

**PICES XIV POC\_Paper-2270 Oral**

**Impacts of the tides and atmospheric forcing variability on salinity and dissolved oxygen in the western subarctic Pacific**

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The impacts of the variation in the wind forcing and the 18.6-year tidal ( $K_1$ ) cycle on surface salinity and the concentration of dissolved oxygen (DO) in the intermediate waters of the subarctic North Pacific were analyzed. Our results demonstrate that the interannual changes of surface salinity and DO on isopycnals in the intermediate waters of the western subarctic Pacific can be described very accurately by a linear combination of the intensity of the Aleutian Low pressure system (North Pacific index) and zonal momentum flux (45°N-52°N, 165°E-170°W) in winter, and an annually averaged cubic of tidal amplitude for the central Aleutian and northern Kuril regions. The residual signal for dissolved oxygen (DO) shows a good correlation with the temporal variations of DO in the Alaskan Gyre.

**PICES XIV POC\_Paper-2483 Poster**

**Oceanographic field variability in the North Pacific by temperature circulation indices**

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Changes in the quantity of commercial fishes are known to strongly depend on oceanographic conditions. There is conclusive proof of a statistical connection between the indices of the Pacific Decadal Oscillation (PDO) as well ENSO (El Niño/La Niña + Southern Oscillation) and fishery areas in the Northwest Pacific (Koldunov A.V., Staritsin D.K., 2005). Thus PDO and ENSO are becoming good predictors for quantifying the estimation of commercial fishes. The PDO and ENSO characterize the temperature modes of a region. A wavelet-analysis of monthly averaged PDO and ENSO results revealed some basic energy areas of the PDO and ENSO variability for various scales and time intervals. The periods 22 years (double the cycle of solar activity), 19 years (period of the Moon and the Sun tidal force action), 11 years (period of solar activity), 7 years (the component nutational period), 14 months (period of the speed of Earth's rotational change – nutational tidal), annual and semi-annual cycles are allocated as characteristic scales of the variability. The fluctuation in amplitudes of these characteristic periods is estimated as nonlinear effects that are determining the energy flows in the field of high and low frequencies. The comparative analysis of PDO and ENSO results leads to a conclusion about a phase delay of a PDO rather ENSO.

**PICES XIV POC\_Paper-2461 Poster**

**Comparative analysis of parameters of Pacific subtropical anticyclones**

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This paper provides a comparative analysis of long-term variability of two Pacific subtropical anticyclones (North Pacific High and South Pacific High) over the period from 1948 to 2003. Among the parameters subject to comparison are long-term variability of pressure in the centre, as well as latitude, longitude and area under the anticyclone. Having analysed over a 56-year period, it can be said with confidence that there are individual periods characterized by a synchronous tendency of the centres' behaviour. These periods are strongly marked in winter and spring (winter and spring in the northern hemisphere), while in autumn they are much weaker. The seventies and the nineties are particular years. Since the mid nineties there has been a tendency towards a synchronous pressure rise, a movement of anticyclones towards each other and an increase of regions being under the centres. The best correlation is between the pressure in anticyclones and their dimensions (correlation coefficients are 0.5-0.6, dependences are positive). In summer weak tendencies observed during the analysis of long-term variability of the parameters are typical of northern and southern centres.

**PICES XIV POC\_Paper-2382 Poster**  
**Intraannual thermohaline dynamics in Aniva Bay**

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Intraannual change of water temperature, salinity and density might be traced almost through the whole water column in Aniva Bay with water dynamics being the main influencing factor. Large-scale reconstruction of thermohaline conditions in the bay is dependent on the combined action of the East Sakhalin Current (ESC), river discharge, precipitation and intrusion inflows of the Japan/East Sea waters. In October-December it is the East Sakhalin Current that transports a lot of fresh and vertically homogeneous transformed Amur River water along the shelf and Eastern Sakhalin slope. This conclusion is well supported by Itoh and Ohshima (2000) who believe the ESC transport to La Perouse Strait increases in autumn and may cause considerable water freshening at the Okhotsk side of Hokkaido Island. The position of the near-bottom isohaline of 32.5 psu (isopycnal of 26.5) and the area bounded by these isolines might serve as an integral index of water freshening in Aniva Bay. Near-bottom intrusions of the Japan/East Sea waters in autumn and winter (October-January) are determined to cause a transformation (*i.e.* annual considerable renewal) of the last-year cold intermediate layer (CIL) in the southern deep-water part of the bay. Near-bottom water temperature within the CIL in January might go above zero up to 1-2°C, thus being considerably higher than in summer (-0.5 to -1.5°C). Water temperature rise near the bottom serves like a “thermal oasis” that is favorable for the development of sea hydrobionts. The CIL registered in Aniva Bay is mainly of local genesis and dependent on convective cooling of waters at the northern periphery of anticyclonic eddy A<sub>1</sub>.

**PICES XIV POC\_Paper-2617 Poster**

**Interannual-interdecadal variability of the mean sea level along the China Coast during 1968-2002**

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The interannual-interdecadal variability of the mean sea level (MSL) at 23 tide-gauge stations along the China coast and its relationship with global SST during 1968-2002 is studied by empirical orthogonal functions (EOF) and linear regression analyses. The first four MSL EOF modes account for almost 80% of the variance on timescales longer than one year. The MSL EOF1 (45.4%) represents the simultaneously same-signed variation of the MSL near the 23 stations. The linear regression of the annual SST anomaly at each grid against the principal component of the MSL EOF1 is similar with the spatial pattern of the SST EOF2, which shows a pronounced east-west seesaw along the equator between the SST anomalies in the central-eastern Pacific and that in the western Pacific/Indian Ocean. This relationship indicates that the rising of the MSL along China coast since late 1977 is mainly due to the rising SST in the Chinese coastal areas, which is teleconnected with the pronounced cooling trend in the equatorial central-eastern Pacific area. The weak interannual variability in this dominant mode shows that most of the MSL variance off the China coast has no apparent relationship with the El Niño phenomenon. The spatial pattern of the MSL EOF2 (17.6%) shows a north-south seesaw, which changes sign near the station Pingtan (119.8°E, 25.5°N). This mode corresponds to a basin-wide variation in both the Pacific and Indian Oceans to the north of 20°S, which is basically in phase (out-of-phase) with the SSH variation at the northern (southern) stations. It exhibits apparent interdecadal variability, *i.e.*, near the northern stations, the MSL was decreasing in the 1970s, rising in the 1980s, and decreasing again in the 1990s, beside some weak interannual variability, while the opposite may appear for the southern stations. Superimposed on this interdecadal variation is mainly a quasi-biennial timescale. The third and the fourth modes basically represent the MSL variability at the stations Tanggu (117.7°E, 39.0°N) in the north, near the estuary of Haihe River, and Gaoqiao (121.6°E, 31.4°N) in the south, near the estuary of the Yangtze River, respectively. Both principal components show apparent interannual variability. The MSL at Gaoqiao seems to be influenced more by El Niño activity than in Tanggu, suggested by the similarity between the fourth linear regression SST pattern and the SST EOF1. It is also consistent with the timing of the major floods events in the Yangtze River valley studied in earlier research.

