approach provides a greater understanding of northern hemisphere climate change and the impacts on the ocean environment. These results will be correlated with other sites to develop an environmental picture for the western North American Upwelling Domain over the last 2000-5000 years.

### OS31D-47 0830h POSTER

## Across the NE Pacific in Spring, 2001: Physical, Chemical and Biological Measures on a Mid-latitude Section

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Twenty-one stations across the NE Pacific were occupied on a transect from Moss Landing, California (36.8 W, 121.8 N) to Honolulu, Hawaii (21.3 N, 157.9 W) by the R/V Western Flyer in March, 2001. CTD casts and net tows were taken at all stations, and ROV and blue-water SCUBA dives were conducted at a subset of stations. CTD-based depth profiles to 1000 m were obtained of temperature, salinity, oxygen, fluorescence, transmissivity, macronutrients, chlorophyll, and primary production. Surface samples were obtained for iron, pC02, fast repetition rate fluorometry, flow cytometry, HPLC pigment analysis, and microscopic enumeration of phytoplankton taxa. Zooplankton counts have been made from ROV and blue water observations, and displacement volumes have been obtained from net tows. An initial description of results is presented here.

We divide the transect into three regions: (1) A coastal margin about 300 km broad (121-125 deg W), showing evidence of coastal upwelling near the surface and the California Undercurrent at depth. Near surface waters of this region were high in macronutrients and iron, chlorophyll, primary production and zooplankton, but low in Prochlorococcus. Picoeukaryote abundance was highest very nearshore while heterotrophic bacteria and Synechococcus counts were highest at the offshore margin of this region; (2) a California Current region from 300-1400 km offshore (125-135 deg W), with low salinity (<33.4) waters to about 200 m deep. Near surface waters across this region had decreasing on/offshore gradients of nutrients and iron, heterotrophic bacteria, picoeukaryotes, Synechococcus, chlorophyll, primary production and zooplankton. Prochlorococcus counts were low but increased at the offshore margin of this current; (3) a North Pacific Central Gyre region from 1400 km offshore to Hawaii (135-158 deg W), with warm high salinity waters above the thermocline at about 200 m. Near surface waters of this region had low nutrients and iron, heterotrophic bacteria, picoeukaryotes, Synechococcus, chlorophyll, primary production and zooplankton abundances, but high Prochlorococcus counts.

### OS31D-48 0830h POSTER

## High Resolution Forcing for the Northeastern Pacific Ocean: Model Fields

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The development of scientifically valid coupled biophysical models for the Northeastern Pacific Ocean will be significantly advanced by the use of accurate surface flux fields at high temporal and spatial resolutions. The Navy's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) is a limited area atmospheric prediction system developed at the Naval Research Laboratory (NRL) and implemented operationally at the Fleet Numerical Meteorology and Oceanography Center (FNMOC) for approximately ten regions around the globe. Surface flux products from

these models are generally archived on a .2-degree lat-lon grid using standard (unconstrained) bilinear interpolation from the model's native grid. The operational COAMPS model output for the northeastern Pacific, designated EPAC, is available at 3-hourly intervals from approximately April 1999 to the present. Additionally, NRL is running a reanalysis COAMPS simulation for the northeast Pacific (CR-NEP) on a triply nested grid with resolutions of 81, 27, and 9 km respectively. The reanalysis simulation currently exists at hourly intervals from November 1998 to September 2000 with extensions to occur in the near future. The availability of the CR-NEP fields on the native Lambert Conformal model grids motivated the development and evaluation of inter-grid mapping techniques or air-sea flux coupling schemes. The surface flux products on the native model grids were blended and mapped to a 1/12th degree resolution lat-lon grid using a scheme that accurately accounts for strong land-sea gradients in order to avoid 'land contamination' of ocean values (constrained mapping). In this presentation, the EPAC and CR-NEP fields are compared to surface flux products from the Navy Operational Global Atmospheric Prediction System (NOGAPS) as well as to the QuikSCAT wind product from the Center for Ocean-Atmospheric Prediction Studies (COAPS). The fields are also evaluated using observations from the Monterey Bay Aquarium Research Institute (MBARI) moorings in the Monterey Bay area. Finally, some of the sensitivity experiments are discussed in which the NRL-Pacific West Coast (NRL-PWC) ocean model is forced by a variety of forcing fields to examine sensitivity to flux coupling methodologies, and to the spatial resolution of the atmospheric forcing.

## OS31D-49 0830h POSTER

### Advection of Red King Crab Larvae in the Southeast Bering Sea: Interactions Between Changes in Spatial Broodstock Population Structure and Physical Forcing Mechanisms

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Red king crab (*Paralithodes camtschaticus*) in Bristol Bay once supported the most lucrative fishery in the world, but catches over the last 20 years have been substantially reduced compared to the 1970's. Since the stock collapse, harvests have been maintained within strict guidelines, with little effect on stock rebuilding. Recruitment levels have remained relatively constant and modest, suggesting that factors outside the fishery may be exert strong influence on abundance. Field studies indicate that the species is reliant upon complex habitat for settlement and establishment early juvenile populations. Such habitat appears to be rare in Bristol Bay, located primarily nearshore along the Alaska Peninsula and in Kvichak and Togiak Bays. During the early 1980's a shift occurred in mature female (broodstock) distribution: once found near Unimak Pass, most broodstock is now located to the northeast, in the center of Bristol Bay. Altered broodstock distributions were accompanied by changes in spatial recruitment. Recruitment to southern areas of the Bay, common in the 1970's, has been rare in recent years; the stock now appears to be more reliant upon nurseries in Kvichak and Togiak Bays. We hypothesize that shifts in spatial recruitment were partly the result of altered larval advection. Female red king crab carry egg clutches throughout incubation. Thus, adult distribution translates directly into the location of the larval pool at hatch. A larval advection model was developed to examine the hypothesis that changes in female distribution decoupled the southern nurseries from the larval pool. The model incorporates long-term averaged coastal flows, wind-driven advection, and temperature-dependent development in predicting advection pathways associated with a variety of hatch scenarios. Model results are consistent with the hypothesis that the broodstock, as presently distributed, is unable to supply southern nurseries with larvae. However, the model fails to explain the manner in which larvae reach the Kvichak and Togiak regions, suggesting either that an important component of the stock has evaded the assessment surveys, or that advection pathways are more complex than assumed. Interactions between larval behavior and tidal transport may play a large role in larval delivery of this species; these processes have not been studied.

