Hawaii. The results indicate shallow (~100-300 m) *in situ* N_2O production. Results of isotope mass balance models constrain the rate of N_2O production and the sea-to-air flux of N_2O. Results of an isotope mass balance model that takes into account the ratios of the vertical gradients in the isotopic abundances of N, O, N^a (central N) and N^b) (terminal N) of N_2O and the measured gradients of N_2O concentration through the thermocline, indicate that *in situ* production contributed 40% to 65% of the sea-to-air flux of N_2O. This model also predicts that the net sea-to-air flux of N_2O was at least 0.4 μmoles m^{-2} d^{-1} and most likely exceeded 0.7 μmoles m^{-2} d^{-1}. We present a new method for calculating N_2O production using the difference between the site preference (= $\delta^{15}N^a$ - $\delta^{15}N^b$) of atmospheric and dissolved oceanic N_2O and the rate of air-sea N_2O exchange. These results suggest a rate of N_2O production of 2.9±1.2 μmoles m^{-2} d^{-1} and indicate that shallow production contributed about 50% of the net sea-to-air flux of N_2O. These results can be used to better constrain the global N_2O budget.

OS21N HC: 316 C Tuesday 0830h

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

Presiding: **P T Strub,** College of Oceanic and Atmospheric Administration**; R M Letelier,** College of Oceanic and Atmospheric Sciences

OS21N-01 0830h

Characteristics and Forcing of the Spring Transition off California

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Fortuitously timed physical observations on a grid of stations off California during March 1995 and repeated the following month captured a dramatic shift from late-winter to spring conditions. The initial period was characterized by a broad coastal zone with weak eddying flow, while the main California Current jet meandered approximately 300 km offshore. While the same dynamic pattern persisted in the offshore region in April, a well-organized equatorward coastal jet had developed, creating strong zonal gradients in temperature and salinity. These observations suggest that the California Current along this part of the coast is regenerated in spring as a coastal upwelling jet that subsequently broadens to join or supplant what had been the main jet. The evolution of this pattern due to local and large-scale wind forcing is examined, and the implications for the offshore and alongshore transport of biological material are explored.

OS21N-02 0845h INVITED

Mesoscale Structure in the Northern California Current System

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During spring and summer 2000, two mesoscale mapping cruises were carried out in the northern California Current System between 41.9 and 44.6N and offshore for 150 km. The primary measurement platform was a towed undulating vehicle equipped with a CTD, fluorometers, a multi-wavelength light absorption and attenuation instrument, and a PAR sensor. A shipboard ADCP measured water velocities and a bio-acoustics instrument measured multi-frequency (38, 120, 200, 420 kHz) backscatter. Surface drifter trajectories and satellite SST imagery provide context for the mesoscale maps. A variety of wind regimes were encountered from strong upwelling to strong downwelling. The data provide good examples of flow-topography interaction including the influence of a major submarine bank and a large coastal promontory on the eastern boundary current circulation. Early in the season the upwelling front and jet followed the bottom topography fairly well. There was cold water inshore of the shelfbreak all along the coast with pockets of elevated biomass (chl up to 4 mg m^{-3}) near the coast. Mesoscale activity was minimal. During the summer cruise, the upwelling front and jet were much more convoluted including major meanders offshore associated with Heceta Bank and Cape Blanco. High levels of phytoplankton biomass (chl in excess of 10 mg m^{-3}) were found over Heceta Bank and near the coast south of Cape Blanco. The large offshore meander near Cape Blanco carried cold, nutrient-rich, high phytoplankton biomass (chl of 2-4 mg m^{-3}) away from the coast over 100 km offshore. Details of the physical and biological structure of the meanders will be presented.

