AN ANALYSIS OF THE EFFECTS OF ENERGY SPREADING LOSS AND TRANSMISSION LOSS ON LOW FREQUENCY ACTIVE SONAR OPERATIONS IN SHALLOW WATER

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Energy Spreading Loss (ESL) is qualitatively defined as the reduction in peak power level due to energy spreading of a transmitted acoustic pulse in time. An analysis of the impact of bathymetric geometry and sediment type on ESL and TL associated with the Low Frequency Active/Compact Low Frequency Active (LFA/CLFA) sonar operations was conducted utilizing the FEPE, FEPE_SYN and EXT_TD programs to model the time spreading of the acoustic pulse due to multipath propagation in shallow water. Both a Blackman windowed pulse and a Continuous Wave (CW) pulse were used in this analysis. The Blackman pulse had a center frequency of 244 Hz with a bandwidth of 24 Hz. The CW pulse had a center frequency of 244 Hz with a bandwidth of 0.0625 Hz. Model inputs were a geoacoustic description of the Tanner flank region off the coast of San Diego and a typical late summer sound speed profile taken from the MOODS database. ESL and TL's impact on low frequency active sonar operations was determined as a function of bathymetry, sediment type, sound speed profile, and pulse length. The results showed that ESL is inversely related to pulse duration and at low frequencies is relatively uninfluenced by sediment type. When pulse lengths were reduced to less than 1 second, ESL became appreciable **(** >6 dB one way) and was an important segment of the active sonar equation. TL was found to be the dominating factor in LFA/CLFA operations for pulse lengths greater than 1 second and was greatly influenced by sediment type and sound speed profile.

ICELAND-FÆROE FRONT STRUCTURE AND VARIABILITY

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During the period June 1991 to August 1993, 107 Argos-tracked drifters, drogued to 15m depth, were released in the Greenland, Iceland, and Norwegian (GIN) Seas. The drifter movements revealed the strong and spatially confined current systems along the Iceland-FÆeroe Front (IFF) and provided tracking of the Norwegian Atlantic Current and the general cyclonic gyre circulation in the GIN Sea.

Of the 107 drifters released, 59 were selected for this study due to their proximity to the IFF. Tracked by the Argos system aboard the NOAA polar orbiters, the drifters provided accurate location and sea surface temperature (SST) data. Interpolated and low-pass-filtered position data were used to construct maps of drifter displacement and surface velocity field estimates and to study the correlation between drifter trajectories and satellite-derived SST frontal features.

Drifter SST data were compared to spatially and temporally coincident satellite retrieved SST data. The individual data sets were in good agreement with each other, resulting in a temperature difference of less than 1^0C. Satellite imagery used to estimate surface currents through SST feature tracking provided a snapshot of the flow field over a short time scale.

The drifters revealed a distinct frontal zone (DFF) where the topographically steered flow field approached velocities of 1 m/s. This relatively strong flow became unstable as it propagated eastward and an intense eddy field developed. What began as a stable demarcation between water masses became a flow field dominated by warm and cold instabilities and intrusions. This dynamic transformation occurred over relatively short time (less than 5 days) and distance (several hundred kilometers) scales, testament to the vigorous activity in the IFF. These Lagrangian drifter measurements compose the first comprehensive, accurate near-surface velocity data set in the IFF region.

CHARACTERIZATION OF OSCR HF RADAR DATA IN MONTEREY BAY

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A 53-hour long record of surface current data from the OSCR HF radar system was gathered over Monterey Bay on 6-8 May 1995. In this study,OSCR data is evaluated with regard to semidiurnal (M2) and diurnal (Kl) tidal period fluctuations, the seabreeze, seabreeze influenced flow, and both standard and cannonical-day mean flow patterns. The OSCR data is considered on its own and in comparison to similar data types previously gathered by CODAR, a previously established Monterey Bay HF radar system. Two of three CODAR sites were co-located with the two OSCR sites.

Internal wave influence is observed in the M2 tidal constituent analysis and the seabreeze greatly influences fluctuations of the K1 tidal period. Results from analysis of OSCR data replicated or reinforced data and results from the CODAR system. Initial OSCR data appears not to have been significantly affected by possible distortion of the phased-array beam patterns. However, contamination of OSCR returns by simultaneous activation of the CODAR systems is apparent in the data.