**PICES XIV POC\_Paper-2226 Poster**  
**Principle of partial similitude for tsunami waves**

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Tsunamis (generally referring to earthquake tsunamis) are the most serious oceanic disasters in coastal countries and one of the most important natural disasters as confirmed by the United Nation's International Decade for Natural Disaster Reduction (IDNDR). The frequency of occurrence of tsunami waves is very low, but they are not easy to dissipate once they take place. Tsunami waves are oceanic small-amplitude gravity waves that transport energy extensively in deep water and break forth vastly in shallow water. The theoretical basis for the principle of wave partial similitude (PWPS) is simply proposed by two ways of studying the mechanism of tsunami occurrence and catastrophic development. Firstly, the PWPS is deduced by formally putting the small-amplitude gravity waves on one-dimensional vertical and two-dimensional horizontal subspaces, respectively, and using the principle of flow similitude (PFS) twice. Secondly, it is demonstrated by directly using harmonic solutions of classical linear small-amplitude wave theory with constant water depth for two-dimensional incompressible non-rotational gravity waves. Its significance lies in the fact that a bridge is built between the familiar surface gravity waves produced by a thrown stone and infrequent tsunami waves, and between the classical linear small-amplitude wave theory and the most serious oceanic natural disaster occurring all over the world. We present a new powerful experimental research method resulting from dynamic theoretical analysis and numerical computation methods to compensate for the lack of detailed observations.

**PICES XIV POC\_Paper-2321 Oral**

**Evolution of sea ice in the Okhotsk Sea in January-April 2003: Analysis with the use of multisensor satellite and auxiliary data**

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During the 2003 winter season multichannel polarized microwave measurements of the ice cover of the Okhotsk Sea were carried out by AMSR and AMSR-E scanning radiometers from ADEOS-II and Aqua satellites, correspondingly. Passive microwave data as well as several acquisitions of Envisat and ERS-2 Synthetic Aperture Radar (SAR) images coupled with QuikSCAT SeaWinds scatterometer, NOAA AVHRR radiometer and other remotely sensed data and surface analysis maps have allowed us to trace the evolution of the Okhotsk Sea ice cover induced by both atmospheric and oceanic processes. Estimation of the atmospheric contribution to the brightness temperatures  $T_B(\nu)$  measured over the ice cover was done on the basis of modeling microwave radiative transfer in the atmosphere-underlying surface system at all AMSR frequencies  $\nu$ . The fields of the  $T_B(\nu)$  at higher frequencies (89.0 and 36.5 GHz) and collocated SAR imagery were used to study the mesoscale and small scale features of the ice cover and their changes. The ice floe drift along the east Sakhalin coast and the coastal polynias off the north-west coast of the Sea of Okhotsk, near the eastern Sakhalin coast and other places, were investigated by joint analysis of datasets formed not only by the corrected  $T_B(\nu)$  but by NOAA AVHRR, Terra and Aqua MODIS images, Quikscat-retrieved ice fields, *etc.* The seasonal changes of radiative and backscatter characteristic of sea ice resulting from the appearance of free water in the uppermost layer of snow-ice cover were compared with the visible/infrared satellite images, weather maps and coastal stations reports. The features of sea ice distribution and forms around Kashevarov Bank were revealed by joint analysis passive microwave, SAR and visible/infrared data.

**PICES XIV POC\_Paper-2440 Poster**

**Spatial and temporal variability in circulation and hydrophysical fields in Tatar Strait**

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The present work is devoted to research on the variability of circulation and thermohaline fields in Tatar Strait. Data from hydrological surveys on research vessels of the TINRO-CENTRE are used as the basis of an article on Tatar Strait for the period 1985-1995. Geostrophic currents are estimated using a dynamic method. The choice of sampling locations was determined by the depth of hydrological stations: 200-500 m. Capacity of currents on dynamic sections was estimated on depth izotahi 1 cm/sec. The 51°45' N latitude was considered to be the northern border of Tatar Strait (Cape Sushev-Cape Tyk), and the southern boundary was determined at approximately 46° N (Cape Belkin-Cape Kuznetsov). In a year with warm waters, the intensity of branches of the Tsusima current in Tatar Strait is high, and this resulted in the generation of the Shrenk and Primorye currents. In thermally cold years, the intensity of branches of the Tsusima current is less, and the probability of generation of the Sakhalin current is more. The circulation is subject to greater variability in the northern half of Tatar Strait than in the southern. In this part of the passage there could be a two-layer structure of currents. Irrespective of the type of a thermal mode, constant components of the circulation in Tatar Strait were branches of the Tsusima, a southern part of the Primorye current and a southern part of the Sakhalin current – the Western Sakhalin. The Shrenk current and the northern part of the Sakhalin current are attributed to variable components of circulation in the passage. Development of the Shrenk and Primorye or Sakhalin currents assumed low temperatures accordingly in western and eastern parts of Tatar Strait. The probability is great that the Shrenk and Primorye currents will be traced in thermally warm years, and the Sakhalin – in cold years at accordingly high or low intensity of the Tsusima current. From spring through summer, disbursements of branches of the Tsusima current which are included in Tatar strait, increased. Thus there were more disbursements of one of the currents - Primorye or Sakhalin.

**PICES XIV POC\_Paper-2293 Oral**

**Modelling and observational studies of the Juan de Fuca Eddy**

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The Juan de Fuca (or Tully) Eddy is a summer upwelling feature located off southwest Vancouver Island at the entrance of Juan de Fuca Strait. Recent studies indicate that the eddy is an initiation site for the toxigenic phytoplankton *Pseudo-nitzschia* that impact shellfish along the Washington coast. As part of ECOHAB PNW (Pacific Northwest), a project funded by the Ecology and Oceanography of Harmful Algal Blooms program, field programs have been combined with bio-physical models to better understand the ecology and dynamics of these blooms. Though the eddy is comprised of nutrient-rich California Undercurrent Water which has been upwelled onto the Vancouver Island shelf via the Juan de Fuca Canyon, the dynamics of its generation remain speculative. Recent simulations with the Regional Ocean Modeling System (ROMS) suggest that eddy formation and its subsequent magnitude are governed by an interaction of winds, estuarine flow, and tides. Model and ECOHAB field survey results will be shown and the eddy's role as an initiation site for harmful algal blooms will be briefly described.

**PICES XIV POC\_Paper-2531 Poster**

**Altimetry estimation of divergence and convergence area dispositions in streams for exchange application**

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Areas of intensive biological and exchange efficiencies in the seas are known to be closely related to frontal zones as well as to the divergence and convergence area dispositions in streams, upwelling/downwelling areas, and synoptical eddies. However, it was very difficult to use this knowledge in operative research because of poor oceanographic information. The situation has changed with the occurrence of satellite altimetry. The change speed is formed through a complete flow divergence which is determined by the  $\beta$ -effect and a rotor tangential wind pressure for synoptic time scales. The complete flow is composed from geostrophic flow, pressure gradient flow and drift flow.

Now it is possible to proceed from exchange experiences and general representations about distribution of commercial fish congregations during feeding migrations to trade recommendations based on altimetry information. Fish congregations are formed in convergence areas of flow (positive level anomalies) causing a feeding plankton concentration in stationary convergence areas (for example, a frontal zone or a stationary anticyclonic eddy) where plankton can be gradually eaten up and then the aggregations are passed to other convergence areas. Comparing altimetry information to temperatures, it is clear that the former is much more representative of thermodynamic peculiarities of the ocean fields.

**PICES XIV POC\_Paper-2530 Poster**

**Factors of the environment and production characteristics in Aniva Bay, Sea of Okhotsk and bordering straits (Laperuz, Tatarsky) in 1996-2002**

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Data on the concentrations of dissolved oxygen, mineral and organic forms of nitrogen and phosphorus, silicon and chlorophyll *a* in the Aniva Bay, and the southern part of Tatarsky and Laperuz Straits in various seasons of 1996-2002 are presented.