URL: http://damp.oce.orst.edu/globec/nep

OS21N-03 0910h

Bio-Optical Patterns Within the Mesoscale Structure of the Northern California Current System

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Mesoscale mapping of the hydrographic and bio-optical properties of the Northern California Current System was conducted during spring and summer 2000 between 41.9N and 41.6N off the Oregon coast. A towed, undulating vehicle carried a CTD, two fluorometers, a multi-wavelength absorption and attenuation meter (ac-9), and a PAR sensor. In addition, an ac-9 and a Fast Repetition Rate fluorometer (FRRf) collected bio-optical data on surface waters throughout the mesoscale surveys. Multiple onshore-offshore transect lines provided repeated crossings of velocity jet and frontal boundaries, and allowed resolution of physical and bio-optical parameters on horizontal scales of 1km or less and on vertical scales of 1-2m. Our results permit assessment of the linkages and the degree of coupling between physical and bio-optical patterns during strong upwelling and strong downwelling events, as well as during low-wind relaxation intervals. The location of the coastal jet and the upwelling front fluctuated considerably under the variable forcing regime, with more extensive mesoscale structure in all parameters in late summer relative to spring, as current meanders developed around subsurface topography (Heceta Bank) and moved offshore near Cape Blanco. Sharp horizontal gradients in autotrophic biomass were observed across the boundaries of the coastal jet and the upwelling front, with chlorophyll levels often in excess of 5 mg m^{-3} on the inshore side of the fronts. Horizontal gradients also were observed in the spectral slope of particulate absorption and attenuation as well as in the physiological properties of the autotrophic assemblages (as determined with FRRf). Details of the spatial correlations of physical and bio-optical parameters will be presented.

OS21N-04 0925h

Mesoscale zooplankton distribution and its correlation with physical and fluorescence fields in the California Current in 2000

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Surveys of zooplankton distribution were conducted in the California Current between 42.5N and 44.7N in spring and fall 2000 as part of the US GLOBEC Northeast Pacific Study to understand the effects of climate variability and climate change on the marine ecosystem. The study focuses on understanding how physical forcing affects the spatial and temporal distribution of zooplankton, and their correlation with physical and other biological fields. The survey was conducted using an Optical Plankton Counter (OPC) and a fluorometer mounted on a vertically undulating vehicle (SeaSoar). The processed OPC data provide a resolution of 4 m in the vertical, and 50 size classes of the Equivalent Spherical Diameter (ESD) between 250 mm and 16 mm. The results show the heterogeneity in zooplankton distribution. Zooplankton are highly abundant in nearshore areas where upwelling was the dominant physical feature, and less abundant in offshore regions. The correlation between zooplankton abundance and chl-a concentration is poor both horizontally and vertically. Taking advantage of zooplankton size spectra provided by OPC measurements, analyses of zooplankton sizes and productivity of zooplankton were conducted to further explore the correlation between physical fields, zooplankton size distribution and productivity.

OS21N-05 0940h

The Recent Northwest Baitfish Boom and Increased Salmon Ocean Survival

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Historical datasets indicate that Northwest baitfish abundance has fluctuated widely over the last 50 years and probably more. Salmon ocean survival has also fluctuated widely since records began. Since 1999 we have noted a marked increase in the number of baitfish (smelt, Northern anchovy, Pacific herring, and Pacific sardine) off Washington and Oregon. This increase appears to be related to decreasing ocean temperatures, changing zooplankton species and abundance, and decreased predator abundance. We hypothesize that baitfish abundance directly affects salmon ocean survival by acting as "alternative prey" for predators and thus decreasing predation rates. Long- and short-term fluctuations in oceanographic conditions that affect baitfish recruitment may be the mechanism that controls baitfish abundance and thus salmon marine survival. Global warming and other anthropogenic factors could directly affect future baitfish recruitment and thus the abundance of Northwest salmonids.

OS21N-06 0955h

Distribution, Growth, Origin, Trophic and Species Associations of Juvenile Salmonids in the Northern California Current Ecosystem

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Information is summarized on juvenile salmonid distribution, size, growth, stock origin, and trophic and environmental associations from the June and August 2000 GLOBEC cruises with particular emphasis on differences related to the regions north and south of Cape Blanco off Southern Oregon. Juvenile salmon were more abundant during the July-August cruise as compared to the June cruise and were distributed northward from Cape Blanco. There were distinct differences in distribution patterns between salmon species with chinook found close inshore in cooler water all along the coast. Coho salmon were rarely found south of Cape Blanco. The nekton assemblages differed significantly between cruises. June samples were dominated by juvenile rockfishes, rex sole, and sablefish, which were almost completely absent in August. The forage fish community during June was comprised of herring and