ADRIATIC SEA CURRENT OBSERVATIONS USING ACOUSTIC DOPPLER CURRENT PROFILER (ADCP) MEASUREMENTS

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The measurement of absolute subtidal currents throughout the water column is a complex task, especially with the presence of strong high frequency events that continuously perturb the mean flow patterns. Shipboard Acoustic Doppler Current Profiler (ADCP) instruments provide a quick, easy way to measure currents relative to an underway vessel. The goal of this work is to analyze and process six shipboard ADCP data sets to study the absolute mean subtidal Adriatic Sea currents. Horizontal charts and vertical sections are presented for the absolute currents. A comparison with historical data, concurrent drifter and moored current meter observations confirms the validity of the ADCP measurements. These current measurements update regional oceanic models, refine the knowledge of basin circulation patterns, and improve our knowledge on how this circulation affects the remainder of the Mediterranean Sea.

WIND-FORCED MODELING STUDIES OF CURRENTS, MEANDERS, EDDIES, AND FILAMENTS OF THE CANARY CURRENT SYSTEM

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A high-resolution, multi-level, primitive equation ocean model is used to examine the response of an eastern boundary oceanic regime to both wind forcing and irregular coastline geometry. The focus of this study is the coastal region from 30°N to 42.5°N, a portion of the Canary Current System (CCS). To study the generation, evolution, and sustainment of the currents, meanders, eddies and filaments of the CCS, the model is forced from rest using seasonal climatological winds. To investigate the role of irregular coastline geometry, the first experiment uses climatological wind forcing along an idealized "straightened" coastline, while the second experiment uses the same wind forcing along an irregular coastline. In both cases a surface current, undercurrent, meanders, eddies, and filaments are generated. The results obtained while using the irregu-

lar, rather than the idealized coastline, however, show preferred eddy generation locations as well as enhanced growth of meanders, eddies, and filaments. The features produced by the model are consistent with available observations of the CCS. The model results support the hypothesis that both wind forcing and irregular coastline geometry are important mechanisms in the generation of many of the observed features of the CCS.

DEVELOPMENT OF A LOW FREQUENCY AMBIENT NOISE STORM MODEL FOR THE ARCTIC OCEAN

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The development of an ambient noise model for use in ice-covered Arctic waters is the primary goal of this research. The generation of ambient noise is considered to originate from large scale deformation of the ice cover (pressure ridge formation) which is caused on a synoptic scale by convergence of the ice cover due to wind stress/speed associated with the passage of Arctic storms.

The Arctic Storm Noise Model (ASNM) has been developed as a dynamic model to predict the occurrence of extreme noise events. The emphasis is on accurately predicting the large increases or decreases in ambient noise, which observations have shown to be in the order of 20 to 30 dB over a matter of hours.

ASNM was adapted from the Ambient Noise Directional Estimation System (ANDES) for use under the Arctic pack ice. ASNM predictions are compared quantitatively to noise measurements made by ice-mounted drifting buoys in the Arctic basin during the early 1990's. Results showed that for extreme events (<5th or >95th percentile) ASNM is accurate in predicting both the level of ambient noise and the large increases in the noise record.

Due to the encouraging results further improvements are recommended to increase the robustness of the model for potential tactical use by submarine units operating under the Arctic pack ice.

TOWED ARRAY PERFORMANCE IN THE LITTORAL WATERS OF NORTHERN AUSTRALIA

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The goal of this research was to investigate the performance of low frequency passive sonars in the Arafura Sea. Sound speed profiles representative of the wet and dry monsoon seasons and geoacoustic data were inputted into a finite element primitive equation transmission loss model to model the expected propagation at three frequencies, 10, 50, and 300 Hz. Initial detection ranges for several source/receiver depth combinations and geoacoustic areas (deep/shallow water) were compared and evaluated. Results demonstrate that low frequency (~10 Hz) detection ranges suffer due to cutoff frequency problems and to surface–decoupling loss. Propagation in deep water has the added disadvantage of excessive loss of signal power due to spherical spreading considerations. Conversely, higher frequencies (300 Hz) provided extended detection ranges in shallow water due to trapping of energy within the entire 50 m to 100 m water column.

Additionally, investigation into advantages to be gained through advanced signal processing techniques shows that improvements of the order of 10 to 15 dB of detection gain are possible through the utilization of inverse beamforming.