## OS31D-50 0830h POSTER

### Contrasting Carbon and Nitrogen Fluxes Within the Vancouver Island shelf-slope System

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We have made a suite of chemical and biological measurements off the southwestern coast of Vancouver Island ($48.5^0$N, $126^0$W) during July 1998. These measurements include inorganic carbon ($TCO_2$), nitrate ($NO_3^-$), total alkalinity, particulate organic carbon and nitrogen, chlorophyll and biological carbon uptake. Physical data collected concurrently were used to identify distinct spatial areas (inner-shelf Vancouver Island coastal current (VICC), the outer shelf and the slope) as well as the physical regime (up- or downwelling). Data were collected during an intense period of summer downwelling, a relaxation period and immediately following an upwelling event. We construct nitrogen and carbon budgets (non-steady state) constrasting physical regimes and spatial areas. The VICC has consistently high $TCO_2$ which does not vary as expected with $NO_3^-$. Over the shelf strong $TCO_2$ drawdown is observed in response to upwelling. Cross-shelf advection of $TCO_2$ dominates the carbon budgets (especially after upwelling) while horizontal $NO_3^-$ gradients are much smaller (presumably due to biological drawdown) making advection less important in the nitrogen budget. The data show that biological uptake of $TCO_2$ and $NO_3^-$ are also decoupled during downwelling. $TCO_2$ (normalized to salinity) below the mixed layer is higher over the shelf relative to offshore. Implications of this elevated $TCO_2$ to annual carbon fluxes are discussed.

## OS31D-51 0830h POSTER

### Coupled Particle-Tracking and Eulerian Models for Understanding Spatial and Temporal Distributions of Mesozooplankton in Coastal Upwelling Ecosystems

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As part of a U.S. GLOBEC funded effort in the Northeast Pacific, we have been developing coupled biophysical models of wind driven upwelling systems that link 1) physical circulation, 2) lower trophic level ecosystems, and 3) higher trophic levels. Here, we present results of some two and three dimensional simulations that use idealized coastal geometry and bathymetry, simple physical forcing, and relatively well understood lower trophic (NPZD) ecosystem models. We model the spatial and temporal distributions of higher trophic levels using individual based models (IBMs) in order to account for physiological and behavioral effects that cannot be easily modeled in the more traditional Eulerian framework. We couple the IBM with the Eulerian models using particle tracking methods. These idealized simulations are a step toward achieving more realistic simulations with fully coupled biophysical models using observed spatially and temporally varying forcing (wind, surface fluxes) and realistic coastal geometry and bathymetry. Particle tracking simulations reveal large differences in source locations of arriving/sampled plankton when forced by advection alone, advection-diffusion (vertical), and advection-diffusion-migration (vertical).

## OS31D-52 0830h POSTER

### Sensitivity studies of biological-physical models for planktonic ecosystems in coastal upwelling regions.

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A primitive equation transport and circulation model was coupled with idealized biological dynamics to explore ecosystem responses to upwelling on the West Coast of the U. S.

Trophic response was simulated using a nitrogen-based model of nutrients, phytoplankton, zooplankton and detritus. Equations were chosen to provide Michaelis-Menten nutrient uptake and Holling Type III grazing; parameter selections compared the effects of microzooplankton grazing rates and feeding efficiencies to those for mesozooplankton.

Three dimensional mesoscale circulation around idealized capes and banks was simulated using the Regional Ocean Modeling System (ROMS). Three wind-forcing regimes were explored: constant wind, a smoothed square-wave, and an idealized wind forcing with spectral qualities based on data from the Newport, OR, region. Initial conditions were chosen as horizontally uniform with a pycnocline at 35 meters. The mixed layer relied on a Mellor-Yamada order 2.5 turbulence closure scheme.

More complex multi-species biological models are routinely used in current ocean modeling efforts. However, our results for biological quantities indicate that even comparatively simple models are sensitive to small variations in biological parameters.

URL: http://zanclopus.biol.berkeley.edu/cvl/roms

## OS31D-53 0830h POSTER

### A Coupled Bio-Physical Model of the California Current System

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A 9-component ecosystem model incorporated into a regional ocean circulation model is used to examine coupled bio-physical processes within the California Current System (CCS). The circulation model is the Navy Coastal Ocean Model (NCOM) developed at the Naval Research Laboratory (NRL) and is configurable as both a vertical 1-D and high-resolution 3-D model. The 3-D version (CCS NCOM) encompasses the region $30^\circ$N-$50^\circ$N and $115^\circ$W-$135^\circ$W at a horizontal grid resolution of 8-10 km. Both versions employ a sigma coordinate with 30 levels in the vertical. The 1-D NCOM employs periodic lateral boundary conditions, while the CCS NCOM is remotely forced along its open lateral boundaries by daily forecasts from the NRL global NCOM nowcast/forecast system. The biological model, a 9-component ecosystem formulation originally developed for the equatorial Pacific upwelling system (Chai et al., DSR, 2001; Dugdale et al., DSR, 2001), includes three nutrients (silicate, nitrate, and ammonia), two phytoplankton groups, two zooplankton grazers, and two detrital pools.

The flexibility of configuring a 1-D and 3-D NCOM enables the importance of horizontal advection and upwelling versus purely local surface-forced processes on ecosystem evolution to be investigated. In-situ bio-optical observations from the MBARI M1 mooring in Monterey Bay, California, for the period 1999-2000 provide an objective measure by which to assess the validity of the model results. Parallel 1-D and CCS NCOM simulations are presented using surface forcing of high temporal frequency from a mesoscale atmospheric model (COAMPS). The coupled bio-physical response to the annual cycle at the M1 mooring is discussed with regard to the importance of the non-local physical processes.

### OS31D-54 0830h POSTER

## Ecosystem Modeling of the Central California Coastal Upwelling System

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In aiming to investigate the central California coastal upwelling ecosystem, especially in the Monterey Bay region, a 11-compartment ecosystem model has been established and coupled with a physical model which is based on the Regional Ocean Modeling System (ROMS). The current model domain covers the Monterey Bay with approximately 1000 km along shore and 500 km offshore. The horizontal resolution is approximately 5 km, and there are 20 sigma layers. The ecosystem model was originally developed by Chai and his collaborators for the equatorial Pacific, and it consists of multiple nutrients and plankton groups, two detritus compartments, and total CO2. The biological model parameters have been adjusted for the coastal upwelling system based upon the time series observations in the Monterey Bay region. The most recent model development has added dissolved oxygen in order to maximize the usage of the observational data and constrain the ecosystem model performance.

The physical-biological model is forced with the QuikSCAT wind, heat and fresh-water fluxes derived from the Comprehensive Ocean-Atmosphere Data Set (COADS). Starting from the observed hydrographic observations of temperature and salinity and nutrients, we integrate the 3D physical-biological model for five years forced with the monthly climatological air-sea fluxes and observed surface photosynthetically available radiation (PAR). The last two years, the model simulation is used to define the climatological mean seasonal cycle. The main goal of the model investigation is to simulate and understand the seasonal cycle of nutrients and phytoplankton dynamics, and importantly the carbon flux in the coastal upwelling region. The model results have been compared with the time series observations in the Monterey Bay region (C1, M1, M2) and transect surveys data (CalCOFI Line 67). The modeled seasonal cycle of the ecosystem will be presented. The nutrients and carbon fluxes will be quantified.