whitebait smelt north of Cape Blanco and surf smelt south of Cape Blanco. The fish community in August was dominated by Pacific sardines and jack mackerel. Significant differences in growth and condition of juvenile salmon indicate different oceanographic environments north and south of Cape Blanco. The condition index was higher in juvenile yearling chinook salmon to the south of Cape Blanco whereas condition was higher in juvenile coho to the north. Genetic mixed stock analysis indicated that during June most of the chinook salmon in our sample originated from rivers along the central coast of Oregon. In August, chinook salmon sampled south of Cape Blanco were largely from southern Oregon and northern California while north of Cape Blanco, most chinook salmon were from the Central Valley in California. Distance offshore and temperature were the dominant explanatory variables related to coho and chinook salmon distribution. These species consumed mainly juvenile fishes, euphausiids, decapod larvae, and hyperiid amphipods. Diet overlap by weight between juvenile coho and chinook salmon was high (> 80%) but was substantially lower between these salmon and other non-salmonid nekton.

OS21N-07 1030h

Columbia River Plume Fronts and Their Influence on Juvenile Salmonids

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Studies have shown that riverine plume fronts can be important to juvenile fish for their role in concentrating prey fields. A field study was conducted in May 2001 to examine the structure and propagation of Columbia River plume fronts, as well as their influence on juvenile salmonids. Over five days, two vessels followed successive greater-ebb plume fronts as they propagated away from the river mouth. Shipboard and helicopter-derived front-tracking maps showed similar front propagation patterns to those seen in SAR and AVHRR satellite observations under similar river flow, tides and coastal currents. The plume was strongly stratified, with a subcritical internal Froude number and a vertical salinity gradient typically ranging from 2-4 m^{-1}. At five hours past higher-high tide, 9 km offshore of the river mouth, the front was characterized by a strong surface across-front salinity difference, $\sim$12. Eight hours later, the seaward (western-most) part of the front was 33 km offshore, reflecting a mean frontal velocity of 3 km h^{-1} (0.8 m s^{-1}); the across-front salinity difference declined to 5. At this time, surface drifter measurements near the inshore end of the front in 40 m water depth indicated front-normal convergence was occurring at velocities of $\sim$0.25 m s^{-1} at 1 m depth on both sides of the front. ADCP current profiler measurements indicated that velocities were convergent at 5 m depth, but divergent in the lower water column. Surface convergence was compensated by downwelling, during some periods at 0.25 m s^{-1} or greater. Although there was convergence in the across-front velocity, the across-front shear in along-front velocity was strong, providing a mechanism for dispersing organisms along the front line.

Juvenile coho salmon were significantly more abundant in the front than in surrounding waters, while chinook showed no discernable pattern. Preliminary analyses show elevated concentrations of certain surface-seeking salmon prey within the front, likely a result of convergent currents and resistance of the organisms to downwelling. These results can be used to estimate the importance of plume fronts to juvenile salmonid growth, in terms of the percentage of outmigrating salmon exposed to the front. Because juvenile salmonid survival is linked to rapid growth, Columbia River plume fronts appear to play a positive role in salmon survival. Physical observations of these fronts from other cruises were also examined to determine how seasonal and interannual fluctuations in riverflow affect this feature.

URL: http://www.ese.ogi.edu/~jaylab

OS21N-08 1045h

Assessing Phytoplankton Biomass and Physiological Variability off the Oregon Coast as Part of the NEP GLOBEC Program

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The phytoplankton community structure off the Oregon coast is characterized by high temporal and spatial variability. The extent to which this variability results from physical forcing, ecological strategy, and physiological adaptation is not well understood. As part of the North East Pacific (NEP) Global Ocean Ecosystems Dynamics (GLOBEC) program we use high resolution physical (temperature, salinity), biomass (fluorescence) and physiological (sea surface Fast Repetition Rate Fluorometry - FRRF) properties to determine and characterize the physical and ecological factors forcing temporal and spatial variability in the biological community in a coastal region extending 60 km offshore. Nighttime portions of east-west transect lines from our May 2000 GLOBEC cruise display high nearshore variability in all parameters. The level of variability decreases offshore. The optimal quantum yield of photosynthesis, as derived from FRRF measurements falls into two distinct patterns offshore. These patterns are correlated with two distinct water masses. Analyses of the data in the temperature-salinity domain (T-S plots) suggest that, while nearshore variability is correlated with changes in upwelling strength, offshore communities are affected by the relative amount of Columbia River water. The data set also allows comparisons of latitudinal and seasonal variability within this upwelling system.