VARIATIONS ON AUTOCORRELATION MATCHING AND THE SIFT LOCALIZATION ALGORITHM

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As part of the existing acoustic transient localization program, a feasibility study was performed to apply existing algorithms to signals at higher carrier frequencies. The coherent matching, autocorrelation matching and SIFT algorithms are time domain Matched Field Processing algorithms based on arrival structures for single hydrophone applications. In previous studies, these algorithms were employed only at lower frequencies using ray propagation models to create the replicas with varying success. This study is meant to investigate the performance of the algorithms at higher frequencies, using both the University of Miami Parabolic Equation (UMPE) Model and the Hamiltonian Raytracing Program for the Ocean (HARPO), to give insight into the previously unexplained inconsistent behavior of the algorithms at low frequencies, to improve and optimize existing algorithms, to point out improvements to existing eigenray extraction programs, and to suggest additional signal processing on the signal. Simulations are performed and synthetic signals are generated using both the HARPO and UMPE models. The arrival structures are investigated and the relation between features in the arrival structures for matching and the physical parameters are identified. Some insight into the performance of the SIFT algorithm is gained which relates matching and physical parameters. Simulations lead to improvements and optimization of the algorithms and give insight into the performance at higher frequencies.

MODELING THE PERFORMANCE OF THE PT SUR HYDROPHONE ARRAY IN LOCALIZING BLUE WHALES

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The acoustic activity of the blue whale is widely documented yet poorly understood. Hypotheses for its vocalizations range from communication, bathymetric echolocation, and echolocation of zooplankton masses. Although extensive documentation of frequency structure and duration exists, a long-term monitoring of where and when the vocalizations are being made must be accomplished to test the validity of these theories.

The Naval Postgraduate School (NPS) Ocean Acoustic Observatory (OAO), which operates a former Sound Surveillance System (SOSUS) at Pt Sur, presents itself as a potentially valuable tool in the detection and localization of Pacific blue whales. By estimating the transmission loss as a function of bearing, range, and frequency and synthesizing the ambiguity surface of various model-data linear correlation localization algorithms, an assessment of the array's expected performance for this purpose was obtained. Important findings of this modeling study include estimated maximum detection ranges are longer than 500 kilometers both seaward and along the continental slope due to array beamforming gains and matched field localization algorithms are accurate and robust in the presence of white noise. The application of the results of this study towards the development of a "real-time," large-area blue whale localization and tracking algorithm is promising.

TIME AND SPACE RESOLUTION AND MIXED LAYER MODEL ACCURACY

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The oceanic turbulent boundary layer is a critical region to understand for oceanic and atmospheric prediction. This thesis answers two fundamental questions: (i) what is the response of the ocean mixed layer system to transient forcing at the air sea surface? (ii) what is the necessary time and space resolution in an ocean mixed layer model to resolve important transient responses?

Beginning with replication of de Szoeke and Rhines' (1976) work, additional physical processes were added to include more realistic viscous dissipation and anisotropy in the three-dimensional turbulent kinetic energy (TKE) budget. These refinements resulted in modification of de Szoeke and Rhines' findings. First, TKE unsteadiness is important for a minimum of 10^5 seconds. Second, viscous dissipation should not be approximated as simply proportional to shear production. Third, entrainment shear production remains significant for a minimum of one pendulum-day.

The required temporal model resolution is dependent on the phenomena to be studied. This study focused on the diurnal, synoptic, and annual cycles, which the one-hour time step of the Naval Postgraduate School model adequately resolves. The study of spatial resolution showed unexpectedly that model skill was comparable for 1 m, 10m and even 20m vertical grid spacing.

DIURNAL VARIATION OVER THE TROPICAL MONSOON REGIONS DURING NORTHERN SUMMER 1991

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This study examines diurnal variation of convection over western India, the Bay of Bengal, Indochina and the northern South China Sea during the 1991 northern summer monsoon using combined Japanese (GMS) and Indian (INSAT) geostationary satellite data, ECMWF 850 hPa wind data, and NCEP sea surface temperature analyses.

The diurnal cycle is examined in terms of spatial and temporal structure prior to onset and during the monsoon. The northern South China Sea is examined to determine how different periods of synoptic influences resulted in an anomalously strong diurnal signal during June. The wind and Sea Surface Temperature (SST) data are used to examine the relationship between the diurnal variation of convection and both low-level convergence and vertical latent heat fluxes.

