PICES XIII S7-1819 Oral
Characterising meso-marine ecosystems of the North Pacific

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Living marine resource management and oceanic conservation are increasingly moving towards ecosystem-level approaches yet our ability to fully characterise and monitor multi-trophic ecosystem constituents and processes remains limited. Remote sensing imagery and advances in underway sampling technology available to survey physical and biological distributions concurrently have facilitated studies from high-speed vessels. Our study, using a commercial vessel as a platform, was designed to examine meso-scale physical and biological variability across a vast expanse of the sub-arctic North Pacific Ocean, from BC (Canada), through the southern Bering Sea, to Hokkaido (Japan). Plankton samples were collected with a Continuous Plankton Recorder (CPR) towed behind the vessel and a trained observer recorded seabird distributions. Physical properties along the survey track were examined using a temperature logger mounted on the CPR and XBTs deployed by the ship. Additionally, sea surface height, temperature and chlorophyll *a* concentrations were available from satellite imagery. Using community composition analyses, we first allowed the biological communities to define distinct geographic regions, which we term 'meso-marine ecosystems' (MMEs). Subsequently we examined the physical characteristics of each region to interpret the processes responsible for the observed biological patterns. There are ten distinct communities of co-occurring lower-trophic and upper-trophic ecosystem constituents, occurring in multiple years, which are associated with different bathymetric domains and the current system of the sub-arctic North Pacific, also influenced by mesoscale features of the circulation. These MMEs differ in the composition and abundance of their fauna and, therefore, almost certainly their productivity. An understanding of how spatial and temporal oceanographic variability forces the physical properties, biological communities and productivity of these MMEs will enhance our ability to detect episodic (regime shifts) and long-term (global warming) environmental change across the North Pacific Ocean. It is our hope that this study, and the ongoing acquisition of seasonal data on this transect since 2003, will contribute to this enhanced understanding.

PICES XIII S7-2160 Oral
Origin and persistence of anomalously cold water in the halocline of the Eastern Gulf of Alaska, 2002 to 2004

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A patch of anomalously cold and fresh oceanic water appeared in the ocean off the west coast of British Columbia, Washington State and Oregon during the summer of 2002. The coldest anomaly resided near 100 to 150 metres below surface, and was the coldest ever measured in summer in this region. Using observations from Argo profilers we were able to track the motion of this water mass through the Gulf of Alaska during the previous six months and into the following years. It may have formed to the northwest near the centre of the Alaskan Gyre during anomalously strong Aleutian Low Pressure Systems between 1999 and 2002, and advected onto the continental margin and then through the coastal waters of the British Columbia inside passage. This anomaly persisted in the Eastern Gulf of Alaska into early 2004, and maintained cool waters at 100 to 150 m depth while the surface waters increased in temperature in late 2002 and into 2003. Therefore, surface dwelling species experienced warmer conditions in 2002 to early 2004, while species below 100 m depth experienced anomalously cooler waters.

PICES XIII S7-1801 Oral
El Niño phenomenon in SODA data

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To study how the air and sea interact with each other during the El Niño onset, the Extended Associate Pattern Analysis (EAPA) is adopted with the Simple Ocean Data Assimilation (SODA) data in the present paper. It has been proven that the associated pattern is actually (more than 90%) the 'absolute' mean state of the climate parameter field with a constant ratio when the Nino3 Index reaches all of its El Niño and La Niña extrema. Therefore, EAPA is skillfully equivalent to the composite analysis of statistical climatology. Results show that as El Niño's parents, the behavior of the air and the sea are quite different. There does not exist a relatively independent tropical atmosphere but does exist a relatively independent tropical Pacific because the air is heated from the bottom instead of from the surface and has much stronger baroclinic instability than the sea. It also has a very large inter-tropical convergence zone covering the most tropical Pacific. It is the western burst and wind convergence, coming directly from the middle latitudes, instead of Kelvin waves, that cause seawater to move eastward and produce a meridional convergence in the upper levels. This results in the typical El Niño sea surface temperature warm signal in El Niño regions.

PICES XIII S7-1967 Poster
Diagnostic simulation of Peter the Great Bay (Japan Sea) currents

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A 3D field of Peter the Great Bay (hereinafter referred to as PGB) currents is calculated for different months of the year using a non-linear diagnostic baroclinic model that takes into account bottom adherence and free surface effects. Input data include a 3D density field, bottom relief, a surface wind field, and water transport at the PGB water boundaries. Water density data were obtained from the FERHRI marine cruises made in the bay in August and November 2001 and in August and October 2003. Wind data were obtained from six meteorological stations located south of Primorsky region (Russia) and from shipboard measurements. Boundary conditions were obtained from linear diagnostic simulations of PGB currents.

Modeling results suggest that the influence produced by the Primorsky current on water movement in the bay is most strongly felt in the open part of the bay. Water circulation in small bights of PGB is dependent on wind and water transport at water boundaries and represents an aggregate of eddies of different scales and directions. The current velocity within the eddies varies between 15 and 30 cm/sec.