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

OS21N-09 1100h

Comparison of Acoustic and Net Sampling Systems to Determine Distribution Patterns of Zooplankton Biomass and Taxonomic Groups

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Spatially and temporally coincident data were collected from a 6-frequency TAPS (Tracor Acoustic Profiling System) and a $1m^2$ MOCNESS as part of the COAST project (Coastal Ocean Advances in Shelf Transport). The combined net/acoustic tows were conducted over the Oregon continental shelf in August, 2001, during both day and night. The TAPS (265, 420, 700, 1100, 1850, 3000 KHz) was mounted on the upper frame of the MOCNESS and ensonified a volume of water directly in front of the net mouth. A 4-frequency (36, 120, 200, 420 KHz) HTI acoustic instrument with down-looking transducers was towed off the port side of the ship during the MOCNESS/TAPS tows providing volume backscatter measurements with 1 m vertical resolution. Preliminary analysis suggests that finescale distributions of zooplankton that were integrated within a sample depth strata of the MOCNESS were resolved acoustically. We will present comparisons of the distribution patterns of zooplankton biomass and taxonomic groups as determined by each of these systems.

OS21N-10 1115h

Mesocale zooplankton productivity in the NEP region in May and August 2000

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Zooplankton (mainly copepods and Euphausids) have been collected off the Oregon coast in May-June and August 2000. Cross shelf variation in the ingestion rates are expected as well as strong relationship with the phytoplankton (Primary production)level. Information collected at the same time on the egg production, as well as on several other metabolic rates will allow us to understand the impact of the zooplankton in this particular oceanic region.

OS21N-11 1130h

Factors Affecting the Structure of the Zooplankton Community off the Central Oregon Coast, USA, 1998-2000

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Although productivity in upwelling systems around the world is well studied, it is not clear which processes influence zooplankton community structure. From previous descriptive work off the central Oregon coast, we know that the nearshore zooplankton community composition is related to circulation patterns–during summer when equatorward flows prevail, the summer zooplankton community is dominated by boreal species; during winter when poleward flows prevail, the zooplankton is dominated by subtropical species. To more formally explore patterns in zooplankton community structure, we used cluster analysis, NMS ordination, and Indicator Species Analysis to examine seasonal, El Niño/La Niña, and onshore/offshore differences in community composition. For this study, hydrographic, nutrient and zooplankton data were collected off Newport Oregon (44.7°N) at nine stations between 1 and 65 miles from shore (30 to 2900m water depth). From 1998 until present, cruises have been conducted seasonally as part of the U.S. GLOBEC NEP LTOP. Zooplankton were collected by vertical lifts of a 202μm, 0.5m diameter net; 15 cruises have been analyzed for zooplankton to date.

The 1997/98 El Niño played an important role in structuring the zooplankton community off Oregon from the beginning of our sampling in Jan 1998 through Nov 1998. The "El Niño" community identified by cluster analysis and NMS was highly diverse and comprised of a number of usually uncommon taxa and was characterized by a shift in dominance of taxa. The "El Niño" community was followed by a "Transition" community with slightly lower diversity; the Transition community existed through the spring of 1999. By summer 1999, conditions had returned to "normal."

Summer upwelling strongly affected the structure of communities in 1999 and 2000, leading to differences between nearshore and offshore groups. The zooplankton community sampled on the continental shelf during summers was unique when compared with both the offshore summertime community and the community present during winter and the El Niño. During winters 1999 and 2000, the zooplankton community did not show strong longitudinal variation; the community sampled during winter was similar to the summer offshore community.

OS21N-12 1145h

Determination of Age Structure, Nutritional Status and Potential for Trophic Transfer in the Euphausiids *Euphausia pacifica* and *Thysanioessa spinifera* using Multiple Organic Tracers

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Euphausiids (krill) serve an important role in several marine ecosystems as a link between primary producers and top predators, particularly for the commercially important fisheries of the Northeast Pacific. Cellular peroxidation products (collectively termed lipofuscins) and lipid biomarkers were used to determine the population age structure and nutritional condition

