IMPROVING MARITIME SITUATIONAL AWARENESS THROUGH THE CORRELATION OF ELINT-DERIVED SHIP TRACKS AND SONAR TIME-BEARING PLOTS (U)

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The purpose of this study was to facilitate the development of a dynamic acoustic noise model based upon correlation of shipping locations and tracks obtained from electronic intelligence (ELINT) and sonar time-bearing tracks from acoustic arrays. This marriage of tracking sources was achieved through the development of the Multiple-Intercept Data Fusion (MIDF) process during the analysis of ELINT and acoustic data collected during FBE-E (Fleet Battle Experiment-Echo). All 28 of the ELINT multiple-intercept tracks of U.S. assets available for comparison with ground truth were correctly identified as military platforms. Twenty-one vessels were correctly typed by category (e.g., DDG, CG) and 19 were accurately identified by hull name.

Correlation between ELINT tracks and acoustic tracks also yielded great success. Of the 28 multiple-intercept ELINT tracks, 23 (82%) were matched to acoustic tracks. Numerous examples were developed to show that when ELINT intercepts are absent, detectable acoustic signatures permit the continued tracking of a vessel. Likewise, the possibility exists to continue tracking a vessel with ELINT data should the acoustic plot become congested as in a near-shore environment. The marriage of ELINT and acoustic tracking methods provides great promise for improving the ship tracking capabilities of the warfighter.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: ELINT, Acoustic, Ship Tracking

EVOLUTION OF BEDFORMS ON THE INNER-SHELF

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Observations of the temporal evolution of the wave-formed ripples are analyzed in terms of geometric properties, migration rate, and forcing by wave and current velocities. Three weeks of bedform observations were obtained using underwater video of a sheet of laser light projected on the bed at the Monterey Bay Inner Shelf Observatory in thirteen-meter depth water. The bed consists of fine sand (mean grain size 0.12mm). Low to moderate narrow-band swell waves occurred during the observation period. Ripple geometry consisted of orbital and suborbital vortex wave ripples, and relic ripples left after larger wave events. The bedforms generally changed size and shape when the grain roughness Shields parameter exceeded a critical value of 0.04 with the exception of the last event bringing into question the appropriate value of 2_{crit} in nature. Ripple migration was offshore at rates of 2-10 cm/day during active sediment transport events. Skewness of velocities (low and high passed) were calculated to explain offshore ripple migration, but showed no preferred direction. Mean currents were weak and also showed no preferred direction. Significant positive (offshore) correlation was obtained between the short-wave envelope and infragravity waves indicating wave-group forced bound long waves (surf beat) combined with stirring by the short waves might explain the offshore sediment transport and ripple migration.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Modeling and Simulation

KEYWORDS: Ripples, Sediment Transport, Shields Parameter, Bound Long Waves

U.S. AND AUSTRALIAN MINE WARFARE SONAR PERFORMANCE ASSESSMENT USING SWAT AND HODGSON MODELS

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The purpose of this thesis was to investigate a shallow coastal region to compile a detailed environmental picture of its sediment composition and water characteristics and from this model MCM sonar performance at the FBE-H exercise location as a means to determine what parameters exerted the greatest effect on performance. Seven parameters were intercompared to assess their sensitivity in detecting mines: bottom type, SSP, water depth/sonar depth, mine depth, frequency, sonars and models. Performance was assessed using several measures of effectiveness including the signal to noise ratio and initial detection range. Variations in these measures were analysed by investigating how TL and RL responded to changing parameters.