PICES XIII S7-2009 Poster
Diagnostic simulation of the Okhotsk Sea currents

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A 3D field of the Okhotsk Sea currents was calculated for June, August, and October using a non-linear diagnostic baroclinic model that takes into account bottom adherence and free surface effects. Input data included a 3D density field, bottom relief, sea level pressure, and water transport in the straits. Average monthly density fields were constructed based on data from RODC FERHRI, ODC RIHMI, and other Russian oceanographic organizations,

Levitus Atlas (on CD-R), and Japanese institutions (starting from the 1930s). Bathymetry data were obtained from the ETOPO5 5-minute grid. Sea level pressure data were obtained from the 1961-1990 monthly average Re-analysis data. Boundary conditions were obtained from the linear diagnostic simulation of the sea currents.

Sea currents were modeled for climatic conditions of June, August, and October. Diagnostic modeling results are in a good accord with existing circulation patterns of the Okhotsk Sea. Sea current simulations revealed the main elements of the water circulation and inter-seasonal variability.

PICES XIII S7-2010 Poster
Diagnostic simulation of the Japan Sea currents

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A 3D field of the Japan Sea currents was calculated for different months of the year using a non-linear diagnostic baroclinic model that takes into account bottom adherence and free surface effects. Input data included a 3D density field, bottom relief, sea level pressure, and water transport in the straits. Water density was calculated by water temperature and salinity data from RODC FERHRI. Bathymetry data were obtained from the ETOPO5 5-minute grid. Sea level pressure data were obtained from the 1961-1990 monthly average re-analysis data. Boundary conditions were obtained from the linear diagnostic simulation of the sea currents.

Sea currents were modeled for climatic conditions of every month of the year. Diagnostic modeling results are in a good accord with existing circulation patterns of the Japan Sea. Sea current simulations revealed the main elements of the Japan Sea water circulation such as warm sea currents in the southern part of the sea and cold sea currents in the northwestern part of the sea.

PICES XIII S7-1870 Oral
A high-resolution assimilating tidal model for the Bering Sea

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The Bering Sea plays a significant role in dissipating both semi-diurnal and diurnal global tidal energy. In this presentation a representer approach is used to assimilate M_2 and K_1 harmonics computed from TOPEX/Poseidon (T/P) altimetry into a high resolution finite element model of the Bering Sea and North Pacific Ocean. A preliminary model solution which employs a conventional drag coefficient for quadratic bottom friction is shown to produce elevation amplitudes and phases that differ significantly from the harmonics arising from analyses of T/P and tide gauge observations. The assimilation of satellite altimetry data not only rectifies this problem but it also identifies regions where dissipation beyond conventional bottom friction is needed to reconcile the model dynamics and the observations. Interesting features of the Bering Sea tides, such as shelf waves along the slope and internal tide generation from Aleutian Passes, will be illustrated and biological implications will be discussed.

PICES XIII S7-2189 Poster

Main effects of the 1997-1998 ENSO event in the tropical coastal ecosystem in the Mexican central Pacific

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The physical-biological coupling as main early effect of El Niño, represented by a decrease of nutrient availability, and a subsequent decrease of primary and secondary production were found in the eastern tropical Pacific coast. As biological indicators for the ecosystem approach, we estimate community multivariate indices (larval fish assemblage, soft bottom macroinvertebrate and coastal fish assemblages -from the first two axis of correspondence analysis-) and other univariate indicators as zooplankton biomass, larval fish, macroinvertebrate and adult fish abundances. An environmental index was constructed from (first two PCA) the ENSO index, upwelling index, local SST and salinity to comprise the regional and local variability under the ENSO event. The main effect of the 1997-98 ENSO event were recorded in pelagic than benthic-demersal communities. However no significant relation was found between fish and invertebrates indicating that there were no cascading effects. The declination of the zooplankton and larval fish biomass and abundance could be attributed to different causes. Two main factors could affect the larval fish abundance during the ENSO event: Changes in the abundance of adult fish community and changes in the reproductive patterns. The reproductive activity of fish community was analyzed and several single-species responses were found, while the reproductive stocks fluctuation could be due to changes in catchability. The larval fish abundances could be determined by mixed effects of an impoverished of the pelagic habitat during ENSO events and by changes in the reproductive activity.

PICES XIII S7-1981 Invited

The Argo Project: New observations of the physical state of the ocean and their potential application to climate, including fisheries and ecosystems impacts

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The international Argo project uses autonomous profiling floats to collect temperature and salinity data from the upper 2km of the ocean. Argo is building towards an array of 3000 floats (approximately 3° spacing) and is approaching 50% completeness. Much of the North Pacific now has full coverage.

Argo is now the major source of CTD profile data from the open ocean. Its data (that are freely available in real time) are being assimilated into models to provide ocean state analyses and forecasts.

Argo-based products, and the Argo data itself (together with satellite remote sensing data) can be used to provide a physical context within which problems of ocean ecosystems can be studied. Autonomous floats such as are used by Argo, have also demonstrated their ability to collect information on other (than CTD) parameters.

The paper will describe the Argo project and its potential to address issues of relevance to climate including ocean ecosystems.