The concentration of dissolved oxygen changed depending on photosynthesis intensity and the amount of organic matter in the water. For example, in bottom water layers (500m) in Tatarsky Strait low oxygen saturation (up to 47%) has been registered, while the nitrate nitrogen content has reached to 28  $\mu\text{M}$ . In spring during phytoplankton bloom, the oxygen saturation of the water in Aniva Bay rose to 163% when the maximum concentration of chlorophyll *a* was 20,6  $\mu\text{g}/\text{dm}^3$ . In some seasons, coastal water at a depth of 30-40 m were subject to an oxygen deficiency up to 67,5%, while in the Laperuz Strait down to a depth of 50m oxygen saturation was more than 80%.

It was noted that the water masses of Aniva Bay were characterized by a rather complicated composition because of agitation of three main water structures: north desalinated waters, entering the south-western part of the bay, more saline transformed waters of the Japan/East Sea, as well as waters transported by the Eastern-Sakhalin Stream of the Okhotsk Sea. Characteristics of these water structures change significantly during the year. In coastal waters of the areas studied, the terrigenous flow is evidently influenced by the qualitative composition of the water.

**PICES XIV POC\_Paper-2283 Oral**

**The analysis of temperature regimes in coastal areas of the north-west Japan/East Sea by climatic periods**

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The tendencies of climate change—global warming are of great interest. To estimate the possible after effects of climatic changes and their impact on the environment and economy, investigations of climatic changes in some regions are of special interest. It is an urgent problem to define the most vulnerable areas of the coastal zone by data analyses of a series of instrumental observations. The long-term series of data from observations of sea water surface temperature and air temperature, conducted at four hydrometeorological stations (HMS) in Peter the Great Bay, the Japan/East Sea were investigated. Analysis was done on the variability of parameters calculated for each thirty-year normal series, determined by The World Meteorological Organization: 1901–1930 (I), 1931–1960 (II), 1961–1990 (III), and the rest following period 1991–2003, equal to 13 years (IV). Selective means of series of monthly averaged water and air temperature for each station accounted for each “normal” period, and then the anomalies ( $\Delta t$ ) were calculated between each neighbour period. The general tendency for the rise of temperature in winter and in spring and fall of temperature in summer and autumn was observed between stations when comparing mean water temperature of periods II and III. At the present stage, when comparing periods III and IV, it was noted that there was both a rise in average monthly water temperature (excluding August at HMS Possyet) and average annual temperature (from 0,5°C at HMS Possyet to 0,8°C at HMS Vladivostok and Nakhodka).

When comparing average monthly air temperature of periods II and III between stations, the tendency is analogous: a rise of temperature in winter and spring, and fall of temperature in summer and autumn, excluding Nakhodka, where the total rise in air temperature is observed from period to period. Comparing periods III and IV revealed a rise in average air temperature through almost all months. Average annual air temperature under transition from period II to III increased from 0,3 to 0,6°C; from III to IV increased from –0,7 to 1,1°C, that is, an almost double increase. Hence for the last 13 years increases in water and air temperature at all hydrometeorological stations in Peter the Great Bay have occurred.

Year-to-year fluctuations in both water and air temperatures are synchronous. The analysis of interannual variations of the temperature regime of coastal waters in the Peter the Great Bay allows us to single out and to assess climatic trends in the distribution of water and air temperatures, and in the distribution of water and air temperatures during the warm and cold seasons. The variations in the regime of the southeastern and southwestern parts of the Bay have been observed, but no differences in air mass temperatures have been registered.

The temperature regime of waters in Peter the Great Bay is influenced both by climatic and advective factors. The results obtained testify to the climatic regime variation in the northwestern Japan/East Sea.

**PICES XIV POC\_Paper-2221 Invited**

**Present and future of the North Pacific simulated by a high resolution coupled atmosphere-ocean general circulation model**

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A high resolution coupled atmosphere-ocean general circulation model is used for future climate change projections. The model includes a T106 atmosphere and an eddy-permitting ocean, and has been run on the Earth Simulator. A control climate run under fixed preindustrial conditions, a twentieth century reproduction run under historical external forcing, two future projection runs based on Intergovernmental Panel on Climate Change (IPCC) emission scenarios, and an idealized global warming run under a 1% yr<sup>-1</sup> increase of the atmospheric CO<sub>2</sub> concentration have been completed. We have also used a lower resolution version (a T42 atmosphere coupled with an ocean of ~1° horizontal resolution) of the same model, where the applied physical

parameterizations are the same as in the high resolution version. Here, projected changes of the North Pacific and associated changes in the climate over the North Pacific region are presented, with contrasting results of the two models. Model performance in simulating the present state of the North Pacific is also presented. Owing to the high ocean resolution, oceanic mean state and variability, such as those related to the Kuroshio and the equatorial currents system, are much more realistically simulated in the control and twentieth century runs of the higher resolution model. Differences in such features between the two models lead to different oceanic responses under global warming. For example, the Kuroshio and its extension are intensified in the higher resolution model, which is related to an El Niño-like atmospheric response to global warming. The atmosphere exhibits a similar response in the lower resolution model, as also seen in many other global warming projections, but the response of the Kuroshio is totally different because of its inability to properly simulate the Kuroshio separation. Some more conspicuous local and basin-scale features of the North Pacific under global warming will be presented.

#### **PICES XIV POC\_Paper-2457 Poster**

### **Incorporating *in situ* data obtained by Japanese fisheries research institutions into the JCOPE ocean forecast system**

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Japanese local fisheries research institutions constitute a horizontally close-arranged monitoring system around the coastal region off Japan in the western North Pacific. Most of these *in situ* data (hereafter FRDATA), however, have not been distributed to the global network; consequently they were not used for operational ocean predictions. The Fisheries Research Agency (FRA) and Frontier Research Center for Global Change (FRCGC) cooperatively incorporated FRDATA into the JCOPE ocean forecast system developed by FRCGC, composed of an Ocean General Circulation Model (OGCM) assimilating satellite SSH/SST and hydrographic data of Global Temperature-Salinity Profile Program designed by NOAA. The incorporation of FRDATA allows better capturing of ocean structures. For example, hydrographic structures in the Kuroshio frontal region were finely depicted as opposed to structures mapped without FRDATA. As a result, initial values obtained by the data assimilation were improved. The hydrographic structures of the Kuroshio small meander event, which occasionally appears southeast of Kyushu of Japan and acts as a trigger of the Kuroshio large meander events, were correctly reproduced. This successful reproduction can improve the prediction accuracy of the system, and hindcast experiments with the assimilation to FRDATA have brought predictions closer to observations compared to hindcasts without FRDATA.

#### **PICES XIV POC\_Paper-2407 Oral**

### **Predictability of location of the Kuroshio Extension and the Oyashio First Branch by JCOPE**

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The Frontier Research Center for Global Change (FRCGC) has conducted the Japan Coastal Ocean Predictability Experiment (JCOPE) and developed an ocean prediction system (JCOPE-system) with a POM based model. The JCOPE-system uses a data assimilation method to include data from satellites, Argo floats

and ships. However, most of the hydrographic data, observed by local fisheries institutions, have not been included because they were not reported by BATHY/TESAC messages. The Fisheries Research Agency (FRA) has started a joint program with FRCGC to develop a data transfer system to improve the predictability of the JCOPE-system. As a first step, we validated the predictability of the current JCOPE-system by comparing model results with observational data. In this study, we focused on the locations of the Kuroshio Extension (KE) and the Oyashio First Branch (OFB) on the east coast of Japan, since those two indices are the most important factors for determining the ocean conditions in the area. The data assimilation appropriately reproduced the position of KE, although OFB was not correctly reproduced. The predicted positions of KE and OFB were both separated from their observational values. However, the predictions had a tendency to follow the data assimilated reanalysis values rather than the purely simulated values (with no data assimilation and realistic forcing). These results showed that the predictability of KE and OFB depends greatly on the initial conditions. The initial conditions are derived by the data assimilation, therefore, the results imply that the model predictions will be improved if data from local fisheries institutions are added to the data assimilation.