No one single parameter was identified that affected sonar performance significantly above all others. Of the environmental parameters considered, variations in bottom type exerted the most influence on TL and RL and ultimately on sonar performance. TL was clearly a significant factor when the bottom type is comprised of absorptive, fine-grained material. Of the sonar parameters, frequency exerted a significant impact on performance with TL the most sensitive term in this comparison. A higher TL associated with higher frequency reduced the signal level and consequently the bottom RL. The higher frequency displayed a stronger SNR than the lower frequency over short ranges, however the higher frequency was limited by TL at greater ranges with the lower frequency achieving greater initial detection ranges.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Reverberation, Bottom Backscatter, Mine Warfare, PC SWAT Model

HIGH FREQUENCY SONAR COMPONENTS OF NORMAL AND HEARING IMPAIRED DOLPHINS

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A data acquisition device was constructed and tested to obtain toothed whale (Bottlenose Dolphin and Beluga Whale) sonar signals and digitally store them to a PC hard drive. The device had the capability of capturing sonar signals by means of a two-hydrophone array, and a digital video camera in a submersible housing. Cooperation with marine biologists at SPAWAR Systems Center-San Diego enabled the sampling of three animals performing echolocation tasks. Their sonar signals, transmissions of rapid high frequency pulses called clicks, were recorded for further processing. Once the data was captured on video and hard disk drive, it was processed using MATLAB.

Data from three different toothed whales, a normal Bottlenose Dolphin, a Bottlenose Dolphin with a hearing impairment and a Beluga Whale, was analyzed. It was observed that the animals reduced the interval between clicks when they located a target. Correlating the signal data to the video data made this observation possible. It appeared the animals searched with widely spaced clicks, then narrowed the click period upon target detection. Also, it was noted that the frequency of isolated clicks decreased as click period decreased. However, the hearing impaired Dolphin maintained his click frequency regardless of click periodicity.

DoD KEY TECHNOLOGY AREAS: Electronics, Sensors, Computing and Software

KEYWORDS: Marine Mammal Systems, Bio-SONAR, Mine Detection, Dolphin SONAR, Echolocation Signals

SHALLOW WATER BATHYMETRY AT LAKE TAHOE FROM AVIRIS DATA

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One of the United States Navy Oceanographic community's roles is to keep an accurate worldwide database of oceanic bathymetry. In the littoral zones, much of the data is out of date or is unavailable. Stuffle et al. (1996) utilized a method addressing shallow water areas using the Hyperspectral Digital Imagery Collection Experiment (HYDICE) sensor on a small region in Lake Tahoe. As a follow-on, this work used a different sensor, the Airborne Visible/InfraRed Imaging Spectrometer (AVIRIS) sensor, and covered a much larger area on the opposite side of the lake. Principle components analysis (PCA) of the region of interest (ROI) revealed nine spectrally unique water classes. *A priori* knowledge of one bottom type in this ROI allowed insertion of a known bottom reflectance spectrum into a derived computer algorithm that, using also diffuse attenuation coefficients from HYDROLIGHT and reflectance just below the water surface derived from AVIRIS data, allowed computation of the bottom depth. Results compared within 30% of depth from a USGS bathymetric chart. This method holds much promise in clear waters, and next needs to be tested in the coastal ocean environment.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: AVIRIS, Hyperspectral, Bathymetry, Lake Tahoe, Optical Properties of Water

INFERRING BOTTOM ACOUSTIC PROPERTIES FROM AN/SQQ-32 SONAR REVERBERATION DATA

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Inversion techniques are used to infer bottom geoacoustic properties using AN/SQQ-32 Reverberation Level (RL) data gathered by USS Avenger (MCM-1) in Rhode Island Sound in February 1993. Based on the hypothesis that the magnitude of backscattered energy is directly related to the acoustic reflectivity of the seabed, a statistical analysis of beam RL time series was conducted to determine its correlation with sediment geoacoustic character.

A technique was developed using the deviation of the RL for an individual ping/beam from an area-wide average RL to generate geographic maps illustrating bottom geoacoustic characteristics. Resulting plots of "relative reflectivity" not only agreed with the existing descriptions of sediment distribution, but also provided more detailed spatial representation of bottom geoacoustic distribution. This highlighted the gross inadequacies, particularly in spatial resolution, of existing information on bottom geoacoustic distribution.

These plots, when produced using appropriately small sample intervals, have sufficient spatial resolution to expose MCM clutter density information. Geographic maps of relative reflectivity can provide an invaluable aid to planning search strategy, a surveying tool to compare clutter densities, appropriate geoacoustic parameters for accurate model (including full wave) predictions, and a means of

real time performance monitoring and assessment (providing the ability to revise and modify search strategy).