Convection over west India is most common during May and June and starts as a diurnal system over land that becomes organized and propagates westward over the east Arabian Sea. The Bay of Bengal follows the classic land-sea breeze model and convection is modulated by convergence between the land breeze and large-scale monsoon flow. The diurnal cycle is generally enhanced over the ocean during active phases of convective activity. The maximum latent heat fluxes generally occurs prior to maximum convection due to strong monsoon flow enhancing evaporation.

THE GENERATION AND CHARACTERIZATION OF SURF ZONE AEROSOLS AND THEIR IMPACT ON NAVAL ELECTRO-OPTICAL SYSTEMS

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Aerosols are generated within the surf zone by the breaking of waves along the beachfront. The concentration of aerosols, size, and structure of these plumes are impacted by the air/sea temperature differences, breaker type, and local winds. During the EOPACE I surf experiment at LaJolla, CA, it was observed that under light wind conditions, standing aerosol plumes would develop to heights of 31 meters. Concurrently, transmittance at FLIR wavelengths would be degraded up to 35%. Similar aerosol plume structures were observed during EOPACE II at Moss Landing, CA. These results are used to characterize and forecast standing plume conditions that may impact electro-optical transmission.

COMPARISON OF LOS ALAMOS NATIONAL LABORATORY (LANL) PARALLEL OCEAN PROGRAM (POP) MODEL FIELDS WITH PACIFIC SURFACE DRIFTER MEASUREMENTS

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Model fields from the Los Alamos National Laboratory (LANL) Parallel Ocean Program (POP) 1/6 degree global circulation model are compared to measurements from over 1300 satellite-tracked surface drifters that were deployed in the tropical Pacific (20N to 20S), between 1979 and 1994, during the TOGA Pan-Pacific Current Study. Geographic averages of 5-day averaged drifter velocity estimates for 2-deg. latitude x 8-deg. longitude bins are compared to similarly binned 3-day model snapshots from September 1992 to October 1994. Eulerian comparisons of the model mean velocities and their observed counterparts show that the model u mean is slightly higher in the equatorial region, while the model v mean is 50% greater in this region. Model SST mean values are 20% less than observed values in the eastern equatorial Pacific. Model variability is about 20% less than the observed quantity in equatorial regions, and 50% less poleward of l0S and 10N. Both model and observed velocity and SST covariance fields imply a net heat convergence toward the equator with the largest values in the region of instability waves north of the equator. Model velocity fields are used to produce simulated Lagrangian trajectories for uniform and nonuniform deployment strategies. Autocorrelation, time and length scales, diffusivity, and polarization are calculated and ensemble-averaged by 5 deg. latitude bands for comparison with drifter-based Lagrangian statistics. Time and length scales are too long and diffusivities too low compared to observations, but data sampling in the simulated fields was biased by trajectories that overlap current regimes. These differences, in both Eulerian and Lagrangian comparisons, may be related to the lack of a surface mixed layer, inadequate representation of wind forcing, still too coarse grid resolution, and deficiencies in simulating the mean structure of the density field in the model. They are also partly related to lack of weighted averages to account for non-uniform drifter sampling.

SET-UP UNDER A NATURAL WAVE

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Field measurements from a cross-shore array of two pressure sensors to measure waves and eight manometer tubes to measure mean water elevation are used to examine set-down/up across the surf zone. The manometer tubes are connected to differential pressure transducers onshore allowing continuous set-down/up measurements. Flume measurements of set-down/up are also examined. Measured values are compared with numeric set-up values incorporating roller theory describing wave breaking. The model has two free parameters, B representing the vertical fraction of the wave covered by the roller and y a scaling parameter for wave steepness. Optimal values of both are chosen by model fitting. Inclusion of the surface roller improves the set-up model fit to both beach and flume measurements.

MONITORING TEMPERATURE VARIABILITY ALONG THE CALIFORNIA COAST USING ACOUSTIC TOMOGRAPHY

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The electronic emissions of a low-frequency sound source placed by the Acoustic Thermometry of Ocean Climate (ATOC) project on Pioneer Seamount were monitored by a bottom-lying receiver on Sur Ridge from April 1996 to February 1997. The processed signals show a stable arrival pattern that was repeated in all the transmissions during the 11 months. Using the processed data, a tomographic analysis to study the coastal ocean variability along this California transmission path was conducted. Systematically, the analysis involved forward acoustic modeling of the arrival structure using ray theory, associating the observed arrivals with the modeled arrivals, extracting the travel times of the arrivals, inverting the travel times for temporal and spatial temperature changes, and interpreting the observed temperature variations. In particular, the tomographic estimate was compared to the temperature and wind measurements from an in situ mooring deployed by the Monterey Bay Aquarium Research Institution (MBARI). The comparison showed that the tomographic estimate is of high quality and that the observed temperature variations were linked to coastal upwelling and downwelling events. The data, methods, and result, demonstrating fully the feasibility of using tomography to study coastal temperature variability in central California on a long-term basis, are presented.