### OS31D-55 0830h POSTER

## Evaluation of a Semi-Analytic Bio-Optical Model Using Shipboard and Mooring Data From Monterey Bay, California

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The Monterey Bay Aquarium Research Institute (MBARI) has been collecting bio-optical and hydrographic data from Monterey Bay, California with moored and shipboard instrumentation since January 1992. A description of this observational database and time-series of these in situ observations are presented. These data provide an excellent background for the development and validation of a new semi-analytic method of modeling light transmission in ocean models. As part of the Simulations of Coastal Ocean Physics and Ecosystems (SCOPE) project funded by the National Ocean Partnership Program (NOPP), this new method will be used in a coupled bio-physical simulation model of the Monterey Bay National Marine Sanctuary. An analysis of the preliminary modeled light fields reveals the nature of additional observational data required to improve the model.

### OS31D-56 0830h POSTER

## Microzooplankton Distribution in Relation to Phytoplankton Community Succession in the Upwelling Ecosystems off Oregon and Northern California

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We analyzed the distribution of microzooplankton in the California Current System (CCS) during 2001 as part of the Long Term Observation Program (LTOP) off the Oregon and Northern Californian coasts. In addition, the abundance distributions of heterotrophic bacteria, coccoid cyanobacteria, and eukaryotic algae in the CCS were assessed via flow cytometry and compared to patterns of sigma-t surfaces and in situ fluorescence obtained from CTD casts. During three spring and summer cruises (March, July, September), we documented planktonic succession in coastal upwelling blooms. Phytoplankton in newly upwelled water near the coast was characterized by blooms of large-sized and chain-forming diatoms. In the mid-shelf region, around the upwelling front, senescing diatom blooms were accompanied by blooms of coccoid cyanobacteria (1-3 x 105 ml-1), nano- to pico-sized eukaryotic phytoplankton (1-3 x 104 ml-1) and heterotrophic bacteria (1-3 x 106 ml-1). Both ciliates and heterotrophic dinoflagellates were important components of the microzooplankton in the CCS. Ciliate biomass tended to be highest in the midshelf region of pico- and nano-phytoplankton blooms, while heterotrophic dinoflagellate biomass was also high in the inshore region of diatom blooms. Our preliminary conclusion is that the role of microzooplankton as grazers of phytoplankton and as food for mesozooplankton should be most important in the 'bloom decay' region of summer upwelling in the CCS, as the base of the food web in this region is dominated by cells too small to be effectively consumed by copepods and euphausids.

### OS31D-57 0830h POSTER

## Satellite-measured Chlorophyll Variability within the Upwelling Zone near Heceta Bank, Oregon

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Four years (1998-2001) of 1km resolution SeaWiFS ocean color satellite data characterize the seasonal and interannual chlorophyll variability along the Oregon coast including the area around Heceta Bank. The 12 month climatological time series show a strong seasonal cycle of chlorophyll peaking in July and August (>6.0 mg $m^{-3}$ within 10km of shore), lagging the climatological upwelling-favorable wind maximum by approximately 1 month. Cross-shelf structure indicates chlorophyll extending farther offshore (∼45 km) over Heceta Bank than areas north and south of the bank, consistent with the additional width of the shelf. The first mode of an EOF decomposition of the twelve-month climatology is dominated (91%) by the seasonal cycle, maximum in July-August with a simple shelf-intensified chlorophyll pattern and a clear enhancement of chlorophyll over Hecata Bank. The spatial pattern of the second mode (4%) also peaks in July-August, showing enhanced chlorophyll over Heceta Bank and off Cape Blanco. The third mode (<2%) shows elevated chlorophyll along the steepest part of the shelf downstream of the bank, peaking in July. Examination of interannual variability shows maximum cross-shelf extension of elevated chlorophyll over Hecata Bank (and to the north) in 1999. Chlorophyll is most closely constricted to the coast in 1998. 2001 appears to have the highest overall inshore chlorophyll concentrations (>7.0 mg $m^{-3}$) on the bank as well as in areas north and south of the bank. EOF analysis of the 4 year time series of monthly means is dominated (73%) by a region-wide, simple, shelf-intensified chlorophyll pattern, with a maximum in July (1998, 1999, 2001) or August (2000). The pattern in the third mode (4%) isolates variability over Hecata Bank and the northern side of Cape Blanco, maximum in July-August, but weakest in 1999. Comparisons of the SeaWiFS chlorophyll variability are made to AVHRR SST patterns and wind forcing.

### OS31D-58 0830h POSTER

## Bio-acoustic Surveys in the Northern California Current System

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During spring and summer 2000, two mesoscale mapping cruises surveyed the northern California Current system from 41.9-44.6N and about 150 km offshore. Concurrent with the physical and bio-optical measurements made from a towed undulating vehicle (SeaSoar), a multi-frequency (38, 120, 200, and 420 kHz) towed bio-acoustics instrument collected backscatter data. The shipboard ADCP provided additional backscatter information at a fifth frequency (153 kHz). The bio-acoustics were collected in 12 s ensembles (about 50 m horizontal resolution) and 1 m vertical bins, comparable to the resolution of the SeaSoar measurements, allowing for close evaluation of the physical control of biological distributions on these scales. The acoustics were sea-truthed using nearby MOCNESS samples. Predicted scattering was computed for each sample using body lengths in a randomly-oriented bent cylinder model, a reasonable approximation for both copepods and euphausiids. Predicted volume backscattering for all MOCNESS samples explained 39% of the variance of the nearby acoustics backscatter, a typical result in this context. A non-negative least squares inverse method will be used in conjunction with the bent-cylinder model, to produce estimates of biomass in size classes over the entire survey region. Preliminary results include high levels of zooplankton biomass over Heceta Bank and near the coast south of Cape Blanco. Obvious diel vertical migration was observed, where a nighttime layer in the upper 50 m moved down to a daytime layer about 10 m above the shelf bottom.

### OS31D-59 0830h POSTER

## Mesoscale physical features and the patchiness of zooplankton and nekton in the northern California Current System

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Mesozooplankton and nekton populations were surveyed using both nets and acoustics during multidisciplinary GLOBEC (Global Ocean Ecosystems Dynamics) fieldwork in the northern California Current System (CCS) during August 2000. The interaction of seasonal upwelling and mesoscale eddies clearly influenced spatial patterns: chlorophyll concentrations, zooplankton biomass, seabird biomass, and the densities of fish and marine mammals were all elevated in meanders of the California Current off of Heceta Head and Cape Blanco, Oregon relative to other parts of the study area. Previous research has suggested that persistent enhancement of epipelagic nutrients through mesoscale physical forcing results in elevated primary and secondary production, and thus favorable habitat

for higher-trophic-level organisms. To test the hypothesis that aggregations of zooplankton and nekton were larger, closer together, and more numerous in these apparently productive waters than in other parts of the study area, spectral and image analysis methods were applied to 'sea-truthed' multifrequency acoustic backscatter data. Preliminary results yield a new description of physically-forced plankton patterns in the CCS, and may have implications for the foraging of fish and other higher-trophic-level predators in regions characterized by mesoscale eddy features. The importance of patchiness patterns for proper sampling of zooplankton and fish in future fieldwork will also be discussed.