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: Acoustics, Reverberation, Bottom Backscattering, Geoacoustics, Oceanography, Inversion Techniques, MCM Sonar Operations, AN/SQS-32

SAND BED ROUGHNESS IN THE NEARSHORE, COAST 3D EXPERIMENT, EGMOND AAN ZEE, THE NETHERLANDS

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Sand bed roughness was measured in the nearshore during a variety of hydrodynamic conditions using an array of seven 1 MHZ sonar altimeters mounted on the WESP (an amphibious vehicle used for measuring large-scale bathymetry) during the COAST 3D Experiment 1998, at Egmond aan Zee, The Netherlands. Corollary waves were modeled using the Thornton and Guza (1983) wave transformation model. Wave height and current measurements were made in the surf zone using pressure sensors and electromagnetic current meters, and offshore wave heights were measured using an advectional wave-rider buoy. Measurements of sand bed roughness showed patterns similar to those observed by Clifton et al. (1971), but are highly variable both spatially and temporally with dependence on large scale morphology and wave and current conditions. Mobility number (Ψ) calculated from the modeled wave field and also from measured currents revealed that roughness is a function of Ψ. Roughness was observed to be highly variable at low Ψ (< 100) calculated from the modeled wave heights. As Ψ increased (100-150), roughness decreased gradually, but was still highly variable. As Ψ reached values greater than 150, roughness was restricted to the lowest observed values (< 3 cm) implying planar beds under sheet flow conditions.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Modeling and Simulation

KEYWORDS: Sand Bed Roughness, Megaripples, Ripples, Sediment Transport, Nearshore Processes, Morphology

INTERNAL TIDAL BORES IN THE MONTEREY CANYON

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A thirty-four day record of near-bottom temperature and horizontal velocity spanning the lower third of the water column from within Monterey Canyon was examined. The observed internal tide is highly non-linear with kinetic energy dispersed among numerous overtides near the bottom and more concentrated in the primary semi-diurnal constituent (M2) higher in the water column. The bottom currents and temperature vary in strength over the record period, taking on the characteristics of an internal bore at times with large up-canyon accelerations accompanied by rapid temperature drops. The bores are nearly phase locked to the sea level variations and arrive at the measurement site ~8.6 h after high tide in Monterey, CA. They are evident in the velocity records up to at least 35-m above the bottom and may be accompanied by high frequency pulses that extend higher. The variation is not caused by direct forcing from the barotropic

tidal range as the strongest bores do not exclusively occur during either the spring or neap phase of the barotropic tide. Speculation on the cause for the temporal variation centers on changes in mid-water stratification observed.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Internal Wave, Internal Bore, Tidal Bore, Internal Tides, Tides, Waves

LARGE EDDY SIMULATION OF INTERACTIONS BETWEEN FREE CONVECTION, WIND DRIVEN CURRENTS, AND BAROCLINICITY IN THE LABRADOR SEA DEEP MIXED LAYERS

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Understanding the dynamics of deep convection leading to the formation of deep water is important not only for studying the small-scale generation regions, but also for studying the global-scale thermohaline circulation. Large Eddy Simulation (LES) is used to model deep convection with an imposed mean horizontal density gradient of two different strengths and wind forcing from various directions, with strong surface cooling representative of the Labrador Sea. Results from these different cases are compared and analyzed to understand the effects of horizontal density gradients and wind direction on turbulence statistics for deep convection. Both the strength of horizontal density gradients and wind direction relative to the gradient affect mixed layer scalar variances, turbulent vertical fluxes, Vertical Turbulent Kinetic Energy (VTKE), and stability during deep convection.

Wind direction dominates over gradient strength in determining vertical flux magnitude with larger variation in strong gradient cases. Levels of VTKE are more dependent on gradient strength, with weaker gradients producing higher values of VTKE than stronger gradients regardless of wind direction. Wind direction does alter VTKE levels in the same manner as it alters vertical flux levels. The presence of a horizontal gradient is a stabilizing factor in areas of strong surface cooling.