PICES XIII S7-2029 Invited

Data assimilation in the Pacific Ocean as an application of an observing system to physical oceanography and climate research

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Sustained ocean observation and comprehensive analysis are crucial for understanding phenomena in physical oceanography and climate research. Using reanalysis products of the MRI ocean data assimilation system (MOVE), we examined ocean states in the Equatorial and North Pacific, and the value of different kinds of observations, such as in situ (ship and ARGO float) observations, and satellite sea surface height and temperature. The assimilation system, MOVE, estimates salinity (S) as well as temperature (T) fields. The system uses a three-dimensional variational method with a vertical coupled T-S Empirical Orthogonal Function mode decomposition with area partitioning (CTSA: Coupled T-S Assimilation). In the western Equatorial Pacific, fresh water is confined and a thick barrier layer develops in La Niña periods. The fresh water spreads to the central Equatorial Pacific and the thick barrier layer appears in the east in El Niño periods. The correlation between surface heat content and the barrier layer thickness is also confined. In the western North Pacific, salinity and temperature variabilities are also examined. The assimilation results show realistic structures of salinity minimum of the North Pacific Intermediate Water in the subtropical waters, and of temperature related to dichothermal and mesothermal structures in the subpolar gyres. We also report preliminary results about the impacts of salinity data on state variables (temperature, velocity and salinity itself). The CTSA is compared with conventional halfway assimilation (CHA: T-assimilation and S-climatology). The comparison shows the power of comprehensive analysis such as CTSA and the importance of each kind of observational data.

PICES XIII S7-2002 Invited

Application of satellite remotely sensed environmental data to pelagic larval transport, growth, and survival

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Larval transport and oceanographic conditions experienced by pelagic larvae were simulated using an individual-based approach to track daily larval movements in a Lagrangian modeling framework. These advection-diffusion models were configured with geostrophic currents estimated from satellite altimetry. Larval dispersal was simulated for each month of the year from 1993-2003 for 3, 6, and 12 month larval durations. Four release locations spanning the Hawaiian archipelago were evaluated, Midway Island, Maro Reef, Necker Island, and Oahu. Retention and the degree of larval influx from other areas were evaluated by tabulating successful settlement, which was scored based on larval proximity to release sites after completion of the pelagic duration. Sea surface temperature and chlorophyll concentration at each daily larval location were tabulated utilizing satellite remotely sensed data products, and these *in-situ* values were integrated over the entire larval duration for each larval track. These oceanographic variables are of critical importance in the early life history because of their hypothesized relationships to larval growth and feeding success, both critical determinants of larval survival and successful recruitment. The sea surface temperature and chlorophyll histories experienced by successfully settling larvae display strong seasonal and interannual patterns. These patterns may be useful towards understanding episodic recruitment events, as well as for posing hypotheses towards understanding the mechanisms underlying spawning seasonality. These transport dynamics and oceanographic patterns have general implications for a variety of vertebrate and invertebrate meta-populations.

PICES XIII S7-2090 Poster
North Pacific surface temperature fields analysis

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In the present paper two methods were used to analyze SST data from the ECMRF dataset. The first is the classical EOF analysis which allows a reconstruction of El Niño–La Niña events with good accuracy by using only the first few EOFs. However, the periods between these events need many more EOFs for their reconstruction. Variability in the mid-latitudes also is not separated because of strong signals in the tropics. Therefore, in order to separate these signals, the cluster method was used. The results show that, except for signals in tropics, there exist well-separated signals in the subpolar gyre and Kuroshio Extension with inter-decadal modulation.

PICES XIII S7-2202 Poster
Mixed layer depth variability in the Gulf of Alaska from Argo and from ship-based observations

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Mixed layer depths are computed, based upon a new method proposed by Kara et al. (2000), for historical measurements along line P, in the Gulf of Alaska. Forty-six years of data are used for the monthly climatological calculations. To examine variability, the data are divided into two periods, based around the changes that occurred in the 1970s, except at Station P, where a sufficient abundance of data permits the examination of the monthly mixed layer changes over 5 year pentads. These results are also compared with the main modes of climate variability in the Pacific, such as PNA, WP (west Pacific) to see which of those climate modes is driving our Station P MLD variability in a given season.

Mixed layer depths are also computed from Argo floats and mapped onto the Line P stations using an objective analysis method. Argo data from 2001, 2002 and 2003 are used. Using the historical measurements for validation, the mixed layer depths estimated from the Argo floats agree well with the shipboard observations. The 2003 data show the reduced mixed layer depths that occurred that winter. Finally, the objective analysis scheme is used to map the Argo mixed layer depths throughout the Gulf of Alaska.

PICES XIII S7-2054 Poster
Regional implementation of GOOS in the Northwestern Pacific: Second phase of the NEAR-GOOS project

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The Global Ocean Observing System (GOOS) has shown tremendous progress of both its open ocean and coastal modules over recent years. Calls by the WSSD and G8 for a global observation system as an important element for sustainable development have brought additional support for the GOOS project. Further implementation of GOOS is expected to be through developing and strengthening of GOOS Regional Alliances (GRA) network. Among the currently existing 14 GRAs, the NEAR-GOOS is aimed at developing a comprehensive and sustained ocean observing network in the North East Asian regional seas. In the initial phase of the project, a regional data management system (physical parameters only) connecting the data bases of China, Japan, Korea and Russia with real-time and delayed-mode components has been established. The objective of the NEAR-GOOS second phase (2004-2008) is an expansion toward the formation of a comprehensive regional monitoring system that will provide information on the past, present and future of the marine environment, ecosystem and climate. This should be accompanied by a pilot project entailing experiments, trials and demonstrations. Among particular actions, the

project is expected to develop new technologies for satellite data applications, coordination of drifting buoy activities in the region, and integration of a Yellow Sea monitoring system. A closer relationship with oceanographic organizations and programs in the area, and in particular with PICES, is of great importance for the success of the NEAR-GOOS plans.