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of the two major euphausiid species as part of the NEP-GLOBEC program in the spring and summer 2000. Lipofuscins were extracted from neural tissues (eye and eye-stalk), quantified, and normalized to protein content to allow comparisons across species and animal sizes. Multiple fluorescent components from krill were observed with the major product having a maximum fluorescence at excitation of 350nm and emission of 470nm. Field-collected krill contained variable levels of lipofuscins dependent on size. Total lipid content of seston (as potential diets) ranged from 25 to 108 (mg/g dry weight) with krill 50 to 152 (mg/g dry weight) and both mainly composed of phospholipids. The fatty acids 16:0, 18:1(n-9), 20:5, and 22:6 were major components in krill and showed only minor shifts between seasons and over spatial scales. In seston, the 16:1(n-7), 16:0, 18:1(n-9), and 18:0 were important fatty acid components and showed significant seasonal and spatial compositional changes. Polyunsaturated fatty acids such as 20:5 (rich in diatoms) and 22:6 (rich in dinoflagellates and chrysophytes), known to be essential fatty acids for the growth and development of fish larvae and juveniles were absent or were at low in seston from offshore stations. Cholesterol was the dominant sterol in all animals (up to 89% of total sterols), with furcilia also containing a number of other sterols from dietary sources. A suite of 15 other sterols was found in seston, a number of which represent specific algal taxa. These results suggest that lipofuscin can be measured among individual krill, and that animals may show ontogenetic changes in lipid composition with age.

OS21O HC: 319 A Tuesday 0830h

Biogeochemical Linkages Between Rapidly Urbanizing Coastal Watersheds and the Coastal Ocean I

Presiding: **E H De Carlo,** University of Hawaii at Manoa**; K J Spencer,** Los Alamos National Laboratory**; F T Mackenzie,** University of Hawaii

OS21O-01 0830h INVITED

The Role of Monsoon and Typhoon Rains in Nurturing Shelf Productivity

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Stretching from northeast Africa and India to east Asia and north Australia lies a vast area highly influenced by both monsoons and typhoons/hurricanes, and naturally many aspects of the oceanic environments of the north Indian Ocean, the East and South China Seas and the many seas of Southeast Asia are no less affected. Torrential rains accompanying southwest monsoons and typhoons, although often raising havoc on many coastal areas, are for the most part greatly welcomed by farmers as these nurture the frequently parched land at the end of the dry, northeast monsoon season.

It is well known that the southwest monsoon induces upwelling of nutrient-rich subsurface waters off the eastern coast of a land mass, such as that off Somalia, the Arabian Peninsula and Viet Nam. In so doing, biological productivity is enhanced. Off the western coast, on the other hand, the southwest monsoon normally induces downwelling, but here it is shown that the increased buoyancy forcing brought on by a larger runoff in the wet season also seems to have induced a weak upwelling off Sarawak, Sabah and Brunei Darussalam despite unfavorable wind conditions. In other words, monsoon rains also appear to nourish the coastal oceans regardless of the direction of the prevailing winds. As a result, nutrient concentration increases, while pCO2 decreases presumably due to higher primary productivity. Similarly, coastal downwelling was seen to shift to a clear upwelling, and primary productivity was found to increase off northwestern Taiwan after a typhoon passed, perhaps also due to the enhanced buoyancy effect.

OS21O-02 0850h INVITED

Anthropogenic drivers of nutrient cycling in the coastal waters of Southeast Asia

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Major economic activities in four coastal watersheds in Southeast Asia were assessed for their impacts in terms of nutrient waste generation, their contribution to nutrient loading into and the resulting metabolic state of associated coastal basins. The study areas included a section of the Red River Delta (Viet Nam), Bandon Bay (Thailand), Lingayen Gulf (Philippines), and the Merbok Estuary (Malaysia). Nutrients released by economic activities were estimated using an economic input-output modeling approach. Non-conservative fluxes of dissolved inorganic nitrogen and phosphorus (DIN, DIP)and system metabolic states were quantified using the LOICZ Biogeochemical Modelling Guidelines (Gordon et al. 1996)

Results indicate that agriculture contributed the most to the total DIN (20-80%) and to the total DIP (20-80%) coming from economic activities in the watershed. In the two sites (Ban Don Bay and Lingayen Gulf) where the household sector was endogenized as an economic sector, sewage was shown to contribute 15-20% of total DIN waste and 15-50% of total DIP waste. An index ratio between generated nutrient waste and total nutrient loading, where 1 indicates highest anthropogenic impact to receiving coastal waters; values $>$ 1, high assimilative capacity; and values $<$ 1, high loading and high impact from natural sources, was used to compare anthropogenic influence on nutrient (DIN, DIP) loading. The Red River Delta showed highest buffering capacity followed by the Merbok Estuary. Lingayen Gulf received the most impact from human generated waste. Ban Don Bay showed the most pristine condition in that loading from natural sources exceeded anthropogenic waste by a factor of 6 in the case of DIN. Except for the Merbok Estuary, all three basins were net autotrophic.