DoD KEY TECHNOLOGY AREA: Other (Meteorology and Oceanography)

KEYWORDS: Large Eddy Simulation, Deep Convection, Labrador Sea, Baroclinicity

HEAT FLUXES ASSOCIATED WITH INTRUSIONS DURING THE SHEBA ICE STATION DRIFT

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A yearlong set of temperature and salinity profiles from the Surface Heat Budget of the Arctic (SHEBA) is analyzed to identify intrusions from the mixed layer to a depth of 150 meters. Ensemble averaged temperature and salinity profiles, spectral analysis of the vertical thermal structure, and bathymetry are used to divide the SHEBA ice station track into four regions: Beaufort Sea; Northwind Rise and break; Chukchi Plateau and break; Mendelev Abyssal Plain. Average vertical gradients of temperature and salinity over intrusive features are used to calculate Turner angles and molecular heat fluxes. Bering Sea Summer Water dominates the structure in the temperature and salinity profiles of the Northwind Rise region, with a maximum temperature intrusion of 2.2°C. Cold intrusions penetrate the upper halocline in the Chukchi Plateau region. The width of the distribution of Turner angle in the vertical profiles is indicative of the degree of the interleaved structure. Mesoscale features and associated internal wave activity accompany highly variable vertical structure over the Northwind Rise and Chukchi Plateau regions. The role of

intrusions in lateral mixing and lateral heat transport is discussed in context of the observed regional differences in water mass properties.

DoD KEY TECHNOLOGY AREA: Battlespace Environments, Modeling and Simulation

KEYWORDS: SHEBA, Intrusions, Heat Fluxes, Halocline, Double-diffusion, Turner Angle

DRIFTER OBSERVATIONS OF THE MEDITERRANEAN SEA SURFACE CIRCULATION

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Since June 2, 1986, several institutions have conducted a variety of drifter studies within the Mediterranean Sea for scientific and operational purposes. The data from these studies include 521 individual drifters and span over 13 years. This thesis examines these data in an effort to better describe the Mediterranean Sea surface circulation. Interpretation of the data is conducted by calculating Eulerian and Lagrangian statistics and evaluating some of the errors they contain.

An Eulerian framework is employed that best represents the surface flow throughout the Mediterranean Sea as a combination of a deterministic mean and fluctuations due to temporal and mesoscale variability. The results of the Eulerian statistics are presented as charts of Mean Kinetic Energy (MKE), Eddy Kinetic Energy (EKE), mean flow, and velocity variance. Seasonality is analyzed in regions where temporal and spatial coverage of drifter observations is adequate. Drifter wind slippage errors and array biases are evaluated to possibly determine a valid correction. The Lagrangian statistics: diffusivity, velocity covariance, and integral time and space scales are computed.

The Eulerian and Lagrangian surface circulation statistics computed from the drifters are in general similar, but much improved and more accurate, to those presented in earlier works.

DoD KEY TECHNOLOGY AREA: Environmental Quality

KEYWORDS: Mediterranean Sea, Surface Circulation, Drifter, Lagrangian Methods, Eulerian Methods

THE ROLE OF THE PLANETARY BETA EFFECT ON CURRENTS AND MEDDIES IN THE NORTHERN CANARY CURRENT SYSTEM

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To investigate the role of planetary beta on classical as well as unique features in the northern Canary Current System (NCCS), four numerical experiments are conducted with varying Coriolis parameterizations (*f*-plane or ∃-plane). The first two experiments use a closed boundary and annual salinity forcing for the Mediterranean Outflow (MO). The latter two experiments use an open Mediterranean Sea at the Strait of Gibraltar and seasonal forcing for MO to permit a more accurate investigation of the role of the beta effect on subsurface spreading of MO and Meddies. All four experiments use seasonal climatological winds and seasonal thermohaline gradients along the western boundary to force the model. Experiments run on a ∃-plane (Experiments 2 and 4) accurately portray classical eastern boundary current (EBC) mesoscale features. In addition, these experiments depict unique NCCS features associated with a large embayment (the Gulf of Cadiz), poleward spreading of MO, and the generation of Meddies. Experiments run on an *f*-plane (Experiments 1 and 3) show the unrealistic dominance of a continuously strengthening equatorward jet that inhibits development of classical EBC and unique NCCS features. The complex upper

layer and subsurface flow regimes of Experiment 4 most realistically portray currents, mesoscale features and Meddies similar to NCCS observations.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Modeling and Simulation