PICES XIII S7-1810 Poster
Improved decade-mean sea level of the North Pacific with mesoscale resolution

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Recent data from the twin-satellite mission GRACE (Gravity Recovery and Climate Experiment Mission) corrected significant large-scale errors in previous models of the shape of the Earth's equipotential surface (geoid). Yet, new models of the mean sea level based on GRACE's data have a too coarse horizontal resolution of 300-500 km to adequately describe complex structures of frontal and boundary jets, which define the pattern of basin-scale circulation in the North Pacific. Improved mean sea level is obtained by combining this oversmoothed large-scale product with dynamical estimates of local mesoscale tilt of sea level obtained from joint analysis of concurrent drifter, satellite altimeter and wind data combined within the horizontal momentum balance equation. The hybrid product reveals complex structures of main currents even after averaging over the 1992-2002 decade and illustrates their places in the large-scale near-surface circulation. Complex dynamics of Ekman currents and contribution of higher order processes are discussed.

PICES XIII S7-2006 Poster
Observing systems in the East (Japan) Sea: A monitoring buoy with moored instruments, surface and subsurface drifting floats, and satellite measurements

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In order to understand the East Sea, we are collecting various time series data by developing a real-time monitoring buoy system with several moored instruments, and by applying new techniques for utilizing surface and subsurface drifting floats and for correcting satellite measured data. The buoy system, the East Sea Real-time Ocean Buoy (ESROB), has been deployed in the coastal ocean near the east coast of Korea. It collects meteorological and oceanographic data and transmits them to the laboratory in real-time. The time series data acquired from the ESROB are then analyzed together with other data observed from other moored arrays in the East Sea. We also are collecting Lagrangian time series data using surface and subsurface drifting floats. There are a number of surface drifters and Argo floats that have been drifting and profiling in the East Sea since 1997. These floats provide data on surface and deep (800 m) currents and profiles of temperature and salinity. From these data we are analyzing physical parameters such as current and water properties in the East Sea. We also have utilized and analyzed sea surface temperature, sea surface height, sea surface wind, surface gravity waves, and internal waves collected by NOAA/AVHRR, Jason-1 altimeter, QuikSCAT scatterometer, and the ERS/ENVISAT/RADARSAT synthetic aperture radar (SAR). The altimetric data have been corrected for high-frequency (2-20 days) barotropic motion in the East Sea. To improve our monitoring capability of physical parameters in the East Sea, we need to apply advanced technologies, for example, in telemetry, electronics, and mechanics.

PICES XIII S7-1861 Poster

Satellite data based determination of SST spatial structure and the forecast of seasonal changes in the Okhotsk Sea

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The influence of SST variations on marine ecosystems is high and has great effect on hydrobiology. The SST structure in the Okhotsk Sea has very complicated distinctive features and this is the objective of our research.

Two methods of research were chosen: the empirical orthogonal functions (EOF) method and the method of harmonic analysis. Both methods allow us to detect the bounds of oceanological structures in different ways, and were used cooperatively. Computations operated on 6 years of satellite data, reduced by 15' × 15' areas and averaged by 15 days.

Detected features included the well characterized known structures such as the Tsushima, Soya and Kuroshio Warm Currents; upwelling zones near the Middle Kuril Islands, Kashevarov Bank, and northeastern Sakhalin shelf. The amplitude of the first EOF vector is close to annual oscillation and the influence of semi-annual harmonics and other overtones is relatively small. In contrast to the first mode, the amplitude of the second vector has two main constituents: semi-annual (greater) and annual (a little smaller). This mode represents peculiarities of SST variability in the northwestern part of the Okhotsk Sea.

Harmonic analysis gives similar results. For example, areas with small annual harmonic amplitudes correspond to upwelling zones mentioned above. The phase of these harmonics increases from northwest to southeast which means earlier warming in the northwestern part of the Okhotsk Sea.

SST forecasting for the year ahead was also prepared and analyzed. Predicted SST values are in good correlation with real data. Areas with low correlation and which have a high dynamic character were contoured.

PICES XIII S7-1926 Oral

Summer circulation in the Bering Sea derived as a variational inverse of climatological data

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An estimate of the summer Bering Sea circulation is obtained as a 4-dimensional variational inverse of monthly hydrographic and atmospheric climatologies. The reconstructed evolution of temperature, salinity, and velocity fields provides the best fit to available observations and satisfies dynamical and kinematic constraints of a primitive equations ocean circulation model. The data-optimized Bering Sea state is in a general agreement with the existing schemes of circulation in the region. The reconstructed circulation allows us to derive quantitative estimates of volume transports along the major pathways and to compute water mass transformation rates typical for the summer season. The utilized technique provides also estimates of the uncertainties of the reconstructed circulation. Optimized estimates of surface heat and salt fluxes are more realistic compared with oversmoothed climatological fields and demonstrate a good agreement with independent observations. The utilized variational inversion technique can be considered as a basis for the development of a monitoring system in the region.