A SIMULATION STUDY OF ACOUSTIC VARIABILITY DUE TO INTERNAL SOLITARY WAVES ON THE MID-ATLANTIC CONTINENTAL SHELF

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During the summer of 1995, a multi-institutional field study called Shallow-Water Acoustic Random Medium (SWARM) was conducted in the Mid-Atlantic Bight continental shelf region off the coast of New Jersey. Environmental and acoustic sensors were deployed as part of SWARM to measure and characterize the internal waves and their impact on the spatial and temporal coherence of the acoustic transmissions. As part of the environmental monitoring network, two bottom-moored, upward-looking acoustic Doppler current profilers (ADCPs) were deployed. Large-amplitude, non-linear, internal soliton wave packets were observed to propagate shoreward from the shelfbreak. Based on the ADCP observations, a

kinematic model of the soliton wave packets was developed to synthesize the corresponding temporal and spatial fluctuations in the sound-speed field. Using a coupled normal-mode sound propagation model and the synthesized sound speed variations, the variability of sound pressure and of the modal amplitudes for a 224 Hz CW transmission were simulated. The auto and cross-correlations of sound pressure at different depths, and of the modal amplitudes at a fixed range, were computed in an effort to estimate the vertical and temporal scales of the fluctuating sound field. The simulation method, the simulated acoustic variability as well as the results of the correlation analysis are presented and discussed in this report.

A STUDY OF SOUTH ASIAN MONSOON CONVECTION AND TROPICAL UPPER EASTERLY JET DURING NORTHERN SUMMER 1991

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This work studies the 1991 northern summer monsoon over India and surrounding areas using Japanese (GMS) and Indian (INSAT) geostationary satellite data, the ECMWF objective re-analysis, and the NMC sea surface temperature analysis. Monthly and weekly mean fields are first used to examine the development of the monsoon over the entire domain and to identify the timing of the onset over India. Latent heat fluxes are shown to be important in the monsoon development process. The relationship between the synoptic variations of a convective index derived from satellite data and the upper tropospheric easterly jet show two possible effects of cumulus convection on the easterly jet. The first is a forcing of the jet maximum near southern India when convection flares up to the north in the monsoon trough. This is believed to be the result of the Coriolis acceleration of the southward outflow of the local Hadley cell. The second is a damping of the upper jet by cumulus momentum transport that occurs at the same location as the jet maximum. This second effect is most clearly shown in regions of strong vertical shear.

A STOCHASTIC MODEL FOR SHOALING WAVES

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Boussinesq-type equations for weakly nonlinear, weakly dispersive waves have been used extensively to model wave shoaling on beaches. Deterministic Boussinesq models cast in the form of coupled evolution equations for the amplitudes and phases of discrete Fourier modes (Freilich and Guza, 1984) describe the shoaling process accurately for arbitrary incident wave conditions, but are numerically cumbersome for predicting the shoaling evolution of continuous spectra of natural wind-generated waves. Here an alternative stochastic formulation of a Boussinesq model (Herbers and Burton, 1996, based on the closure hypothesis that phase coupling between quartets of wave components is weak) is implemented that predicts the evolution of a continuous frequency spectrum and bispectrum of waves normally incident on a gently sloping beach with straight and parallel depth contours. The general characteristics of the model are examined with numerical simulations for a wide range of incident wave conditions and bottom profiles. Stochastic and deterministic Boussinesq model predictions are compared to field observations from a cross-shore transect of bottom pressure sensors deployed on a barred beach near Duck, NC, during the recent DUCK94 Experiment. Predictions of the two models are similar and describe accurately the observed nonlinear shoaling transformation of wave spectra.