KEYWORDS: Primitive Equation Model, Northern Canary Current System, Currents, Meanders, Eddies, Meddies, Filaments, Mediterranean Outflow

A COMPARISON OF OUTPUT FROM THE LOS ALAMOS NATIONAL LABORATORY (LANL) PARALLEL OCEAN PROGRAM (POP) MODEL WITH SURFACE VELOCITY DATA FROM DRIFTING BUOYS IN THE NORTH ATLANTIC OCEAN

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Surface velocity fields from two configurations of the Los Alamos National Laboratory (LANL) Parallel Ocean Program (POP) model are compared to surface velocity data from satellite-tracked buoys in the North Atlantic. Separate analyses are conducted for each model configuration. In the first analysis, output from a 1/6-degree, 20-level model version is compared with five years (1993-1997) of drifter data, based on both Eulerian and Lagrangian statistics. In the second analysis, newly-available output from a 1/10-degree, 40 level version is compared to a two-year subset (1993-1994) of the data, and to 1/6-degree output over the same time frame. The latter comparison is based on Eulerian statistics alone.

The five-year comparison shows that the 1/6-degree model produces inaccuracies in some features, and generally underestimates velocity variance. Modeled Lagrangian time scales are too long, while the length scales are too short. The two-year comparison shows that at the higher vertical and horizontal resolution of the 1/10-degree model, there is a striking improvement in the spatial distribution of energy and resolution of the variance field.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Battlespace Environments

KEYWORDS: Numerical Modeling, Ocean Forecasting, Model Evaluations

VOID FRACTION UNDER BREAKING WAVES

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Bubble injection due to breaking waves within the surf zone is inferred by measuring void fraction using a 3 m vertical array of eight conductivity cells in conjunction with video pixel intensity. Void fraction errors associated with the conductivity measurements are examined, including vertical variations in the temperature and conductivity (measured), proximity effects near the surface, and estimates of the surface elevation using pressure sensors.

Energy loss is due to conversion of kinetic and potential energy of a wave to buoyant potential energy by the injection of air into the water column, which is then lost as the bubbles raise to the surface and escape to the atmosphere. Void fractions up to 40% were observed in intense breaking events penetrating to depths over 0.5 m confined within the crest-trough region. Production of potential energy due to buoyancy of bubbles was nearly instantaneous with the majority of energy dissipating within 0.25 s.

Pixel intensity qualitatively correlated with surface elevation and injection events. Crests in cross-shore intensity time stack plots are clearly visible and show good correlation with breaking events.

However, pixel intensity values did not correlate quantitatively with surface elevation or production of buoyant potential energy.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Bubble Injection, Void Fraction, Energy Dissipation, Video Pixel Intensity

MINE BURIAL IN THE SURF ZONE

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The volumetric rate of scour and burial of a MK-83 mine by waves in the swash and surf zone were measured in two experiments. The beach was near planar with a 1:40 slope and mean grain size of 0.2 mm. The deep water significant wave height was about 2 m with peak periods of 13 sec. An Acoustic Doppler Velocimeter recorded orbital velocities of the waves. Three dimensional scour was measured manually and with video. Volumetric rate of scour over time relative to the volume of the mine was as high as one during the first hours of mine deployment. Maximum scour volume occurred at 6 hours after deployment and the scour changed from removal to fill after this time. The Shields parameter as a measure of total shear stress experienced by the sand bed was an order of magnitude greater than that required to initiate sediment transport. The mine was completely buried after 24 hours in the surf zone to a depth of 10 cm below the surface of the sand bed.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Mine Burial, Scour, Surf Zone, Mine Warfare