PICES XIII S7-2007 Poster
Upper ocean response to typhoons and tropical storms

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Profile data from Argo floats enable us to understand air-sea exchange of heat and fresh water during passage of typhoons and tropical storms in the North Pacific during the period 2000-2003. We made about 750 match-up Argo profiles before and after passage of the storms within ±10 days and 200 km distance from the typhoon center. Comparisons of the pre and post profile pairs demonstrate that the storms produce cooling of 1.0^{o}C and salinity freshening of 0.12 psu on average in the ocean mixed layer (ML). It is noted that the temperature cooling case and salinity freshening case are dominant by about 89% and about 78% of all the matching profiles, respectively. About 60% of the profiles show deepening of the ML during typhoon passage while in the other cases the ML remained the same or shoaled. We found that the change in ocean mixed layer depth (MLD) is negatively correlated with the initial value of the MLD prior to arrival of a storm. The salinity freshening in the ML has a positive correlation (with statistical significance of 99%) with cooling under weak wind gusts (less than 30 m/s), whereas salinity has a negative correlation under the strong wind gust (more than 50 m/s). We have also been monitoring other oceanic and meteorological parameters associated with characteristics of the typhoon using multi-satellite data, for example, sea surface temperature, sea surface wind vectors, precipitation, water vapor, and other variables from NOAA/AVHRR, geostationary satellite (GOES), QuikSCAT, Aqua/AMSR-E, and TRMM.

PICES XIII S7-2164 Oral
Phytoplankton distribution in the Queen Charlotte Basin: Regions of high productivity

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Sites and seasons in which phytoplankton are most abundant provide critical foraging habitat for zooplankton and higher trophic level predators. Information on phytoplankton distribution is needed to identify where and when the marine ecosystem is most vulnerable to environmental disturbance related to climate variability and to human activities. In this study, six years of SeaWiFS color satellite data (Sept. 1997- Dec. 2003) were examined to identify sites and seasons in which phytoplankton are most abundant within the Queen Charlotte Sound / Hecate Strait region. Phytoplankton aggregations were spatially related to physical forcing patterns (currents and bathymetry), but shifted location and intensity season to season and year to year. Patterns in satellite chlorophyll data were compared to local differences in wind forcing and tidal mixing to provide an indication of local versus remote forcing. Variability in the site, timing, and amplitude of peak plankton productivity should be considered when evaluating the vulnerability of this ecosystem to oil and gas exploration and extraction.

PICES XIII S7-1803 Oral
Seasonal variation of the salinity belt structure off the Primorie coast: A numerical study

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Seasonal variation of the Japan/East Sea (JES) circulation was studied by means of numerical modeling with implications for a simple assimilation technique. The main objective was to get a better understanding of the sea dynamics and thermodynamics on the basis of the GDEM dataset of monthly temperature and salinity climatology. The model developed at the ICMMG has proven to be capable of simulating the most prominent features of the JES circulation pattern. A particular problem of the salinity belt off the Primorie coast was investigated in connection with the Japan Sea intermediate water (JSIW) formation. It was found that the salinity belt structure experiences a seasonal variation due to the variation of the Tsushima Strait transport. The transport through the Tsugaru Strait is

almost constant over the whole year, while the Soya Strait transport varies over a wider range. This makes the Tsushima salty and causes warm water to flow further north and to produce an intrusion of this water type into the northern region. Entrained into the Liman Current, this water flows southward over the Primorie shelf break until it reaches the topographic shelf before broadening at around 44°N. An anticyclonic eddy formed this way involves a greater volume of Tsushima water at its southern end which makes it flow along the Primorie coast and which ends up with a salinity belt. The accumulation of this relatively salty water at this latitude brings about a deep convection during the winter season. During this period, when the intensity of the subpolar front is weak, this water penetrates further south to form the so-called JSIW.

PICES XIII S7-1974 Poster
Climate variations during the 20th century in the Northwest Pacific region

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There are many sources of observed daily/monthly mean data of the ocean - atmosphere system to study climate and its variability. The main difference between data from various sources deals with the methods applied to data augmentation. This is related particularly to filling gaps in missing data and their interpolation to regular bins, taking into account spatial and temporal variability of these data. Methods of augmentation can be based on knowledge about the structure of explored data (*e.g.* by the methods of statistical modeling), as well as on the application of hydrodynamic models for the reanalysis of the observed data.

It seems to be common practice to explore climate variability based on data from different information sources in order to compare results. Here, we study climate variations using the data of NCEP-NCAR and GHCN for the surface air temperature, and GLBSST and HadISST for ocean, Sea Surface Temperature (SST). Our main goal is to reveal the anomaly propagation of air temperature for North East Asia and SST for the Northwest Pacific. We use Complex Empirical Orthogonal Function (CEOF) decomposition, which allows us to reveal propagating signals, taking into account phase shifts between field points. The corresponding cores of the CEOF decomposition modes are situated in areas where the most significant positive or negative climatic trend takes place.