The protocols used in this regional study indicate prospects of assessing anthropogenic influences on biogeochemical cycling in coastal waters using relatively simple but robust approaches that are amenable to iterative validation. Scientists in both developed and developing countries can use these in evaluating their study sites, thus allowing for more sound comparisons across wider areas.

OS21O-03 0910h

Climatic Regulation of Water and Nutrient Export from a Coastal Watershed to the Coastal Waters in Barkley Sound, British Columbia, CANADA

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In recent years, pressures to develop watersheds in the Canadian pacific region have intensified. The Land-to-Oceans Project is a new initiative that seeks to improve our understanding of coastal watershed processes to their impacts on the coastal ecosystem. Specifically, the objectives of the Land-to-Oceans Project are to develop a coastal watershed model that predicts the export of water and nutrients that can be scaled to other coastal watersheds in the Strait of Georgia and along the western coast of Vancouver Island; and to explore linkages between changes in Land Use or Land Cover (LU/LC), changes in loadings of dissolved and particulate organic matter from the watersheds to the coastal zone, and the patterns of growth and toxicity of harmful algal blooms. Our initial focus has been on the Carnation Creek watershed, the focus of harvesting experiments over the past 30 years, which drains into Barkley Sound along the west coast of Vancouver Island. In this watershed, the climate is complex, with multi-temporal climatic oscillations including El Nino, La Nina and the Pacific Decadal Oscillation, and thus, the natural variability in hydrological linkages between the watershed and the coastal waters had to be established before the potential impacts of LU/LC changes could be considered. A coastal watershed model was used to establish the relationship between return period (ranging from 1 to 100 years) and peak discharges and, in turn, the relationship between peak discharges and their contributing source areas within catchments of the watershed. A comparison of these relationships for natural and disturbed conditions indicated that LU/LC activities resulted in an increase in: (1) number of peak flows; (2) magnitude of smaller peak flows ($<$ 1 yr return period); and (3) magnitude of associated surface saturated areas. These relationships and associated maps provide simple management tools that can be used to minimize the potential impacts of harvesting activities. By introducing the concept of risk (as defined by the return period) into harvest plans, the climatically-influenced susceptibility of catchments to changes in the distribution of surface saturated areas and the frequency and magnitude of peak flows to harvesting practices may be evaluated. By understanding the climatic controls on the contributing source areas of water to the stream, we can extend the coastal watershed model to predict the export of water-soluble nutrients, pollutants or contaminants to coastal waters.

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Nutrient Loading as Reflected by Tissue N and P Concentration of Three Marine Macrophytes

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Mesocosm experiments were used to determine the relationship between nitrogen (N) and phosphorus (P) loading and the resulting tissue nutrient content (percent dw) of eelgrass shoots (Zostera marina), and two species of macroalgae, Ulva lactuca and Gracilaria tikvahaie. Data were combined from two experiments in which treatments consisted of high N and high P loading (HNHP), high N and low P loading (HNLP), low N and low P loading (LNLP) and controls with no added nutrients. Loading rates (mmol m-2 d-1) for the treatments consisted of 8.24 N and 1.7 P in the HNHP, 8.24 N and 0.22P in the HNLP and 1.94 N and 0.15 P in the LNLP. Controls received 0.35 N and 0.11 P from incoming water and wet and dry deposition. The selected macrophytes from highly loaded (N or P) mesocosm treatments had significantly higher tissue nutrient concentrations than those from treatments with low loading or controls. N and P loading rates were significantly ($p<0.05$) correlated with tissue nutrients for all species during the summer months. The ranges in tissue concentrations in these species along with tissue nutrient concentrations from the literature were used to create a preliminary index of nutrient loading. The index and correlation analysis may provide valuable information for ecosystem modelers and managers.

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Chemical Indicators of Anthropogenic Nitrogen Loading in Four US Estuaries

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