### OS31D-60 0830h POSTER

## "Do fish feed at fronts?" Feeding Ecology of Juvenile Salmon in Frontal Regions of the Columbia River Plume

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River discharge results in predictable physical and biological features in the coastal ocean. A well-defined front develops at the seaward edge of riverine plumes where suspended materials and planktonic organisms are concentrated in a relatively restricted area. Riverine fronts are hypothesized to be favorable habitats for planktivorous fish because they result in localized prey aggregations. Here, we examine the spatial distribution and food habits of juvenile chum (*Oncorhychus keta*) and coho (*Oncorhychus kisutch*) salmon in frontal areas of the Columbia River plume to determine if these juvenile salmonids ingest more prey at riverine fronts. The front at the leading edge of the brackish plume was an ephemeral but recurrent feature characterized by sharp color discontinuities that dissipated on a tidal cycle. Fish and zooplankton were sampled at the surface expression of the front, and also at stations 1 km away in both the low-salinity plume and the more saline coastal marine water. Chum salmon were rare in the plume, but were abundant in both the frontal regions and in marine waters. Coho salmon were more abundant at the front compared to plume or ocean stations. Initial analysis of stomach contents does not support the hypothesis that more prey was ingested in the vicinity of the front. Thus, although juvenile salmonids were more abundant at frontal regions, our results are not consistent with the paradigm that fish congregate to feed at fronts.

### OS31D-61 0830h POSTER

## Linking Vertical Advection and Diet to Juvenile Salmon Condition and Parasite Load: A Study Using $^{14}$C, $^{13}$C, and $^{15}$N Natural Abundances

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Significant and variable $^{14}$C depletion in muscle tissue was found among juvenile chinook and coho salmon sampled during the GLOBEC cruises off Oregon and California, USA in June and August, 2000. Because $^{14}$C depletion in marine consumer biomass serves as a measure of the amount of feeding that has occurred in recently-upwelled water, the $^{14}$C/$^{12}$C variability among these fish shows the diversity of advection regimes they encounter in this region. There is considerable overlap in $^{14}$C/$^{12}$C between species, and the larger fish on average have lower values. This implies that both coho and chinook feed in the same range of advection, and that older fish more generally feed in areas experiencing greater upwelling. A negative relationship exists between the various measures of fish condition and $^{14}$C/$^{12}$C in both species, suggesting that fish in better condition feed in waters experiencing greater vertical advection. A range in stable isotope abundances ($^{13}$C/$^{12}$C and $^{15}$N/$^{14}$N) was also found in these fish, with significant $^{13}$C and $^{15}$N depletion evident in the youngest specimens. This appears to reflect the isotopic imprint of nursery stream feeding that is later "overwritten" by a $^{13}$C- and $^{15}$N-enriched marine diet. Stable isotope abundances are relatively uniform in the larger fish with considerable overlap between species. On average, coho had somewhat higher $^{15}$N/$^{14}$N than chinook, implying that coho feed at a somewhat higher trophic level. There is a general increase in fish condition with increasing $^{15}$N/$^{14}$N and especially $^{13}$C/$^{12}$C in both species, suggesting that selective feeding may be contributing to fish condition. Relationships between parasite loads and isotope abundances in these fish will also be presented, and use of isotopes to test hypotheses about spatial/temporal variations in feeding and condition will be further addressed.

### OS31D-62 0830h POSTER

## Island Wake Effects around Santa Catalina Island, Southern California Bight

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The formation of the island wakes formed around Santa Catalina Island was investigated from June 1999 to November 2001 using in situ, remote sensing and model simulations. In situ data was collected over a 32 stations grid around the island using a CTD profiler. Results have shown: (a) a warm water surface wind wake to the southeast of the island. Coincidental SST data from AVHRR (Advance Very High Resolution Radiometer) sensors from NOAAs satellite have showed the continuous presence of a warm surface wake during the cruise dates; Ekman Depths (DE) were shallower in the wind wake region under weaker wind regimes; (b) Mixed layer depths were deeper on the windward side and near the islands coasts; (c) a current wake signature was measured on the North side of the island bellow 10m depth throughout all the cruises (d) Two-dimensional model simulations determined Reynolds number (Re) conditions under which the current wake is formed. Future work will include the study of the dynamics of the zooplankton communities around the island coast due the formation of these island wakes i.e. island mass effect; Three-dimensional fluid simulations will be used to study the vertical component of these wakes.

### OS31D-63 0830h POSTER

## Spatial Patterns of Benthic Community Structure on Pacific Coast Rocky Intertidal Benches

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Evidence suggests that patterns of community structure in rocky intertidal communities are functionally linked to oceanic processes and physical characteristics of the shoreline. However, there is a lack of information on physical and biological patterns across large spatial scales (100s of km) that would allow rigorous assessments of the relationship between intertidal community patterns and the physical and biological interactions on rocky shorelines, and in the nearshore and offshore ocean. As a major research component of PISCO (Partnership for the Interdisciplinary Study of Coastal Oceans), a consortium of four West Coast Universities, a multi-scale dataset is being developed to evaluate these associations. Rocky shorelines at 16 areas along the Eastern Pacific upwelling system from Northern Washington to Southern California were partitioned into relatively homogeneous 100 m alongshore segments based on slope angle, topographic complexity, nearshore bathymetry, and wave runup. Within each of the 16 areas, three sets of three replicate segments were selected for annual biological sampling. Macro-organisms (primarily invertebrates and algae) were sampled along horizontal transects at three elevations within each replicate alongshore segment. We compared the community structure among each set of three replicates, among the three sets of replicates within each area, and among the 16 areas. Results suggest that nearshore bathymetry, wave energy dissipation, and the presence of sand are strongly correlated with low zone patterns and that physically similar low zone habitats supported similar biological communities even when separated by distances of 100's of kilometers. We conclude that this supports the hypothesis that rocky intertidal community structure is predictably associated with physical characteristics of the shoreline and the physical and biological characteristics of the nearshore ocean. This information is being used to guide process-oriented research on the roles of upwelling, productivity, larval transport, recruitment, and species interactions aimed at understanding the mechanisms underlying the observed patterns, thus providing a unique source of relevant information for managers and policy makers.

URL: http://www.piscoweb.org

### OS31D-64 0830h POSTER

## Integrated Database Development for U.S. West Coast Groundfish and their Habitats

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Abstract

The goal of this project is the creation and use of a comprehensive, helpful and easily accessible, multi-layer GIS database and associated web-site for groundfish habitat in the Pacific Northwest. The most direct and immediate need for such a database is as a tool for use by fishery managers to support future marine fisheries management decisions. This information also relates directly to the consultation responsibilities of fishery management councils under the essential fish habitat provisions in federal law, and will serve as a resource for other agencies and entities in their decision processes. The database will provide marine researchers ready access to available information in order to establish and test hypotheses concerning marine habitat and resource distribution and change; limited data availability often constrains the questions that can be productively addressed. The database is a geologic, geophysical, and bathymetric system of data, metadata, and interpretive and derivative layers created from the raw data. The raw data sources include multi and single beam bathymetry, numerous sidescan sonar surveys, academic and oil industry rock, dredge and core samples, and academic and oil industry seismic reflection data. These main data sources are augmented by auxiliary data from submersible observations, cable route surveys, cable burial video, trawl video, and others. These basic layers will be integrated into a bottom type classification, an iterative process that cannot be completely objective, but will include geologic interpretation of the data. Seismic reflection data for example, can be used to interpret rock outcrop, though the surface return in archived industry data cannot generally be used to distinguish other lithologies. Each interpretive layer will be tested against similar layers derived from other sources to iteratively converge on the best-fit classification. Derivative layers include slope, drainage, geologic structure and others. In areas of low data density, slope angle can be used as a crude predictor of rock outcrop, and will be combined with the data-based interpretive layers where no other data exist.