PICES XIII S7-1782 Oral
The impact of the wind stress curl on the sea level and boundary currents in the Pacific western subarctic

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During the past decades significant temporal variability in the Pacific western subarctic gyre has been reported. A major challenge is to understand the mechanisms that determine variability within the Pacific western subarctic boundary currents: the Kamchatka Current with its continuation, the Oyashio. CERSAT IFREMER satellite wind data, CTD and sea level observations are used to investigate large-scale changes in the high-latitude of the Pacific western subarctic gyre.

Sea level in the Kamchatka Current exhibits large seasonal and interannual variations (of order ~12 cm) superimposed on a pronounced decadal trend (~3cm/10 years); we focus here on the multiyear variations of sea level. Sea level in the Kamchatka Current had minimum values in 1990-91, rose through to 1997 and dropped to the year 2000. We show that interannual deviations of sea level are associated with variations of the depth of halocline. Along with the variations of sea level, the wind stress curl in the region significantly varied during the past decades (~$2\cdot10^{-7}$ Pa/m). Wind stress curl anomaly was negative in 1993-1997 with minimum in 1995, and positive in 1998-2002 with maximum in 1999. We argue that wind stress curl forcing over the region is the most important factor in generating sea level variations within the Kamchatka Current. The ocean response on Ekman pumping is thus a major source of multiyear variability in the thermohaline structure and sea level in the Kamchatka Current. Such

anomalies in the Kamchatka Current are a response to the convergence or divergence of the anomalous Ekman fluxes. Interannual variability of the Kamchatka Current and Oyashio is thus determined by the ocean's baroclinic response to wind stress curl.

PICES XIII S7-1911 Oral
A new daily SST product of JMA (merged satellite and *in-situ* data Global Daily SST)

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Merged satellite and *in-situ* data Global Daily Sea Surface Temperature (MGDSST) analysis has been in operation at the Japan Meteorological Agency (JMA) since April 2004. SST grid point values with 0.25 degree resolution are generated in near real time. SSTs derived from AVHRR (Advanced Very High Resolution Radiometer) boarded on the NOAA-16, -17 and AMSR-E (Advanced Microwave Scanning Radiometer-EOS) on the AQUA are used in the analysis. AMSR-E Level2 data are provided by the Japan Aerospace Exploration Agency (JAXA) operationally in real time.

Satellite SST anomalies (SSTA), which are produced by subtracting daily SST climatology from satellite SSTs, are decomposed into two temporal-scale and three spatial-scale components : low- (σ> 10 days, σ; e-folding scale) and high- frequency (10>σ>5 days) for temporal; large- (σ> 100 km), middle- (100>σ>25 km) and small-(σ<25km) scale for spatial. In order to remove the biases, the decomposed low-frequency and large-scale SST fields are adjusted to *in-situ* data, by solving Poisson's equation with the similar method of Reynolds (1988). An optimal interpolation method is introduced to construct SSTA fields for each scale, and a daily anomaly is calculated as a sum of those fields. A comparison with moored and drift buoys shows the RMS and bias are about 0.6, and +0.04 degrees Celsius, respectively. The daily SSTs are available in the NEAR-GOOS Real Time Data Base (http://goos.kishou.go.jp/) and the JMA Japan-GODAE LIVE ACCESS SERVER (http://godae.kishou.go.jp/).

PICES XIII S7-1946 Oral
Bio-optical properties and in-water algorithm validation for ocean color remote sensing in the sub-arctic North Pacific

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The sub-arctic North Pacific represents one of the world's most biologically productive regions. The quantitative assessment of phytoplankton production in this region is very important to estimate global primary production. Recent development of ocean color sensors such as SeaWiFS, MODIS and GLI has been accompanied by an increased effort to establish algorithms for determining ocean optical properties, phytoplankton pigments, and primary production from ocean color imagery. However, there are still some problems of in-water algorithms for ocean color sensors in the sub-arctic North Pacific, and the bio-optical database in this region is very sparse. We carried out bio-optical measurements in the sub-arctic North Pacific from 1996 to 2003, including the sub-arctic marginal seas of the Okhotsk Sea, Bering Sea and Japan Sea. Chlorophyll-a concentrations (Chl-a) and the absorption coefficients of particulate matter, phytoplankton, detritus and colored dissolved organic matter (CDOM) were also measured in seawater samples. We examined the bio-optical properties and three kinds of bio-optical algorithms, the current NASA global algorithms, OC2, OC4 and JAXA global algorithm, GLI-OC4. Our measurements show that OC2 and OC4 algorithms tend to overestimate Chl-a in the Bering Sea and underestimate Chl-a in the northwestern North Pacific. The GLI-OC4 algorithm tends to overestimate Chl-a in the Bering Sea and Okhotsk Sea, and has higher accuracy in the northwestern North Pacific compared with OC2 and OC4. The

overestimation of chl-a in the Bering Sea with these algorithms was considered to be caused by the higher CDOM absorption in short wavelength.