EFFECTS OF THERMOHALINE GRADIENTS AND THE COLUMBIA RIVER PLUME ON THE CALIFORNIA CURRENT SYSTEM

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To study the combined effects of thermohaline gradients and the Columbia River plume on the ocean circulation of the California Current System (CCS), results from three numerical experiments of increasing complexity are examined. In all three experiments, seasonal climatological winds are used to force the model. In the first experiment, the effects of seasonal thermohaline gradients along the western boundary are evaluated. In the second experiment, the additional effects of thermohaline gradients along the northern and southern boundaries are investigated, while in the third experiment, the effect of the Columbia River plume on the CCS is explored. The results from the first two experiments show that thermohaline gradients associated with the North Pacific Central, Pacific Sub-Arctic, and Southern waters help to maintain more realistic temperatures and salinities in the CCS, particularly in the coastal regions. The third experiment shows that the Columbia River plume exhibits a strong seasonal signal with poleward flow close to the coast in winter and equatorward flow farther offshore in summer. The plume also has a significant impact on the near-surface stratification and baroclinic structure of the velocity field of the CCS from Washington to San Francisco.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Modeling and Simulation

KEYWORDS: Primitive Equation Model, California Current System, Currents, Meanders, Eddies, Filaments, Columbia River Plume

AMBIENT NOISE CHARACTERISTICS DURING THE SHEBA EXPERIMENT

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The ambient noise data recorded by two free-drifting buoys during the 1997-98 SHEBA experiment presented a unique opportunity to gauge the noise field of the Arctic Ocean in a unique and changing environment. The two buoys drifted in unison for 12 months, providing an hourly ambient noise data set between 50 and 1000 Hz. The drift pattern was divided into five legs in response to the season or major changes in the direction of ice flow. The two buoys exhibited similar median spectra for all frequencies. When examined on a seasonal basis, summer low frequency (< 200 Hz) noise levels were much closer to winter noise levels than past studies. This was mainly due to the low number of storms during the winter of 1997-98, which resulted in lower winter median noise levels. When compared with previous ambient noise studies in the Beaufort Sea, the SHEBA noise data were consistent with the concept that noise levels decrease (especially in summer) during the years when cyclonic atmospheric circulation dominates the west Arctic. Cross correlation analysis indicated a strong association of wind speed and wind stress to ambient noise. Locally measured wind stress (as opposed to that computed using the geostrophic wind) did not substantially improve the correlation with ambient noise. Two tools to conceptualize the Arctic noise field were employed during the SHEBA experiment: the use of RADARSAT with RGPS and the PIPS computation of energy dissipation rate. By comparing the output from these two systems with the ambient noise record, their effectiveness and usefulness as input to an Arctic ambient noise model could be determined. Several notable events in the winter and summer noise record were examined utilizing RGPS and PIPS. The event analysis confirmed the fact that distant noise sources can have an effect on a local noise field. RGPS and PIPS were not useful in the summer due to the open nature of the icepack.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Ambient Noise, SHEBA Experiment

VALIDATION OF THE MINE IMPACT BURIAL MODEL USING EXPERIMENTAL DATA

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The Navy's Impact Burial Prediction Model creates a two-dimensional time history of a bottom mine as it falls through air, water, and sediment. The output of the model is the predicted burial depth of the mine in the sediment in meters, as well as height, area and volume protruding. Model input consists of environmental parameters and mine characteristics, as well as parameters describing the mine's release. The model user seldom knows many of these parameters, and those that are known may be of questionable precision. In order to run a realistic validation of the model, an experiment was conducted using a simulated mine and carefully controlled observations while simultaneously taking gravity cores. The model was then run and calculated results were compared to observed.