W E D

## OS31D-65 0830h POSTER

### Relationships Between Phytoplankton Pigments, In Situ Spectral Absorption and Reflectance Measurements in Coastal Waters

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Pigments are commonly used to characterize variations in species composition and physiology of phytoplankton assemblages. In situ spectral absorption measurements provide indices that correlate with phytoplankton pigments on fine vertical and temporal scales. In this study, we compare phytoplankton pigments and in situ optics (spectral absorption and reflectance) for a protected coastal fjord (East Sound, Orcas Island, WA) and for the coastal waters off Oregon. Phytoplankton pigment concentrations were determined for discrete water samples using High Performance Liquid Chromatography (HPLC). High-resolution vertical profiles of in situ spectral absorption were obtained with a WET Labs ac-9 (nine wavelength absorption and beam attenuation meter). Spectral reflectance measurements (downwelling irradiance and upwelling radiance) were collected with a seven wavelength Tethered Spectral Radiometer Buoy (TSRB). Changes in the shapes of the absorption spectra were estimated from reflectance (Rrs) measurements ((1/Rrs488 nm - 1/Rrs555 nm) × Rrs443 nm) and particulate plus dissolved absorption (apg) measurements ((apg488 nm - apg 555 nm) ÷ apg 676 nm) in East Sound. We observe strong correlations between these reflectance and absorption parameters and between each of these parameters and photoprotective: photosynthetic pigment ratios (wt: wt). Pigments and optical measurements are compared to physical forcing mechanisms such as light and density stratification in an effort to further understand the environmental factors driving phytoplankton species composition and physiology.

## OS31D-66 0830h POSTER

### Brood Size and Hatching Success of the Euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* from the Oregon Coast Population

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The brood size and egg hatching success of *Thysanoessa spinifera* and *Euphausia pacifica* were studied under laboratory conditions from specimens collected in the Oregon upwelling region. Fecundity was estimated on thirteen oceanographic cruises (July, 1999 to September, 2001). Brood size (eggs fem$^{-1}$), was higher for *E. pacifica* (137.6 eggs fem$^{-1}$) than for *T. spinifera* 109.6 (eggs fem$^{-1}$). *Euphausia pacifica* a larger average percentage of female weight as eggs (9.6%) than *T. spinifera* (3.6%), suggesting that the former species expends about 2.7 times more energy in reproduction. Average egg hatching success (EHS) was 51.4 % (n=15 broods) for *E. pacifica* and 16.3% (n=8 broods) for*T. spinifera.* Hatching success for both species showed very high variability between females, even when they were collected at the same station and incubated at the same experimental temperature (10.5°, ± 0.5°C). We found a significant correlation between the average brood sizes per cruise and Chl-*a* concentration ($\mu$g Chl-*a* l$^{-1}$) for *T. spinifera* ($r^2$=0.77, *p*-value =0.009, d.f.=6), but not for *E. pacifica* ($r^2$=0.04, *p*-value=0.539, d.f.=11). This suggests the former species may get most of its energy for reproduction from herbivory, while the latter perhaps also depends upon other food resources like zooplankton (carnivory). *Thysanoessa spinifera* is a neritic species and spawns in coastal regions during upwelling events with high Chl-*a* concentration, while *E. pacifica* usually is evenly distributed over the continental shelf and off-shelf, sometimes inhabiting and reproducing in regions with lower Chl-*a* concentration.

## OS31D-67 0830h POSTER

### Trophic Cascades Within Coastal Gulf of Alaska Plankton Communities Revealed Using Imaging-in-Flow (FlowCAM) Analysis

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As part of the U.S. GLOBEC program in the coastal Gulf of Alaska, we used a new imaging-in-flow system (FlowCAM) to analyze trophic relationships within the plankton. During three process cruises (April, May, and July 2001), the effects of microzooplankton and copepod grazing on microplankton community composition and size structure were studied by coupling FlowCAM analyses with deckboard incubation experiments. Copepod species studied included *Pseudocalanus* spp., *Calanus marshallae*, *Metridia* sp., and *Neocalanus* spp. Results demonstrate the use of different prey size classes by the various dominant copepod species. Some experiments also clearly indicated the existence of trophic cascades, whereby in situ microplankton community structure was apparently maintained by top-down control involving several trophic levels of grazers. For example, during an aging diatom bloom in April, large heterotrophic dinoflagellates were important consumers of chain diatoms, while these dinoflagellates were in turn regulated by copepod (*Neocalanus flemingeri*) grazing. Examples of grazing interactions representing a wide range of environmental conditions will be presented.

## OS31D-68 0830h POSTER

### Climate-Regulated Microplankton Ecology in the Coastal Gulf of Alaska

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The mission of the northeast Pacific GLOBEC program is to gain an understanding of the relationships between climate variability and the success of marine fish, bird and mammal populations. As part this program, we studied the response of the microplanktonic community to variations in the chemical-physical structure of the coastal Gulf of Alaska. Plankton community structure and rates of microplankton growth and grazing were measured at four sites across the Alaskan continental shelf during April, May and July 2001. During this study, chlorophyll concentration and size structure varied cross-shelf on fine temporal and spatial scales, with as much as a 14x increase in chlorophyll within 10 km$^2$. Bloom concentrations of chlorophyll (defined as >1 $\mu$g chl l$^{-1}$ [study site range 0.09 to 14 $\mu$g chl l$^{-1}$]) were seen at inner and mid-shelf stations where salinity-driven stratification often precipitates the onset of phytoplankton accumulation on the Alaskan shelf; these blooms were dominated by cells >20 $\mu$m. Across all size fractions and seasons, phytoplankton growth rates were moderate and showed no relationship with temperature. Phytoplankton growth rates averaged 0.45, 0.29, and 0.37 d$^{-1}$ for >20, 20 to 5, and <5 $\mu$m cells, respectively. Within a given month, phytoplankton growth rates varied among shelf locations for all size fractions. Based on nutrient addition experiments, low phytoplankton growth rates were the result of nutrient deplete conditions, and cells >20 $\mu$m consistently showed greatest nutrient limitation. Microzooplankton grazing was high in relation to phytoplankton growth. This was especially true for cells <20 $\mu$m; in most experiments, phytoplankton production in this size class was entirely consumed by microzooplankton. Phytoplankton >20 $\mu$m were grazed substantially, but during this study, their growth was rarely limited by microzooplankton predation. Exceptions to this were seen in May and July when, in combination with some degree of nutrient limitation, microzooplankton grazed >%100 of the >20 $\mu$m phytoplankton growth during several experiments. Variability in plankton rate processes and community composition, as seen in this study, appear dependent on physical and chemical water properties, which in turn are dependent on climate and weather. Because of this, an intimate relationship exists between climate and Gulf of Alaska biology, and changes in the former should directly influence the latter.