### **PICES XIV POC\_Paper-2409 Poster**

#### **The comparisons between JCOPE and observed data in Tohoku regions**

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An ocean circulation model assimilating satellite altimetry, SST and hydrographic observations has been constructed to investigate ocean predictability around Japanese coastal regions under the Japan Coastal Ocean Predictability Experiment (JCOPE) by the Frontier Research Center for Global Change. Monthly repeated hydrographic section data measured by prefectural fisheries research institutes located on the east coast of Tohoku (the northeastern area of Japan) are used in the comparisons against three model runs (without assimilation, with assimilation and for hindcast). The simulated temperature and salinity were improved by assimilation, though the hydrographic data used for comparisons was independent to the assimilation. The hindcast forced by climatological monthly wind stress and heat/salt fluxes showed increasing differences from observed data with the increase in the integration time. However the difference induced by the hindcast was smaller than that between initial conditions and observed data. These results indicate that appropriately assimilated initial conditions are important to predictions within about two months. For the improvement of initial conditions, we are also developing the system to collect and assimilate the near real time hydrographic data observed by prefectural fisheries research institutes, which are now not included in the assimilation.

### **PICES XIV POC\_Paper-2456 Poster**

#### **Verification of JCOPE ocean forecast system using *in situ* data of Japanese fisheries research institutions**

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JCOPE, the ocean forecast system of the Frontier Research Center for Global Change (FRCGC), is an eddy-resolving Ocean General Circulation Model (OGCM) assimilating *in situ* temperature/salinity profiles and satellite SSH/SST which succeeded in forecasting information on the Kuroshio large meander last spring.

However, its reproducibility, especially for hydrographic structures, has not been verified adequately using *in situ* data. We verified the accuracy of the OGCM and data assimilation of JCOPE, comparing its hindcast and reanalysis data with hydrographic data in the western North Pacific observed by Japanese fisheries research institutions. The hindcast data indicated some systematic biases of the OGCM, representatively, faster propagation of the Kuroshio meander to downstream and frequent formation of large meanders accompanied by detached-eddies, although reproducibility increased remarkably in comparison with the no-assimilation case. The reanalysis data, as the initial condition, are calculated in sequential processes: gridding observational data with an optimal interpolation (OI), estimating T/S profiles with a multivariate OI (MOI), and noise elimination. Among these processes, the OI tended to make frontal structures looser in the Kuroshio and Mixed Water regions partly due to the constraint of the Nyquist time-space scale of 10 days and 50 km. In the MOI, discrepancies appeared in salinity profiles, especially in the subarctic region, which was attributed to a procrustean estimation of salinity profiles from SSH with weak signals. These are expected to be corrected by incorporating the horizontally close-arranged hydrographic data of Japanese fisheries research institutions into the data assimilation with revision of the assimilation parameters under the cooperative project between the Fisheries Research Agency and FRCGC.

**PICES XIV POC\_Paper-2446 Poster**  
**Hydrographic and hydrodynamic variability in Kangjin Bay, South Sea, Korea**

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In a separate paper by Ro and Jung, a realtime monitoring system which has produced a time series of 16 oceanic state variables (such as temperature, salinity, currents, dissolved oxygen, air temperature, solar radiation, wind, *etc.*) since April, 2003 was described in detail. Time series analyses of these oceanic state variables were carried out in terms of harmonic, spectral and coherency analysis, multiple correlation analysis among variables, and heat budget decomposition. The annual temperature range was 27.5°C with the lowest, 1.9°C, occurring on January 26, 2004 and the highest, 29.4°C, occurring on July 31, 2004. The latter is regarded as extremely high compared to other neighboring water bodies. Salinity ranged from 10.63 psu in July to 33.35 in February, 2004. Tidal currents ranged from a maximum of 37.1 cm/sec at flood to 32.5 cm/sec at ebb. In the heat budget analysis, in summer, the average net heat gain was 127.2 watt/m<sup>2</sup> while in winter the average net heat loss was 132.7 watt/m<sup>2</sup>. Latent heat during typhoon passage in summer increased remarkably by around 13 times to be 389.2 watt/m<sup>2</sup> compared to an average value of 29.0 watt/m<sup>2</sup>. In winter, latent heat loss was 144.7 watt/m<sup>2</sup> compared to sensible heat loss of 56.8 watt/m<sup>2</sup>.

**PICES XIV POC\_Paper-2512 Poster**  
**Low salinity signal propagation in the western part of the Sea of Okhotsk**

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Based on numerous mooring observations and CTD surveys, the effect of the fall in peak propagation of the East Sakhalin Current is demonstrated. In Aniva Bay, it is shown how the dichothermal layer changes. The influence of Japan/East Sea water is overestimated as early investigations have noted. The main cause of the disappearance of the dichothermal layer in Aniva Bay is due to the seasonal propagation of the East Sakhalin Current.

**PICES XIV POC\_Paper-2543 Poster**

**Flow through the Ulleung Interplain Gap in the southwestern East/Japan Sea**

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The Ulleung Interplain Gap (UIG) is about 90 km wide, and serves as a main passageway for the exchange of deep waters below 1500 m depth between the Ulleung Basin (UB) and the Japan Basin. A map of bottom potential temperature indicates that the densest flow into the UB, colder than 0.1°C (the East Sea Deep and Bottom Waters according to Kim *et al.*, 1996), must take place through the UIG (Chang *et al.*, 2002). Chang *et al.* (2002) conjectured a net inflow of about 0.5 Sv into the UB through the UIG using a single mooring at EC1 (Fig. 1). A high-resolution numerical model, however, predicts that the deep inflows occur in the western UIG and outflows occur in the eastern UIG (Hogan and Hurlburt, 2000), suggesting the necessity for measuring flows over the entire gap to estimate the deep water flux. An array of five current meter moorings, each of which was equipped with two current meters at around 1800 m depth and 20 m above the seabed, was deployed in November 2002 for reliable flux estimates of deep water through the UIG. Each mooring was successfully recovered in April 2004. The mean flow pattern is characterized by a strong and narrow outflow in the eastern UIG strengthening to the east near Dokdo, and a broad inflow in the western UIG, strong in the mid-UIG and weakening to the west near Ulleungdo. The results show that the deep flow near Dokdo has significant effects on the deep water exchange between Ulleung Basin and Japan Basin.

**PICES XIV POC\_Paper-2358 Oral**

**Analysis and modeling of north and tropical Pacific SST variability**

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In the present paper, two methods are used to analyze the SST data of the ECMRF and NCEP/NCAR/NOAA datasets. The first is the classical empirical orthogonal function (EOF) analysis, which allows the reconstruction of the El Niño and La-Niña events with good accuracy by only the first few EOFs. However, the periods between these events need many more EOFs for their reconstruction. The variability in the midlatitude is also not separated because of a strong signal in the tropics. Therefore, for the separation of these signals the cluster method is used. The results obtained show that, except for signals in the tropics, there exists a well-marked signal in the subpolar gyre and the Kuroshio Extension with inter-decadal modulation. The modeling of the ocean response to atmospheric forcing during the 1981-1990 period shows reasonably good agreement in the phase and the amplitude of the simulation of the tropical (El Niño, LaNiña) events of the model during this period. The subtropical anomalies are described more poorly.