PICES XIII S7-1860 Oral
Seasonal variations of Okhotsk Sea circulation from Topex/Poseidon satellite altimetry data

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Topex/Poseidon altimetry data (1993-2002) for the Okhotsk Sea and adjacent areas were collected with an along-track step of 0.25 degrees. All standard corrections, including inverse barometer (except GOT correction), were used. Tidal harmonics for 18 main constituents were estimated for each site separately using a special modification of the least squares method. Tides were predicted and subtracted from initial altimetry data. Residual series were grouped by month and used to investigate seasonal sea level changes in the Okhotsk Sea. The total range of monthly mean sea levels is about 20 cm. Geostrophic current velocities and direction were also estimated for each month. We found a well-expressed sea level minimum in the central part of the sea and a maximum in the coastal zone in winter. This indicates an amplification of the cyclonic circulation in the Okhotsk Sea in the winter season. This conclusion agrees with results of Hokkaido University long-term direct current measurements off-shore of the eastern Sakhalin shelf. (An amplification of southward-directed currents in winter was discovered.) Low sea level values and relatively weak current velocities were observed in spring. A weak maximum in the central part of Okhotsk Sea and correspondingly weak anticyclonic circulation was found in the summer as well as high sea levels along the northern coast. Probably, this maximum was induced by a so-called summer monsoon with southerly winds. Winter monsoons with stable and strong northwesterly winds are a cause of a well-expressed minimum in the northern part of the Okhotsk Sea in October and November. This result agrees with the estimation of large-scale upwelling that was made by the TINRO-Center from CTD-surveying.

PICES XIII S7-1854 Oral
Spatial anchovy availability index for northern Chile

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Historical anchovy (*Engraulins ringens*) fishery (catch, fishing effort, CPUE, characteristics and operation of purseiner fleet), environmental remote sensing (AVHRR and SeaWiFS) and oceanographic *in situ* sampling databases from northern Chile, were produced for analysis and validation purposes. Using geographical information system (GIS) and statistical software, a hindcasting analysis of relationships between anchovy distribution and the associated environmental conditions (sea surface temperature, thermal gradients, chlorophyll concentration and wind fields) was made. A model to estimate a Spatial Anchovy Availability Index (SAAI) was formulated based on fishery-environment hindcasting relationships and using GIS functions such as fuzzy logic, bayasian theory and multicriteria evaluation. The application and validation of the SAAI images in northern Chile was done during El Niño 1997-98 and La Niña 1999-2000.

PICES XIII S7-2044 Oral

Comparison of climatic signals (winds, satellite SSH, SST and surface chlorophyll-a pigment concentrations) in the NE and SE Pacific: 1993-2004

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In the NE Pacific, seasonal cycles and non-seasonal anomalies in the basin scale forcing, circulation and biological response are characterized by NCEP surface wind stress (WS), satellite altimeter sea surface height (SSH), satellite sea surface temperature (SST) and satellite (SeaWiFS) chlorophyll pigment concentrations (Chl). During the last twenty years, these show several moderate El Niño's (1986-87, 1991-92, 2002-03), a strong El Niño in 1997-98, La Niña's in 1996 and 1998-99, and a possible regime shift and intrusion of subarctic water into the California Current in 2002-03. Other papers presented in this session will describe some of the details of those events. In this paper, we identify similar events in the SE Pacific (the Humboldt and Cape Horn Currents). For example, the two pulses of high SSH during the strong 1997-98 El Niño left the Equatorial eastern Pacific and moved into each hemisphere simultaneously, but were modified differently as they traveled to mid-latitudes in each hemisphere. The other climatic signals will be examined for similar types of behavior. The motivation to link climatic signals in the eastern Pacific's two hemispheres comes from a number of studies, which find some level of synchrony in small pelagic fish populations in the Pacific and Atlantic eastern boundary currents (EBC's). Thus, we seek to link the climatic signals in the NE Pacific to other global EBC's. Our initial emphasis is on the Humboldt Current in the SE Pacific, which should be more closely connected to the same large-scale Pacific Ocean modes (atmosphere and ocean) that affect the NE Pacific. While wind and SST data sets allow us to look at a longer time period (1985-2003), emphasis will be on the shorter period covered by altimeter SSH (1993-2004), which includes the majority of the strong signals and also coincides with major field programs in the NE Pacific (GLOBEC, CoOP, NOPP, *etc.*).

PICES XIII S7-2027 Oral

Temporal and spatial variability of phytoplankton biomass and productivity in the Eastern Kamchatka Current region and along the Kuril Islands

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The temporal and spatial variability of phytoplankton biomass and productivity was investigated by multi-sensor remote sensing in the East Kamchatka Current region and along the Kuril Islands which are very important regions for various fisheries resources, such as the migration of Pacific saury. We applied ocean color (Chlorophyll-*a* (Chl-*a*), SeaWiFS), photosynthesis active solar radiation (PAR, SeaWiFS), sea surface temperature (SST, AVHRR), wind (SSM/I) and sea surface height anomaly (SSHA, AVISO) datasets to these regions. Monthly fields of primary production were calculated using the vertically generalized production model (VGPM) of Behrenfeld and Falkowski (1997). Phytoplankton biomass was higher in this study area than in the western sub-arctic gyre region. However, significant geographical differences of high biomass were identified around the Kamchatka Peninsula and along the Kuril Islands. Despite increased Chl-*a* in spring in both areas, the increase along the Kuril Islands was later than that around the Kamchatka Peninsula. Chl-*a* along the Kuril Islands was much lower than that around the Kamchatka Peninsula. Although our results showed that strong wind forcing in winter deepened the surface-mixed layer along the Kuril Islands, an increase in Chl-*a* was not observed in the same period. A possible reason for the late increase in Chl-*a* in spring may be due to the late surface stratification in spring. Our results will be an important step in clarifying the mechanism for the variability of phytoplankton biomass and productivity in the sub-arctic North Pacific.