## OS31D-69 0830h POSTER

### Spatial and Temporal Variability of Abundance and Biomass of Microplankton in the Gulf of Alaska

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We determined spatial and seasonal changes in microplankton (phytoplankton and microzooplankton <200 um) abundance and biomass during six GLOBEC LTOP cruises in the Gulf of Alaska (GAK) from April to December 2001. We sampled all stations along the Seward Line (SL), select stations along the Cape Cleare Southeast, Hinchenbrook Entrance, and Cape Fairfield Lines as well as selected stations within Prince William Sound (PWS). Along the SL during the spring and early summer, phytoplankton assemblages showed a great deal of spatial heterogeneity with little correlation to physical factors. In April, chlorophyll fluorescence values were relatively low at all stations and the phytoplankton community was dominated by cyanobacteria, cryptophytes and 3-5 um flagellates. During May, elevated chlorophyll was observed at stations in PWS Sound and at inshore stations along the Seward (GAK 2&3) and Cape Fairfield (CF3) Lines. The phytoplankton community at these stations was composed of the large chain-forming diatom Thalassiosira sp., other diatoms, cryptophytes and cyanobacteria. The Thalassiosira sp. was visibly healthier in PWS than at the GAK or CF stations, and was not found at any of the upstream stations. These observations support the notion that the bloom started in PWS and was transported out on the shelf, but was not seeding the offshore blooms. Cyanobacteria and picoeukaryotes were increasing important in the offshore GAK stations, reaching 76,000/ml (GAK13) and 10,000/ml (GAK9), respectively. During the June/July cruise, elevated fluorescence values occurred at both ends of the SL, but were caused by different phytoplankton assemblages. Inshore, the community was dominated by the large chain diatoms Guinardia and Chaetoceros spp while the large diatom Corethron hystrix, Nitzschia spp.,small flagellates and cyanobacteria dominated the most offshore station. A mixed assemblage of small pennate diatoms, cryptophytes, and cyanobacteria was seen at stations along the shelf to the shelf break. Large (>40 um) heterotrophic dinoflagellates and oligotrich ciliates were associated with high phytoplankton biomass areas. Heterotrophic protists (flagellates, dinoflagellates and ciliates) were abundant at all stations and increased in number and biomass as the season progressed.

## OS31D-70 0830h POSTER

### Summer Phytoplankton and Microzooplankton Trophic Dynamics on the SE Bering Sea Shelf

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The Bering Sea shelf is one of the widest shelves (>500 km) and the site of some of the most productive fisheries on earth. Much of the lower trophic level research on the SE Bering Sea Shelf has focused on the role of the spring diatom bloom as the main production event. However, substantial production occurs outside of the short spring bloom that must fuel the developing stages of juvenile fishes and their copepod prey. Examining community structure and lower trophic food web dynamics during summer is therefore important for understanding the drivers of high fish production and ecosystem responses to climate change. As part of a North Pacific Marine Research project, two cruises were made to the Middle Shelf Domain region in July 2000 and August 2001. During both time periods, most

phytoplankton were, as expected, <10 um in size; however, the species composition was quite variable. Surprisingly, cyanobacteria and picoeukaryotes were significant at some stations, and both dinoflagellates and ciliates were observed to graze on these picoplankton. No massive Emiliania huxleyi bloom was observed on either cruise, although accumulations were found in restricted areas. At the station of highest coccolithophore concentrations, grazing of the <10 um fraction exceeded growth (0.25 d-1 vs 0.21 d-1). In August 2001, a persistent Rhizosolenia bloom was found at stations with elevated nitrate. The large diatoms were actively grazed (1.25d-1). Protistan grazers were abundant, with numbers and biomass dominated by heterotrophic dinoflagellates at most stations. The balance between grazing rates and growth rates of total and size-fractionated chlorophyll varied in time and space, but grazing was usually substantial (>70% of growth rate) even on the >10 um size fraction, indicating that summer production was tightly coupled to protistan consumption.

### OS31D-71 0830h POSTER

## Spatial Variability of the Annual Signal in Hydrographic Parameters Along the Seward Line

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Temperature, salinity, and density data along the Seward line in the northern Gulf of Alaska are analyzed for seasonal variability. The Seward line starts at the inner shelf (GAK1) and extends a distance of 213 km to the edge of the continental slope (GAK13). The hydrographic stations are spaced at varying distances ranging from 2 to 20 km. The temporal coverage is from October 1997 to April 2001 with approximately 7 cruises per year. Orthogonal reduction techniques, Normal Mode Analysis (NMA), and Empirical Orthogonal Functions (EOF) are used to find dominate seasonal spatial modes and to relate these variations to the seasonal forcing functions of heat flux, freshwater discharge and wind.

### OS31D-72 0830h POSTER

## Nitrate Sources and Sinks in the Shelf Waters of the Northern Gulf of Alaska

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Nutrient data collected in 1998 and 1999 from the northern Gulf of Alaska shelf as part of the Global Ocean Ecosystem Dynamics (GLOBEC) Gulf of Alaska Long Time Series Observation Program (LTOP) have provided preliminary data on the sources and sinks of nitrate to the shelf waters. Deep-water measurements provided evidence of a summer onshore flux of dense, nutrient-rich bottom water onto the shelf when the predominant downwelling regime relaxed. This seasonal flux created a reservoir over the inner shelf that was ultimately mixed into the upper water column through winter wind mixing. Calculations of vertical diffusion and surface Ekman transport indicated that vertical diffusion plays a much larger role in transporting nitrate to the upper shelf waters. Nitrate concentrations over the shelf in spring 1998 were notably lower than those measured in spring 1999 due to stronger stratification of the water column from above average freshwater inputs. Additionally, chlorophyll a concentrations over the shelf were higher in spring 1998. First order new production estimates revealed that for the time periods March-July 1998 and March-August 1999, nitrate utilization was highest over the inner shelf, with 1998 being higher than 1999. More precise measurements were made through the use of an in situ nitrate instrument that was integrated into a biophysical moorring deployed on the inner shelf. This data displays the drawdown of nitrate throughout the spring and the constantly low nitrate concentrations throughout summer with short periods of enrichment from storm events. Overall, it is apparent from this data that new production is an important element for supporting the grazing populations that resident in the study area.