**PICES XIV POC\_Paper-2491 Poster**

**Multivariate statistical study on the chemical composition of rainwater at Zhoushan Archipelago**

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The chemical characteristics of rainwater at stations located in the East/Japan Sea were studied for the period between January 2002 and December 2003. The stations are located in northeast of Zhejiang Province (latitude 29°32'N to 31°04'N and longitude 121°30'E to 123°25'E), where the largest archipelago in China exists. Rainwater samples were collected and major species (F<sup>-</sup>, Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, K<sup>+</sup>, Na<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, NH<sub>4</sub><sup>+</sup>, pH) were determined. Concentrations varying in range and character were depicted. On the basis of the data, principal component analysis (PCA) and factor analysis (FA), such as the kinds of multivariate statistical techniques, were used to acquire further knowledge on the characteristics of species analyzed. The distribution character of

samples was clearly depicted in the new PC1-PC2 ordinate generated by orthogonal projection and the reasons that caused the outliers in samples were discussed. In order to get the latent variables which most distinguishably effect the sample distribution, data profiles were investigated by factor analysis. Three latent variables were responsible for the sample distribution within sufficient analysis accuracy,  $\text{NO}_3^-$ - $\text{SO}_4^{2-}$ - $\text{NH}_4^+$  factor (FA1) called an “anthropogenic factor”,  $\text{Na}^+$ - $\text{Cl}^-$  (FA2) called a “marine factor”, and  $\text{Mg}^{2+}$  factor (FA3).

### ***PICES XIV POC\_Paper-2247 Poster***

#### **Bottom drag coefficient estimates in the tidal bottom boundary layer from acoustic Doppler velocimeter data**

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Bottom friction is very important to coastal hydrodynamics. Reliable bottom drag ( $C_d$ ) depends on the bottom layer turbulence structure. Turbulence characteristics in the bottom boundary layer (BBL) of coastal water (the Yellow Sea, dominated by semi diurnal tides) were measured during the spring cruise of the R/V *Dongfanghong 2* in March, 2005. A 64-Hz Nortek Acoustic Doppler Velocimeter (ADV) and a RDI 600-kHz ADCP were anchored at station A1 (35.90°N, 121.58°E, at 40m depth). The sampling was carried out every 10 min to get 2048 samples of bottom 3D velocity and one profile of ensemble velocity each time within 24 hours.

Bottom stresses were estimated by two methods: COV (direct Covariance measurement) and TKE (Turbulent Kinetic Energy). These two methods yielded similar estimations of bottom stress based on ADV output. The mean calculated bottom drag coefficient  $C_d$  from estimated stress and the mean bottom velocity was  $3.6 \times 10^{-3}$ , which was obviously larger than the typically assumed value of  $2.5 \times 10^{-3}$ . The intense variation of  $C_d$  reached two orders of magnitudes ranging from  $3.4 \times 10^{-4}$  to  $3.0 \times 10^{-2}$  during the observation. Turbulent kinetic energy dissipation rate ( $\epsilon$ ) was estimated from a fit of the Kolmogorov  $-5/3$  spectral slopes in the inertial range of the 1D frequency spectrum. Near the bed, vertical velocities are less contaminated by vibration than the horizontal velocities, and the fluctuations  $w'$  are more likely to be due to turbulence (Stapleton and Huntley, 1995), so in this study, we systematically applied the method only to vertical velocities. Most of the calculated  $\epsilon$  had an order of  $10^{-6} \text{ m}^2 \text{ s}^{-3}$  with maximum and minimum values of  $4.6 \times 10^{-4} \text{ m}^2 \text{ s}^{-3}$  and  $2.8 \times 10^{-7} \text{ m}^2 \text{ s}^{-3}$  respectively. The comparison between time evolutions of  $\epsilon$  and tide indicated a strong ebb-flood asymmetry of  $\epsilon$ . The vertical velocity spectrum showed good agreement with the corresponding Nasmyth Universal Spectrum. Both  $C_d$  and  $\epsilon$  have an obvious frequency 2 times that of tide.

### ***PICES XIV POC\_Paper-2582 Oral***

#### **Interannual changes of dissolved oxygen in an active layer of the Okhotsk Sea**

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For data obtained from 1930-2002, maps of monthly distributions of dissolved oxygen in the surface layer of the Okhotsk Sea are constructed and interannual variability is analyzed. The temporary variability of oxygen in the Okhotsk Sea is illustrated by the slowing down of the reorganization of the field of oxygen structure and in the small changes in the absolute size of its concentration. It is well traced in the surface layer which is most subject to the influence of external factors. Therefore, on the surface, the amplitude of interannual fluctuations reaches 1.5 ml / l, and in the 50 - 200 m layer it is 0,5 ml / l which demonstrates the fast attenuation with depth of seasonal changes.

The spatial distinctions due to geographical features in various areas of the sea, are most strongly determined by the dynamics of the waters, and by the beginning and end of the photosynthesis period. In June, in northeast part of sea, the oxygen content exceeds 12,0 ml / l, and in a northwest part of the sea it is reduced to 7,5-6,5 ml / l.

The structure of the oxygen field in the surface layer essentially changes within one year. In the summer in the top part of the layer (0-100 m), it is characterized by the general reduction in oxygen concentration from the central areas of the sea to the shelf. In the bottom part of the layer (100-200 m), conversely, there is an increase in concentration in the same direction. In the winter the structure of the dissolved oxygen field with depth does

not change and also it characterizes increase in concentration from the central areas of the sea to shelf. Changes in the structure of the field are caused by the seasonal reorganization of thermal structure of the surface layer, *i.e.* the formation of a seasonal thermocline in the summer, its destruction in the winter, and also by intensive mixing in the winter in coastal areas and at the beginning of photosynthesis in these areas. Changes in the distribution of dissolved oxygen at the beginning of late autumn occur at intermediate depths and are probably connected to the increased flow of Pacific water to the Okhotsk Sea.

**PICES XIV POC\_Paper-2310 Oral**

**Detecting the 1972/73 El Niño in the Northeast Pacific with an improved tropical teleconnection index**

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Our inability to detect a major El Niño in the extra-tropical North Pacific in 1972/73 was perhaps one of the major contributors to the view that all El Niños are different. A re-analysis of tropical forcing/extra-tropical SST response reveals that the 1972/73 El Niño went undetected because the background state of nature during the early 1970s was not given adequate consideration, particularly the concept of persistent states of nature in the climate system. As it turns out, coastal North American SSTs increased in 1972/73 as in all other major El Niños of the twentieth century, but because the initial state was significantly colder than average when the El Niño occurred, the increase did not stand out as a positive anomaly against the entire record. It appears that the 1972/73 El Niño was not the anomaly; the anomaly was the cold regime in the Northeast Pacific that lasted from 1968-1975, the most dominant feature in the 500 hPa height anomalies in the Gulf of Alaska. A new Western Tropical Pacific Index of the mid-latitude teleconnection shows this regime rather clearly and is sufficiently invariant that it may be useful as a forecast tool for Northeast Pacific ecosystem variability.