VARIATIONS IN COASTAL CIRCULATION OFF CENTRAL CALIFORNIA, SPRING-SUMMER 1993, 1994, 1995

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In situ measurements of hydrographic, wind, and Acoustic Doppler Current Profiler (ADCP) data, along with satellite imagery, were collected off central California during the upwelling season of three successive years, 1993, 1994, and 1995. The survey was conducted three times in the late spring of each year within 75 km of the coastline from Point Reyes south to Cypress Point, along a region of irregular coastline and bathymetry. The upwelling circulation was found to be distinct from the California Current System and unlike circulation defined in recent conceptual models for this region. Persistent or recurring circulation features were observed throughout the upwelling season that acted as dynamic boundaries to this system. A varied response by upwelling centers in this region to a fairly uniform wind field was also observed. Water upwelled within this system is considered to recirculate and mix, retained within the system for a relatively long period of time. This long retention period of upwelled water is thought to promote the high productivity associated with coastal upwelling. The circulation patterns found in this region, and the dynamic boundaries to the principal equatorward current may represent upwelling circulation at multiple locations in this and in other eastern boundary current systems, inshore of the principal equatorward current.

LAGRANGIAN MEASUREMENTS OF EDDY CHARACTERISTICS IN THE CALIFORNIA CURRENT SYSTEM

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During the Eastern Boundary Current program in 1993, 96 Argos-tracked surface drifters, drogued to 15 m depth, and satellite thermal imagery were used to provide a description of the mesoscale features in the California Current System off the northern California coast. The drifter movements and satellite images revealed a highly energetic series of filaments and eddies that dominated the summer flow field off the coast, similar to those noted in the earlier CODE, OPTOMA, and CTZ studies. Winter mesoscale activity in the region was less energetic, with the principal feature being the poleward-flowing Davidson Current.

Translation rates for mesoscale eddies were deduced from drifter trajectories in the summer period. Translation rates, vorticity, divergence, and eddy center positions were also estimated for a cyclone and anticylone sampled in July and September, respectively, by constraining observed drifter velocities to a linear Taylor expansion in the least square sense. Translation rates from this technique were similar to those observed from previous shipboard surveys and drifter motions. Using observations over 7 (12) days, the cyclonic (anticyclonic) eddy was determined to have a translation rate of 3.7 (4.2) cm/s to the southwest. The least square technique, applied to shorter time periods, however, provided unreliable estimates of eddy properties when drifters were not evenly distributed around the eddy.

ANALYSIS OF MODAL TRAVEL TIME VARIABILITY DUE TO MESOSCALE OCEAN STRUCTURE

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This dissertation examines the effects of ocean mesoscale variability on acoustic arrival time patterns for two separate ocean environments. First, for an open ocean environment away from strong boundary currents, the effects of randomly phased linear baroclinic Rossby waves on acoustic travel time are shown to produce a variable overall spreading in the arrival pattern, primarily producing a delay in the later, axial arrivals. Second, using the state-of-the-art Semtner-Chervin eddy resolving global ocean circulation model coupled with the University of Miami Parabolic Equation (UMPE) acoustic propagation model, the effects of a fluctuating frontal region created by the California Current on the temporal, spatial and seasonal variability in the individual modal arrivals of the first thirty modes over a one-model-year time span is assessed. The mesoscale bias variability is also examined by comparing the various peak arrival times for the range-averaged environment to that of the range-dependent environment. To support this work, approximate “wide angle PE mode functions” were newly developed which form a different basis set for modal expansion from that obtained using standard normal mode theory. These new mode functions provide the proper basis set for modal expansion of the field computed by wide-angle PE models.

COMPARISON OF TRAJECTORIES GENERATED BY THE NOAA OIL SPILL MODEL TO TRAJECTORIES PRODUCED USING HF RADAR-DERIVED SURFACE CURRENTS IN MONTEREY BAY

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High Frequency radar-derived surface current data was examined for use in oil spill trajectory prediction in Monterey Bay. Trajectories produced by the NOAA/HAZMAT On-Scene Spill Model (OSSM), using different combinations of surface currents and winds, were compared to trajectories generated using HF radar-derived surface currents. Currents examined included output from the NOAA circulation model and canonical-day averages of the HF radar-derived current maps, either as spatially constant but temporally varying currents (time file) or spatially varying two-hourly current patterns (grids). Results from OSSM using the NOAA circulation model currents did not compare favorably with HF radar-derived trajectories inside Monterey Bay. OSSM produced realistic overall trajectory patterns throughout the Bay using the canonical-day grid current files and, to a lesser degree, canonical-day time file currents. Both OSSM and HF radar-derived trajectories show sensitivity to release time. In the afternoon, trajectories display rapid southeastward flow. At night, currents are weaker. The week’s worth of direct surface current data used in this study was found to be representative of the seasonal summertime pattern in Monterey Bay and provided realistic current patterns for use in OSSM for initial trajectory prediction in lieu of real-time HF radar-derived surface currents.