PICES XIII S7-2196 Poster

Interannual and seasonal variability of satellite-derived chlorophyll pigment, sea surface height, temperature and wind stress in the northern California Current System

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The monthly seasonal climatology and interannual variability are examined in satellite-derived fields of surface chlorophyll pigment (CHL) concentration, sea surface height (SSH), sea surface temperature (SST) and wind-stress (TAU) in the northern California Current System between 1997 and 2003. The CHL concentrations in the study area show highest values (more than 8 mg/m3) next to the coast, especially north of the Columbia River, but decreasing in the offshore direction. The long-term mean dynamic topography comes from the Levitus hydrographic climatology and decreases next to the coast south of the Columbia River, especially south of Cape Blanco. This pattern is roughly consistent with the temporal mean of the scatterometer wind stress field, which is downwelling-favorable north of the Columbia River and upwelling favorable in the south, strongest south of Cape Blanco. SST values are also coldest next to the coast south of the Columbia River; the width of the cold coastal band increases as one move farther south. North of the Columbia River, there is a narrow band of colder water next to the coast, but also a general meridional cooling trend as one move to the north, caused by the latitudinal gradient in surface heating. Removing the harmonic seasonal cycles leaves the interannual variability, as summarized by the first 3 EOF's. El Niño conditions (1997-1998, low CHL concentrations, high SSH and SST) and La Niña conditions (1998-1999, high CHL concentrations, low SSH and SST) are observed in the 1st (and sometimes 2nd) modes of the EOF's. Maximum anomalies in CHL concentrations occurs at inshore locations north of the Columbia River during much of 1998-2000 and at inshore locations south of the Columbia River during spring and early summer of 2001-2003 (2nd EOF). Higher levels of CHL concentrations occurred along most of Pacific Northwest during 2002 (first and third mode), attributed to an intrusion of subarctic water.

PICES XIII S7-2176 Oral

Seasonal cycle of topography in the Bohai Sea and Yellow Sea and its Relationships with atmospheric forcing and oceanic adjustment

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The seasonal cycle is the most significant signal of topography and circulation in the Bohai Sea (BS) and Yellow Sea (YS). Though forced by the prevailing monsoon, it is still poorly understood due to the lack of data in the interior BS and YS. In the present study, the seasonal cycle of topography in the BS and YS and its relationships with atmospheric forcing and oceanic adjustment are examined and discussed using TOPEX/Poseidon and ERS-1/2 Sea Level Anomalies (SLA) data. The analyses revealed complicated seasonal cycles of topography mainly composed of 2 REOF modes, the winter-summer mode (WIM) and spring-autumn mode (SAM). The WIM with an action center in the BS displayed a peak and southward pressure gradient in July, and a valley and northward pressure gradient in January, which is obviously the direct response to the monsoon with about a 1-month response time. The SAM with an action center in the western south YS displayed a peak and northward pressure gradient in October and a valley and southward pressure gradient in April. After the mature period of the monsoon, the action center in the BS became weakened while that in the western south YS became strengthened because of regional convergence or divergence induced by seasonal variations of the Taiwan Warm Current and Yellow Sea Coastal Current. The direct response of topography to the monsoon resulted in the WIM, while oceanic adjustment of topography played an important role in the forming of the SAM.

PICES XIII S7-1832 Oral

POST: The development of a permanent continental-scale acoustic tracking array for west coast fisheries research

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The Census of Marine Life is helping to develop "POST", a permanent seabed acoustic array for tracking marine animals. Current plans involve the deployment of 30 or more permanent cross-shelf monitoring lines spaced along the west coast of North America, each consisting of autonomous seabed nodes spaced at roughly 1 km intervals, which would be capable of measuring direction, speed of movement, depth, and survival for tagged animals as small as 11 cm in length. Nodes would be modular and use an acoustic modem to periodically communicate with an overhead ship, which would upload data and download new programming. We are currently beginning a two-year demonstration phase for POST, involving tagging and tracking several thousand salmon smolts over a large-scale demonstration array. I will provide an overview of the results from the 2004 field season. The establishment of an acoustic array for fish tracking will also provide the data transmission and power supply backbone needed to host other ocean sensors. For example, temperature and salinity sensors could be placed on the seabed nodes, providing detailed fields of the changes in bottom temperature and salinity over time, while upward looking ADCPs and seabed current meters could provide detailed data on changes in current structure. These data could be meshed with the fish movement data to describe how animals move relative to changes in the three dimensional structure of the ocean. The ability to develop such a coastal-GOOS capability is an important aspect of the development that we must plan for.