**PICES XIV POC\_Paper-2222 Poster**

**Natural and anthropogenic sources of chemical elements in aerosols over Vladivostok**

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A comparison of natural dust storms and anthropogenic effects of Vladivostok City on air quality was done on 2004 data set. At the beginning of sampling the highest concentrations of elements in aerosols were connected with strong dust storms in China. Concentrations then decreased sharply to background levels, with some oscillations. Local minimum data were observed when wind directions were mainly from west to north and element concentrations in aerosols were not influenced by the anthropogenic sources of Vladivostok's industry and transport.

To identify and account for the contributions of source elements in the content of aerosols, a Target Transformation Factor Analysis (TTFA) was applied, which has been thoroughly described in Hopke *et al.* (1976). For the total set of data in 2004, TTFA demonstrated that clay and slates, and sandstone and soil are the most important natural sources of elements (54.42% - Na; 43% - Fe; 59% - Mg; 47% - Mn; 31% - Cu; 1.96% - Zn; 41.8% - Co; 32% - Ni; 36.0% - Pb) while coal fly ash is the primary anthropogenic source (20.5% - Na; 39.9% - Fe; 25.9% - Mg; 48.1% - Mn; 57.9% - Cu; 26.9% - Zn; 45.8% - Co; 31.8% - Ni; 47.0% - Pb).

At the beginning of observations of dust storms coming from China to Vladivostok, the elements found in natural abundance were Na, Fe, and Mg with strong anthropogenic influence on concentrations of Zn, Pb, Co and Ni by coal fly ash. This is not unusual because coal is widely used in China for domestic heat and for coal-fired power plants. These results confirm our data about active transport of matter by atmospheric jet currents which can quickly and unexpectedly bring various substances to different regions of Russian Far East. After a change in meteorological conditions from 16-30 March 2004, we observed a sharp decrease in the content of atmospheric aerosols and only natural sources affected aerosol content. From 6 April 2004, the TTFA analysis revealed that coal fly ash appeared to be the main contributor of anthropogenic sources to the aerosol in Vladivostok.

**PICES XIV POC\_Paper-2244 Poster**

**Water structure and circulation variability in the Kuril Straits area**

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This study was based on the resources of the Pacific Oceanological Institute Far Eastern Branch of the Russian Academy of Sciences (POI FEB RAS) data bank, including the archive materials of the national research cruises in the Kuril Islands area, the data of the modern field observations carried out by POI FEB RAS in 1977-1993, as well as the global array of average long-term hydrological data of the more than semi-centennial period covering the whole area of the NW Pacific. The role of the Kuril Island Straits in the formation of water characteristics of the Kuril-Oyashio current zone was analyzed. The dependence of water structure formation in the current zone on the variability of water exchange through the straits was revealed. New information about hydrological water characteristic variability was obtained. It was shown that the Kuril-Oyashio Current zone – supplied by transformed Sea of Okhotsk waters, takes place in the sub-strait zones of all relatively deep water straits. In summer, the Sea of Okhotsk water inflow through the straits is the most intense. The Bussol' Strait is the main supplier of the transformed Sea of Okhotsk waters but in the sub-strait zone of the Friz Strait, the current is replenished both by the warmest and saltiest waters, and the coldest and least saline Sea of Okhotsk waters. As a result of the variability of the water discharge to the ocean through the straits, there is a variation of water circulation in the sub-strait areas, and correspondingly, of the thermohaline and dynamic characteristics of the particular zones of the Kuril-Kamchatka Current-Oyashio system. Such variability has both seasonal and interannual character.

**PICES XIV POC\_Paper-2389 Poster**

**Temporal variation of the estimated volume transport through the Korea and Tsugaru Straits**

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The volume transports (VT) of the Korea and Tsugaru Straits was estimated using sea level differences (SLD). The conversion equation from SLD to VT can be computed according to the linear correlation between the VT and the SLD. The sea level data along the Korean and Japanese coasts have been measured for several decades. Thus the VT of the Straits can be estimated by applying the conversion equation to the whole period that the sea level data are present. In the case of the Korea Strait, the SLD was calculated using the sea level data of Pusan and Moji. The transport data by submarine cable was used to get the conversion equation from the SLD to the VT (Lyu and Kim, 2003). The atmospheric pressure effect and the baroclinic part of SLD were removed before computing the conversion equation. In the case of the Tsugaru Strait, Tappi and Yoshioka were selected for the calculation of the SLD. The conversion equation from the SLD to the VT was obtained using the transport data by a vessel-mounted ADCP (Ito *et al.*, 2003). As a result, the mean value of the VT through the Korea Strait is 2.53 Sv and that through the Tsugaru Strait is 1.6 Sv since 1984. Approximately 63% of the VT of the Korea Strait flows out through the Tsugaru Strait.

**PICES XIV POC\_Paper-2249 Poster**

**Monitoring of Peter the Great Bay (Japan/East Sea) on IK-images and hydrological data in April-May of 2005**

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Hydrological surveys in the Peter the Great Bay of the Japan/East Sea and in Ussuriyskiy Bay – part of the Peter the Great Bay - were conducted in April - May of 2005 as part of the TINRO-Centre program of investigations of the biological resources of the Far East seas. At the same time, monitoring of the thermal conditions of the bay was made using data from IK-images from the NOAA meteorological satellite of high resolution (1 km). Intrusion of the cold and salty surface coastal waters along the western coast of the bay and removal of the

warm and less salty near estuary waters along the east coast, were observed in the hydrological data at the end of April. It is necessary to note that a coastal water mass was traced in the north of the bay up to depth of 10-20 meters. In comparison with the first survey in May, the northern and western half of the bay was entirely occupied by near estuary waters, and southern and eastern parts were occupied by coastal masses. IK-images also showed that the coastal waters were superseded in northern and coastal parts of the bay. Downwelling was precisely traced, its border coincided with the frontal zone on the surface and passed on isobath 40-50 meters. This hydrological situation in Peter the Great Bay is a consequence of an abnormal early establishment of strong summer monsoon conditions. Thus, the joint analysis of the IK-images and hydrological data has demonstrated interesting spatial - temporary structure in the waters of Peter the Great Bay, which can be used to determine the hydrological condition of the bay for short-term and long-term forecasts.

#### **PICES XIV POC\_Paper-2248 Poster**

### **Thermal features of water structure of the Japan/East Sea on satellite and ship observations**

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Investigation of thermal fronts and eddies in the Japan/East Sea is of scientific and practical interest. Modern investigations of fronts are practically impossible without use of satellite information. Knowledge of the basic features of the hydrological regime of the Japan Sea has been provided by Uda, (1934); Suda, (1938); Istoshin, (1960); Nikitin, Kharchenko, (1989); Isoda *et al.*, (1991); Isoda, (1994); Ostrovskii, Hiroe, (1994); Danchenkov *et al.*, (1997); Nikitin, Dyakov, (1998); and Zuenko, (1996, 1999, 2000).

In this work IK- and TV-images of high solution (1 km and 4 km) of the surface of Japan/East Sea for 1975-2002 were used. Data from ship observations on sections along 132 °E, (Sangarskiy, Antonovskiy) and oceanographic surveys of 1979-97 were used in addition. More than 900 maps of frontological analysis were constructed. Satellite data on sea surface properties is non-uniformly distributed. The greatest quantity of maps is constructed in March-May and October-November. Fewer maps are constructed in December-February. The greatest coverage fell to 1980-1982, 1985-1986, 1987 and 1992-1996. Hydrological seasons in the Japan/East Sea were based she classification of G. I. Yurasov (1977) in view of variability of vertical thermal structure of waters.