USE OF SHIP-MOUNTED ACOUSTIC DOPPLER CURRENT PROFILER DATA TO STUDY MESOSCALE OCEANIC CIRCULATION PATTERNS IN THE ARCHIPIELAGO DE COLON (GALAPAGOS ISLANDS) AND THE GULF OF THE FARALLONES

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Ship-mounted acoustic Doppler current profiler (ADCP data are used to study regional ocean patterns around the biologically rich regions of the Archipiélago de Colón (Galápagos Islands) and the Gulf of the Farallones to test the assumptions about the circulation derived primarily from hydrographic samples. West of the Galapagos, an equatorial undercurrent transport ~7 Sv was present in November 1993, which decelerated within 30 km of the archipelago, shoaled, and diverged with a strong deflection to the southwest. A method of removing tidal velocities from ADCP measurements by creating an empirical model of the tides and using it to predict and subtract the tides in described. It is shown that in the Gulf of the Farallones, a large number of observations, typically more than acquired on one cruise, are necessary to reduce tidal model error. Detided ADCP data are used to describe the circulation in the Gulf under various wind conditions. Over the continental slope, surface-to-depth poleward flow is present throughout the year. During wind relaxations, poleward flow strengthens and warmer, fresher water is transported onshore.

DEEP MIXED LAYER ENTRAINMENT

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A bulk turbulence-closure mixed layer model is generalized to allow prediction of very deep polar sea mixing. The model includes unsteady three-component turbulent kinetic energy budgets. In addition to terms for shear production, pressure redistribution, and dissipation, special attention is devoted to realistic treatment of thermobaric enhancement of buoyancy flux and to Coriolis effects on turbulence. The model is initialized and verified with CTD data taken by R/V *Valdivia* in the Greenland Sea during winter 1993-1994. Model simulations show: (i) mixed layer deepening is significantly enhanced when the thermal expansion coefficient's increase with pressure is included; (ii) entrainment rate is sensitive to the direction of wind stress because of Coriolis; and (iii) the predicted mixed layer depth evolution agrees qualitatively with the observations. Results demonstrate the importance of water column initial conditions, accurate representation of strong surface cooling events, and inclusion of the thermobaric effect on buoyancy, to determine the depth of mixing and ultimately the heat and salt flux into the deep ocean. Since coupling of the ocean to the atmosphere through deep mixed layers in polar regions is fundamental to our climate system, it is important that regional and global models be developed that incorporate realistic representation of this coupling.

BATHYMETRY FROM HYPERSPECTRAL IMAGRY
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This work used hyperspectral imagery to derive shallow water depth estimates. A technique to classify substrates and estimate reflectance values for the substrate types is the major contributions of this work. This was accomplished by masking different bottom types based on spectra, effects that were not included in previous methods. HYDICE data was taken over Lake Tahoe on June 22, 1995. The high altitude of the lake provided a low aerosol content within the atmosphere. This allowed for relatively straightforward atmospheric corrections. This was substantially easier than in an oceanic environment. The atmospheric radiative transfer code MODTRAN3.0 was used to model the atmospheric conditions at the time of the experiment. The radiative transfer code HYDROLIGHT3.5 was used to model the attenuation coefficients of the relatively clear water of the lake. Minimal river input and low chlorophyll concentrations made it simpler to determine these values. Making use of the full spectral content of data within the optical range, multiple substrates were differentiated and masked off. This allowed for an estimation on wet substrate reflectance and a straightforward calculation of bottom depth.

BUBBLE INJECTION BREAKING WAVES
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Wave energy dissipation due to bubble penetration and inferred turbulent penetration from breaking waves in the surf zone is related to the total energy of dissipation. Bubble injection is inferred from void fraction measurements obtained using a 2.3 meter vertical array of eight conductivity sensors extending from the bottom through the water surface. Potential energy and dissipation associated with bubble injection are calculated and compared with total wave dissipation. Total wave dissipation is calculated from the energy flux balance measured using an array of seven pressure sensors in the surf zone.