### OS31D-73 0830h POSTER

## Effects of different nutrients on the nutrient uptake rates and species composition of summer phytoplankton in the southeastern Bering Sea shelf during 2000

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We investigated the effects of different nutrient treatment on the biomass, nutrient uptake rates, and species composition of the summer phytoplankton community in the southeastern Bering Sea shelf during June 2000. Seawater for the experiments was collected at the 50% light level depth using Niskin bottles and transferred into 10L polycarbonate carboys. The carboys were treated with different nutrients (control, $NO_3$, $NH_4$, $NO_3$+$SiO_4$, $NH_4$+$SiO_4$, and $SiO_4$). Nutrient concentrations decreased generally with time except for $SiO_4$. SiO4 concentration remained constant for all treatments throughout the experiment. In vivo fluorescence increased with time in most treatments but remained constant in the control and silicate treatments. Fluorescence reached maximum values earlier in the ammonium treatments than in the nitrate treatments. Flagellates were the dominant phytoplankton species at the termination of all treatments. The relative abundance of diatoms was high in the nitrate treatments compared to the ammonium treatments. POC and PON increased with time in most treatments except for the control and silicate treatments. The slopes of the increase of POC and PON were higher in the ammonium treatments than in the nitrate treatments but maximum values of POC and PON did not differ. Carbon uptake rates reached a maximum at day 2 in the ammonium treatments and showed a maximum between day 3-4 in the nitrate treatments. High nitrate and ammonium uptake rates were observed in the nitrogen treatments and maximum nitrate and ammonium uptake rates occurred at day 3-4. These results showed that the phytoplankton community over the middle domain of the southeastern Bering Sea shelf dominated by flagellated during summer. Primary production is limited by the depletion of nitrogen in the upper layer. The addition of nitrogen compounds in the carboys stimulated the carbon and nitrogen uptake rates of phytoplankton and increased the total biomass. The effects of different nutrient treatments resulted in different species compositions of the summer phytoplankton community over the middle shelf of the southeastern Bering Sea shelf.

### OS31D-74 0830h POSTER

## Preliminary Observations on Chlorophyll a and Primary Productivity Distributions Obtained During the Gulf of Alaska GLOBEC Monitoring Program.

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As a part of the GLOBEC monitoring program for the Gulf of Alaska, chlorophyll a distributions were monitored from October 1997 through December 2001. These collections were obtained during the months of March, April, May, July or August, October, and December. Collection times were chosen to provide an opportunity to observe the seasonal and inter-annual variations in phytoplankton standing stock associated with changing nutrient concentrations and hydrographic conditions. Fluorescence patterns and chlorophyll a distributions suggest increased phytoplankton concentration in the early spring, extending throughout the water column. In April, phytoplankton concentrations were enhanced over the inner-shelf and shelf-break regimes. By late summer, standing stock estimates were highest in a sub-surface layer extending across the entire shelf. Primary production estimates using conventional stable isotope protocol have been analyzed for an eight-month period. These data have provided a preliminary look at the concentrations and distributions of phytoplankton pigments and activity across this dynamic down-welling shelf.

### OS31D-75 0830h POSTER

## Distribution of Zooplankton Communities Relative to Hydrographic Features in the Northern Gulf of Alaska

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The cross-shelf distribution of zooplankton on the northern Gulf of Alaska shelf in May 1998, 1999 and 2000 was related to the distribution of water properties on the shelf. Conditions which promoted a distinct shelf-break front resulted in distinct zooplankton communities. Multidimensional scaling grouped stations by the species composition and developmental stages of the zooplankton taxa. When a strong front was present, distinct station groupings were observed. The dominant taxa within the groupings were related to the origin of the water mass: Alaska Stream, Shelf, Coastal Current or fjord-estuary. The water masses were identified primarily by salinity, secondarily by temperature. The cross-shelf distribution of water masses was also identified by SeaWifs images of the chlorophyll distribution. When distinct zooplankton communities were present, the satellite image revealed sharp boundaries between regions of high and low chlorophyll concentrations. The intensity of the shelf break frontal boundary was related to the position of westward propagating eddies off the shelf break. The time scale of small eddy propagation past the Seward Line (off Resurrection Bay, Alaska) was on the order of days to weeks. The timescale for large eddies propagating past the Seward Line was on the order of weeks to months.

### OS31D-76 0830h POSTER

## Revealing Cross-Shelf Exchange Patterns in the Northeast Pacific Ocean Using Natural Stable Isotope Abundance During SEA and GLOBEC

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The combination of a natural-occurring cross-shelf stable isotope gradient and the interzonal nature of life history staging by Neocalanus copepod species creates a scenario whereby cross-shelf movements of individuals can be reconstructed from their isotopic composition. When actively feeding in surface waters, the majority of individuals from a given hydrographic station, or an aggregate from several stations within an area, had consistent isotopic signatures. However, a small number of individuals from a given area had isotopic values more similar to those from outside the area. Furthermore, a significant portion of copepods in diapause (over-wintering resting phase just prior to reproduction) within deep portions (greater than 400 m) of Prince William Sound (PWS) were isotopically diagnostic for originating offshore, on the Gulf of Alaska shelf (GOA). The fraction of GOA copepods diapausing within PWS with varied from year to year. Fish isotopic signatures paralleled those observed in diapausing copepods. In 1995, there were concomitant isotopic shifts across several taxa such that copepods diapausing within PWS were nearly all of GOA origin while most juvenile herring and pollock from PWS had GOA carbon isotope signatures.

### OS31D-77 0830h POSTER

## Seabird Distribution and Abundance in the Northern Gulf of Alaska in Relation to Physical Hydrography

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We studied the distribution and abundance of eight seabird species (common murre, glaucous-winged gull, black-legged kittiwake, northern fulmar, laysan albatross, black-footed albatross, fork-tailed storm-petrel,

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and tufted puffins) in the Northern Gulf of Alaska, in relation to the distribution of water masses and acoustic measures of water column volume scattering. We surveyed a 200 km transect (inner-shelf, mid-shelf, shelf break, and oceanic domains) during April, May and July 2001 along the Seward line. Stratification increased seasonally due to surface layer freshening, and warming of the shallow mixed layer ($\sim$ 10-20 m) along the Seward Line in July. Diversity and abundance were low in April and high in May and July. Highest seabird concentrations occurred at the shelf break in April and May, and on the mid-shelf in July. Evolution of the physical properties of the water column in association with changes in volume scattering along the transect suggests that the cross-shelf circulation may have a fundamental role in shaping the distribution and abundance of seabirds.

### OS31D-78 0830h POSTER

### Preliminary Data on Euphausiid Distribution and Growth in the Northern Gulf of Alaska.

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Seasonal and interannual variability in distribution and population structure of two major euphausiids species Thysanoessa spinifera and Euphausia pacifica were studied in the northern Gulf of Alaska in 1998-2001. Other common euphausiid species were T. inermis, T. longipes, T raschii and T. inspinata. Euphausiid aggregations were related to water mass properties with E. pacifica frequently observed on outer shelf during years, when a strong shelf break front was developed. In contrast, T. spinifera was more abundant on inner shelf in spring . Individual euphausiid growth rates were minimal in early spring, showing indications of body shrinkage under unfavorable food conditions. Intermolt periods were ranging from 12 to 7 days in average as temperature varied from 5oC to 10oC over sampling season. Reproduction of T. spinifera seemed to coincide with the phytoplankton bloom in spring, while E. pacifica continued to spawn from May through October. Egg production rates of E. pacifica tended to be higher in mid summer.