Results of the analysis of satellite images have allowed solution of several problems:

- To allocate areas where surface thermal fronts and eddies are observed.
- To define position of fronts and eddies in various years and seasons.
- To study seasonal variability of position of fronts and eddies in inneryear cycle (time of occurrence and disappearance, the period of existence).
- To investigate interannual variability of position of fronts.
- To study dependencies of distribution and migration of pelagic fishes and other fishery properties from the oceanic phenomena observed on IK-images.

As a result of the analysis of the satellite and hydrological information the following conclusions were reached:

- The satellite information adequately displays basic elements of the hydrological structure, and allows development of valuable qualitative and quantitative information on parameters, existential variability and small-scale structure of frontal zones.
- The basic elements of hydrological structure in the Japan/East Sea are quite stable in all seasons. Some exceptions were seen in the summer period.
- Migratory pathways and distributions of pelagic organisms like *Sardinops sagax melanosticta* and northern fur seals (*Callorhinus ursinus*) can be traced from the position of the Subarctic front along warm and cold streams especially in the spring and autumn periods.
- The generalized scheme of position of surface thermal fronts and eddies of Japan/East Sea is made and their interannual and seasonal variability is considered.

Classification of thermal structure in a northwest part of Japan/East Sea and some elements of its variability will be presented.

**PICES XIV POC\_Paper-2359 Poster**

**The phenomenon of warm water allochthonts in the north-western Japan/East Sea during winter-spring 2003-2004 and peculiarities of the thermal regime**

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According to satellite information, an intensive transfer of subtropical waters to the north-western Japan/East Sea has been taking place since the middle of the summer 2003 and has caused a significant extension of the summer hydrological season. Field investigations have shown that, in general, the thermal conditions of the north-western Japan/East Sea were greatly above the standard during 2003. High temperatures (1-3 degrees above) were observed along the coast of Primorye (except for the zone between 44-45°N). The intensive penetration of warm waters into the north-western part during autumn led to the later intensification of the subarctic front. This process also took place in winter 2003-2004. As a result, patches and streams of water with temperatures above zero were recorded near the Middle Primorye's offshore in November 2003 and in Peter the Great Bay in February 2004.

These processes affected the structure of the plankton community: the presence of the warm water allochthonts (a ocean subtropical zooplankton species) was recorded in winter-spring period which is not their usual time. In the beginning of December 2003 in the Kievka Bight (Middle Primorye), calanoid copepods *Mesocalanus tenuicornis*, *Calanus pacificus*, *Paracalanus parvus*, *Clausocalanus* sp. and siphonophores *Halitemma rubra* were registered in plankton samples. In March 2004 in Vostok Bay (Peter the Great Bay, Southern Primorye), copepods *Mesocalanus tenuicornis*, *Microsetella rosea*, *Oncaea conifera*, *Sapphirina* sp. and *Stephos* sp. were registered in waters with temperatures below zero. So, the bioindication method of research has let us ascertain the facts of warm water coming to the north-western part of the Japan/East Sea during winter-spring period 2003-2004, and this is confirmed by instrumental methods (satellite and hydrological observations).

The research in the Kievka Bight was supported by Award VL-003X1 of CRDF and grant of FEB RAS (04-3-Г-07-056). The research in the Vostok Bay was supported by grants of FEB RAS "Reaction of a biota to changes of the natural environment and a climate" and "Methodology of monitoring of a sea biodiversity".

**PICES XIV POC\_Paper-2302 Oral**

**Water and chlorophyll circulation modeling of Aniva Gulf according to oceanographic data from the year 2002**

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Aniva Gulf is located at the southern end of Sakhalin Island. Questions about the interaction between people and the gulf ecosystem are important, especially with the development of oil projects in gulf area. Calculation of contaminant distribution (oil, dredging and other) is one of the important tasks. Solution to this problem cannot proceed without making prognostications of water circulation in gulf. The gulf is also important as an area of biological productivity. In this paper we make an attempt to use data from oceanographic stations to make prognostications using numerical methods. Data were obtained from 15 oceanographic stations in 2002 (11-12 April, 20-21 June, 07-09 August, 30-31 October). Fields of water circulation, temperatures, salinity and chlorophyll concentration were analyzed. We used the three-dimensional numerical Princeton Ocean Model (POM) for the calculations.

**PICES XIV POC\_Paper-2484 Oral**

**One type of eddy development in the north-eastern Kuroshio branch**

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The analysis of satellite infra-red images indicates that interactions of frontal zone eddies play a basic role in the formation of large eddies going to Southern Kuril region. Several anticyclonic eddies were observed in frontal Kuroshio zone in spring 2004. The first eddy was the large stationary anticyclone A24 (with a 130-mile diameter) and was observed south-east of Hokkaido. The second eddy was mesoscale anticyclone A25 (with a 50- to 60-mile diameter). It was observed at 40°N and probably was formed by the Tsugaru Current. The third eddy was a warm stationary Kuroshio ring A26 and was observed at 37-38°N. The last eddy was a large warm stationary Kuroshio ring A28 (with a 130-mile diameter) and was observed in the southern part of the frontal zone at 151-154°E.

The interaction of eddies A26 and A28 was considered. A26 eddy's centre moved quickly along the anticyclonic circulation path and arrived on the Honshu coast during 2004. From there it moved away from the Honshu coast in December 2004. This movement can be considered as a wave reflecting from an obstacle. A28 eddy moved quickly westward (1-2 miles/day) along the Kuroshio front. This movement can be considered as an opposite wave along the front. A28 eddy moved along anticyclonic circulation path between 146-148° E and reached 145° E at the end of November 2004.

The centre of A26 eddy was found at 143°E during this period. The distance between the centres of the eddies decreased to 90-100 miles and the edges of the eddies contracted. A new anticyclone (with a 100-mile diameter) was formed as result of this interaction. The new eddy was probably formed by the interactions of direct and reflecting waves from the Honshu coast. The new anticyclone was situated at 145° E in mid December 2004. Part of A26 eddy's water remained near the Honshu coast. The size of the formatted eddy did not exceed more than 40-50 miles. This new eddy was called A28 again. The eddy's centre moved quickly northward to 40° N and then occupied a stationary position. A28 eddy will probably define conditions in the southern Kuril region in summer 2005.

**PICES XIV POC\_Paper-2459 Oral**

**Flux of methane to the atmosphere from the Okhotsk Sea**

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It is known that methane concentration is growing in the atmosphere by about 1% per year. Methane creates a greenhouse effect that contributes to Global Climate Change. What is the source of methane in the Okhotsk Sea? Previous investigations of methane distribution in water columns of the Okhotsk Sea (1984-2004) and the monitoring of methane have shown that the methane flux from the interior to the water column increases during a period of seismo-tectonic activity. In this case, fault zones open and gas hydrates destroy. Methane goes from the decomposition of gas hydrates to the water column and creates sound-scattering flares (acoustic anomalies) in an echogram. Methane flare concentrations in water columns are usually high, 10000-20000 nl/l or more. From oil-gas bearing layers, methane migrates via fault zones to the water column as well as seeping out of vents with and without acoustic anomalies, correspondingly. Methane anomalies (500-2500 nl/l) form in bottom water and upper layers of the water column. As a result of our investigations, we found the following:

1. Sources of methane are oil-gas bearing sediments, discharges of gas hydrates and modern bacteria-generating production.
2. Methane anomalies exceed background values by about 10-10000 times.
3. The flux of methane goes from sediments to the water column and to the surface and to the atmosphere mostly in the shelf area. More methane occurs in the spring and autumn seasons. Therefore, the methane flux from the Sea of Okhotsk will increase the methane concentration to the atmosphere which will add to the greenhouse effect and drive Global Climate Change. Methane will also increase during the period of seismo-tectonic activity this area.