Percent of total wave potential energy of the bubbles due to spilling breakers is on the order of 0.18% to 0.62%, consistent with past measurements in the surf zone. Percent of the bubble potential energy dissipation rates to total wave dissipation in the cross-shore direction is on the order of 8% to 20%. The potential energy dissipation is largest immediately after injection, decaying exponentially after that. Bubble potential energy dissipation results within 1.2 seconds even for void fraction events greater than 36% and usually in less than 1.0 seconds. Energy dissipation was found linearly related (0.95 correlation coefficient) with the ratios of wave height to water depth, a measure of the percent of breaking waves within the surf zone.

THE ASSIMILATION OF SATELLITE ALTIMETER DATA INTO A GLOBAL EDDY RESOLVING OCEAN MODEL

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Two assimilation experiments have been conducted using the Semtner/Chervin Parallel Ocean Climate Model at 1/4˚ resolution to investigate the dynamical changes which occur with the application of the nudging method to incorporate sea surface height observations (with associated vertical corrections to temperature and salinity) into a global eddy resolving ocean model. The first experiment used a previous model run as the observational field to determine if the assimilation technique, nudging, produced significant changes in the simulated fields to adjust the model to the observed fields when starting at a statistically different initial condition. The twin experiment has shown that the model does respond to the inclusion of the observed fields. Both the surface fields and subsurface fields have been adjusted towards these synthetic observations. The second experiment involved the use of a combined altimetric sea surface height anomaly field from the ERS-1 and the T/P satellites. The surface height fields are extended vertically by using the Levitus 94 monthly climatological fields. This dissertation has shown that assimilation of surface height data and an associated vertical adjustment to temperature and salinity, modifies both the surface and subsurface fields. Changes can be seen in both prognostic and diagnostic quantities (such as heat content and meridional overturning) while remaining dynamically consistent with the numerics of the model itself. Comparison of the simulated fields with in situ observations of temperature and salinity show that the model has adjusted towards observation not included in the assimilation process.

A STUDY OF THE SURFACE HEAT BUDGET OF THE WEDDELL SEA USING A RADIATIVE TRANSFER MODEL DURING THE AUSTRAL WINTER 1994

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This study uses rawinsonde soundings and irradiance measurements taken in the Weddell Sea during the 1994 ANZFLUX experiment. A radiative transfer model was used to determine the influence of aerosols, cloud droplet size, and water content on the radiative heat budget of the Weddell Sea. The modeled irradiances were compared with observations, and the model calculated the upward longwave irradiance from the Weddell Sea ice pack. Turbulent heat fluxes were calculated and combined with radiative terms to provide a net heat flux at the ice surface. While turbulent heat flux is the major factor affecting the Weddell Sea's heat budget in windy conditions, during calm conditions longwave radiative transfer becomes important. The modeled downward irradiances were compared to results obtained from empirical equations developed for the Weddell Sea during the winter. The atmosphere above the Weddell Sea appears to have an aerosol structure similar to marine environments. Stratus clouds over the Weddell Sea appear to be made up of cloud droplets with an effective radius of 2.5 microns and a water concentration close to 0.05 grams per cubic meter. The dominant terms in the surface heat budget are the longwave irradiances with the upward longwave term being the largest.

MODELING STUDIES OF WIND AND THERMOHALINE FORCING ON THE CALIFORNIA CURRENT SYSTEM

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A high-resolution, multi-level, primitive equation model is initialized with climatological data to study the combined effects of wind and thermohaline forcing on the ocean circulation of the California Current System (CCS). The ocean circulation is generated by the model using a combination of climatological wind stress and thermohaline forcing. In the first experiment, the effects of thermohaline forcing alone are evaluated, in the second experiment, previously conducted, the effects of wind forcing are isolated, while in the third experiment, the combined effects of wind and thermohaline forcing are looked at. The results from the combined experiment show that even though the effects of wind forcing dominate the CCS, the additional effects of the thermohaline forcing results in the following: the seasonal development of a poleward surface current and an equatorward undercurrent in the poleward end of the model region; an onshore geostrophic component, which results in a temperature front and stronger surface and subsurface currents between Cape Mendocino and Point Arena; and a region of maximum eddy kinetic energy inshore of ~125°W between Cape Mendocino and Point Arena, associated with the temperature front. These model simulations are qualitatively similar to recent hydrographic, altimetric, drifter, and moored observations of the CCS.