Final results showed the model tended to over predict burial depth by an order of magnitude due to a

lack of sensitivity to hydrodynamic effects in the water column.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Mines, Sediment, Hydrodynamics, Mine Warfare

THE ROLE OF THE PLANETARY BETA EFFECT ON CURRENTS AND EDDIES IN THE LEEUWIN CURRENT SYSTEM

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To investigate the effect of the role played by planetary beta in the generation and maintenance of the Leeuwin Current System (LCS), several numerical experiments are conducted with varying Coriolis parameterizations (*f*-plane or β-plane). The seasonal effects of thermal gradients, wind forcing and North West Shelf (NWS) waters are also systematically explored in the numerical experiments. Additionally, the generation mechanisms for undercurrents along both the western and southern coasts of Australia are investigated.

Although surface currents, undercurrents, and mesoscale activity are present in both the *f*-plane and β-plane experiments, those run on a β-plane show a more realistic depiction of these features due to the significant role played by the planetary beta effect in the LCS. The combination of thermal forcing, wind forcing, and NWS waters were found to be essential to maintain the highly seasonally varying LCS. Alongshore temperature gradients, which are generated at deeper levels by the strong flow of the Leeuwin Current, are sufficient to establish and maintain an equatorward (westward) undercurrent along western (southern) Australia.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Modeling and Simulation

KEYWORDS: Primitive Equation Model, Leeuwin Current System, Currents, Meanders, Eddies, Filaments

SWELL TRANSFORMATION ACROSS THE CONTINENTAL SHELF

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A preliminary analysis of swell decay across the continental shelf was conducted using data from the SHOaling Waves EXperiment (SHOWEX). Six Datawell Directional Waverider buoys were deployed along a cross-shelf transect, offshore of Duck, North Carolina during an active hurricane season in the fall of 1999. Estimates of the frequency spectrum, $E(f)$, mean propagation direction, $q_{mean}(f)$, and directional spread, $\sigma_\theta(f)$, were obtained from the auto-, co- and quadrature spectra of the horizontal and vertical orbital displacements measured by the buoys. Twelve cases were analyzed including eight cases dominated by remotely generated long period swells arriving from various directions. The last four cases were characterized by active wave generation by strong winds on the continental shelf, including the passages of Hurricanes Floyd and Irene. Comparisons of significant wave heights of swell observed at all buoys show a consistent strong decay across the shelf supporting the major role of bottom friction in swell transformation. A decline in wave heights near the coast was also observed during the passage of hurricanes, due to limited fetch and enhanced bottom friction in shallow water. Estimates of q_{mean} show the expected refraction of waves to shore-normal directions on the inner shelf. Estimates of σ_θ generally do not vary much across the shelf. However, a sharp increase of σ_θ across the inner shelf was observed for

directionally narrow swells from Hurricane Gert, possibly due to wave scattering from bottom irregularities. In all cases, σ_θ was at a minimum at the spectral peak frequency.

DoD KEY TECHNOLOGY AREA: Environmental Quality

KEYWORDS: Swell Transformation, Continental Shelf, Directional Wave Spectra, Wave Dissipation, Wave Buoy, Refraction

MEGARIPPLE MIGRATION IN THE NEARSHORE

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Seafloor morphology in the surf zone of a sandy ocean beach was measured nearly continuously for 45 days with a 1.4 X 1.4 m coherent array of 7 sonar altimeters. Migrating megaripples, seafloor bedforms with amplitudes of O(10-50 cm) and lengths of O(1-5 m), were observed in about 2 m water depth in the trough between a sand bar and the shoreline for a wide range of wave and current conditions. Megaripple migration speed and direction are estimated from the array data using cross-correlations between seafloor elevation time series observed along the cross- and alongshore array legs. Megaripples were shown to be aligned in a direction that maximized the gross sediment transport normal to the bedform crest (Rubin and Hunter, 1987; Gallagher, *et al*. 1998). It is hypothesized that megaripple migration rate is related to the net transport in the direction of bedform alignment. The speed of megaripple migration is compared with the magnitude of the velocity field normal to the bedform crest in the direction of the mean, wave orbital, and resultant velocities.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Megaripples, Sediment Transport, Nearshore Processes, Bedforms, Morphology