### OS31D-79 0830h POSTER

### Importance of Nutrient-Foodweb Dynamics of Freshwater Ecosystems in Determining Sockeye Salmon Production

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The number of adult salmon allowed to escape for spawning has fundamental significance for productivity and recruitment of sockeye salmon. In addition, sockeye lakes are fertilized and stocked with sockeye fry to compensate for reduced nutrient loading from salmon carcass or for low smolt production. In this presentation, we will discuss how the changes in nutrient loading and fry density, associated with variable escapements, fertilization and fry stocking, can potentially affect the productivity of sockeye salmon. We demonstrate the importance of nutrient-foodweb relationships in determining the patterns of long-term changes in the growth and production of juvenile sockeye salmon. We use a large data set on nutrients, algal biomass, size-distribution, biomass and composition of zooplankton, and the density and size of the juvenile and smolts of sockeye salmon from Alaska. Specifically, we show how the variable escapement and associated changes in nutrients and fry density could potentially change the size distribution, composition, and biomass of zooplankton, and their relationship with the growth and production of sockeye smolts. Nutrients are most effective in producing large-sized smolts when large filter-feeding zooplankton such as Daphnia are present in substantial numbers. Escapement or fry stocking beyond the carrying capacity of sockeye systems dampen the impact of nutrients on the growth and associated size of smolts produced.

### OS31D-80 0830h POSTER

### On the microbiogeophysiochemistry of intermittently anoxic fjords on Vancouver Island, British Columbia

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Barkley and Clayoquot Sounds, along the outer coast of Vancouver Island, BC, have numerous fjords containing semi-permanent anoxic bottom waters with renewal time that range from seasons to decades. Within the framework of providing undergraduate research experiences, we have combined approaches from organic geochemistry, microbiology and physical oceanography in order to assess the health and function of these unique coastal environments. In this poster we will present the results from the first two years of a five year project. During 2000, the visited inlets were all anoxic, yet during the summer of 2001 many of the inlets turned over, resulting in large fish kills and large scale changes to the water column and sedimentary systems. Both the preservation of organic materials in the sedimentary record and the growth activity of heterotrophic watercolumn bacteria reflect the physical conditions of the varous fjords. See also: Grocock and Keil, Preservation of Terrestrial and Marine Organic Matter in an Intermittently Anoxic Coastal Fjord; Effingham Inlet, BC.

URL: http://boto.ocean.washington.edu/aog

## OS31E HC: Hall III Wednesday 0830h

## Linking Modern and Past Biogenic Fluxes III

*Presiding:* **R Francois,** Woods Hole Oceanographic Institution**; R A Jahnke,** Skidaway Institute of Oceanography

### OS31E-81 0830h POSTER

### Organic Matter Burial in Modern and Ancient Sediments of the Northern Gulf of Mexico

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The accumulation of terrigenous and marine organic matter (OM) in the northern Gulf of Mexico throughout the Holocene is examined using stable carbon isotopes and terrigenous biomarker analyses. The stable carbon isotope composition of sedimentary OM at the base of the Mississippi Canyon (27.96°N, 89.47°W) ranges from -20 $^{o}/_{oo}$to -23 $^{o}/_{oo}$during the late Holocene. Enriched isotopic composition at ca. 1000 ybp coincides with lower C/N ratios and greater calcite content (%CaCO3), indicating an increase in marine OM input during this time. The isotopic variation prior to 1000 years is not accompanied by a shift in %CaCO3 nor in C/N, suggesting that marine OM input alone does not explain the isotopic variability throughout the record. Preliminary analyses of lignin, a terrigenous biomarker, indicate that changes in the flux and composition of terrigenous OM have occurred during the late Holocene, and may explain the fluctuation of stable carbon isotopes at this site. The isotopic composition of sedimentary organic matter deposited in the Pigmy Basin (27.20°N, 91.41°W) varies between -22 and -26 $^{o}/_{oo}$. Calcite content is higher at this location than in the Canyon (12 to 25%CaCO3), but is less variable downcore. Carbon to nitrogen ratios range between 4 and 12 in sediments deposited within the past 3000 years, but little variability is observed in early Holocene sediments. Quantification of terrigenous and marine OM content, based on isotopic and terrigenous biomarkers, will provide more detailed information regarding the relative importance of marine and terrigenous carbon input throughout the Holocene. The processes responsible for the observed isotopic trend, such as changes in terrigenous vegetation, will be evaluated using lignin content and composition.

### OS31E-82 0830h POSTER

### Phosphorus Distribution in Oceanic Particulate Matter

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Despite the recognition of the importance of phosphorus (P) in regulating marine productivity in some modern oceanic systems and over long timescales, P cycling within the ocean is not well understood. The major carrier phase of P to marine sediments is likely particulate organic matter, although few direct measurements of particulate P flux in the oceans have been made. Little is known about the distribution of P within different fractions in marine particulate matter, and how it differs from P in sediments.

We analyzed particulate matter from sediment traps for their P concentration and association. Samples represent 3 different oceanic regimes: a coastal environment (Monterey Bay), an open ocean environment (Equatorial Pacific), and a polar environment (Ross Sea) as well as different depth (300-4000 m), and temporal (seasonal to annual) distributions. Reactive P concentrations, defined as the sum of oxide-associated and labile organic (includes P sorbed to and incorporated in oxyhydroxides as well as any P associated with labile organic matter), authigenic (authigenic carbonate fluroapatite), and acid-insoluble organic P, range from 13-36 $\mu$mol P $g^{-1}$. These concentrations are of the same magnitude, but slightly higher than those found in recent sediments (9-24 $\mu$mol P $g^{-1}$). Particulate P values are consistent with loss of reactive P between the shallower sediment traps (26-36 $\mu$mol P $g^{-1}$, 1200 m) and the core top sediments, although the range of reactive P values from the deeper sediment traps (15-24 $\mu$mol P $g^{-1}$, 4000 m) is similar to the range in the sediments. P in the sediment traps is primarily composed of oxide-associated and labile organic P ( 32%) and acid insoluble organic P ( 36%) with lesser proportions of authigenic P ( 23%) and detrital P ( 9%). Reactive P in particulate matter likely represents a transitional distribution between very labile organic P present in the photic zone and authigenic P eventually buried in the sediments, with some P lost to regeneration in the water column. These associations of P should be considered when interpreting P cycling in the oceans and burial in the sediments.

### OS31E-83 0830h POSTER

### Factors Controlling the Transfer of Organic Carbon to the Deep sea

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Particle fluxes measured with sediment traps deployed below 2000m at 11 sites in the North Pacific are combined with satellite-derived export production estimates in the overlying water to assess the factors affecting the transfer of particulate organic matter from surface to deep water. Multiple linear regression is used to derive an algorithm suggesting that the transfer efficiency of organic carbon, defined as the settling flux of organic carbon normalized to export production, increases with the flux of carbonate and decreases with water depth and f-ratio. The algorithm predicts more than 80 percent of the variability in organic carbon transfer efficiency at 43 additional sites from oceanic regions ranging from tropical gyres to the Antarctic and the Arabian Sea. The influence of the carbonate flux suggests that the ballasting effect of this biogenic mineral may be an important factor promoting export of organic carbon to the deep sea by increasing the density of settling particles. However, the lack of a similar effect for biogenic opal suggests that other factors, such as the hydrodynamic properties of settling particles, also play a role. The adverse effect of increasing