**PICES XIV POC\_Paper-2485 Oral**

**Bidecadal variability in the intermediate waters of the northwestern subarctic Pacific and the Okhotsk Sea in relation to the 18.6-year nodal tidal cycle**

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Using historical oceanographic data, we investigated the long-term variations of the intermediate waters in the four regions in the northwestern subarctic Pacific: Oyashio (OY), Okhotsk Sea Mode Water (OSMW), Upstream Oyashio (U-OY) and East Kamchatska Current (EKC). We found bidecadal oscillations in various water properties that are synchronized with the 18.6-year nodal cycle. In periods when the diurnal tide is strong, apparent oxygen utilization (AOU) and phosphate are low in OY and OSMW, and the thickness of the intermediate layers is large in OY, OSMW, and U-OY. Around the mesothermal (temperature maximum) water, potential temperatures are low in the areas on the Pacific side, and high in OSMW. The mixing ratio of OSMW in the U-OY water is high. These bidecadal oscillations can be explained by the vertical mixing around the Kuril Straits induced by the diurnal tide whose amplitude is modulated by the 18.6-year period nodal tidal cycle. Higher sea surface salinity (SSS) water around the Kuril Strait caused by stronger tidal mixing is transported northward along the cyclonic Okhotsk Sea Gyre, and possibly enhances the formation of the dense shelf water (DSW). This makes AOU, phosphate and potential vorticity lower in OSMW and OY.

**PICES XIV POC\_Paper-2432 Oral**

**Meridional mass and heat transport across the 38-40°N line in the East/Japan Sea**

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By combining velocity estimates at 700m levels from Argo data, and geostrophic calculations from a CTD section made across the East/Japan Sea between 38-40°N in 1999, we were able to obtain a section of absolute zonal velocity. In general, barotropic components are dominant especially below the thermocline, since the vertical stratification is very low. The velocity section well reflects the meander of the flow along the polar front. The total volume and heat transports through the section are 1.6 Sv and 0.15 PW respectively. These numbers are smaller than those estimated in the Korea Strait by 30 to 40% because the CTD section does not capture the strong and narrow currents along the Korean and Japanese coasts. A meridional overturning stream function estimated from the velocity section shows that a meridional overturning circulation exists about 1 Sv below the thermocline.

**PICES XIV POC\_Paper-2228 Oral**

**On the problem of bottom water formation on the shelf of Peter the Great Bay (Japan/East Sea) in spring**

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Variability of water structure on the shelf and at the continental slope is investigated using data from two surveys carried out in Peter the Great Bay in late April of 2004 and 2005. The basic water masses of the area were determined and their distribution was considered. The year 2004 was peculiar in the sense that water stratification remained rather strong for the spring period. The Surface Coastal water mass was observed down to a depth of 30-50 m. Intermediate and bottom layers on the shelf were occupied mostly by Deep Shelf water. Bottom Shelf water with a thickness of 5-20 m from the bottom and high density (temperature 0.0 to -0.6°C, salinity 34.00-34.12 psu), occupied a sufficiently large area in the center of the Bay between isobaths 40-90 m. This water was formed as the result of winter convection and, most likely, was slowly displaced downwards on the slope. The Japan/East Sea Proper water was observed near the continental slope below the 50 m horizon. In the spring of 2005 the conditions differed considerably. Water stratification was weak. Influx of subarctic waters to the central and southern parts of the Bay was traced in the surface layer. The Surface Coastal water was replaced to the northern part of the Bay. Water temperature at the surface of the Bay was 0.5-1.5°C below

that in the previous year. Strong downwelling was observed near the frontal zone between Surface Coastal and Surface Subarctic waters. The downstream caused fast destruction of the Bottom Shelf waters, which were observed in the western part of the Bay with the temperature only 0.1 to -0.8°C and salinity 33.96-34.04 psu. Water temperature near the bottom on the shelf was 0.5-1.0°C higher than in the previous year. The intensive advection of shelf waters to the continental slope area was noted. These waters were traced at a distance of 10-15 miles from the slope at the 80-350 m layer. Water temperature near the continental slope in this layer was 0.7-1.2°C lower than in the last year. The hydrological situation of 2005 was the consequence of an anomalous early establishment of a summer monsoon and its high intensity. In April the frequency of winds in the southern quarter was 74 %, and 48 % the wind rate was >10 m/s. In the same period of the previous year winds in the southern quarter were only 24 % and their rate and usually did not exceed 10 m/s. Thus, besides winter processes, spring processes are also concluded to be an important factor controlling deep water formation and ventilation. Slope convection can be cancelled by vertical mixing and downwelling in spring which limits deep layer ventilation. On the other hand, downwelling is an effective mechanism for the shelf bottom ventilation.

#### ***PICES XIV POC\_Paper-2296 Poster***

### **Research on Bering Sea geostrophic circulation from satellite altimetry data: Two approaches to solving the problem**

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In order to find the best way to analyze water dynamics in the Bering Sea using satellite altimetry data, two ways of calculating geostrophic currents are considered:

1. Calculation of geostrophic currents using the sea surface height from satellite altimetry data and the geoid model.
2. Calculation of geostrophic currents using the average climatic field of geostrophic currents constructed from Levitus climatology and from sea level anomalies calculated from satellite altimetry data.

A comparison of the results of current calculations using these methods with the survey data of the R/V *TINRO* (25 June – 27 September, 2002) was done. The results of the analysis showed that:

- from constructed charts of the currents using the ocean climatology, and from constructed charts of the currents constructed using the geoid model, all basic dynamic formations allocated on oceanologic survey data were observed;
- geostrophic currents estimated with the ocean climatology better correspond to the currents estimated according to oceanologic survey data;
- the greatest distinctions for the currents calculated from the ship data and currents calculated from the satellite altimetry data are observed in the shelf zone of the Bering Sea;
- on charts of the geostrophic currents constructed from the ship data, small-scale formations in some cases are not displayed owing to the large distance between oceanological stations.

#### ***PICES XIV POC\_Paper-2344 Oral***

### **Numerical study of the general circulation in the Japan/East Sea with simple assimilation of temperature and salinity data**

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The numerical model of the Japan/East Sea seasonal variation was performed by means of a regional ocean circulation model. The main objective was to get a better understanding of the Japan/East Sea dynamics and thermodynamics on the basis of the available Generalized Digital Environmental Model (GDEM) dataset of climatological temperature and salinity annual variations. The study focuses on the following issues: a) the analysis of seasonal variation associated with varying Tsushima Strait transport and annual variability of the wind stress; b) the salinity belt structure produced by reverse motion of the Tsushima warm and salty water, its origin and dynamics; c) the Japan/East Sea intermediate water dynamics and its dependence on the seasonal variation of the subpolar front strength. The model results show that seasonal factors like winter convection, strong monsoon and weakening subpolar frontal currents are responsible for the intermediate water spreading

from the region of their origin off Peter the Great Bay. The thermohaline property of this water is a result of a mixture of northern cold and less saline flow with salty and warm water intruded into the northern gyre system due to changing inflow-outflow balance among major straits.

***PICES XIV POC\_Paper-2381 Poster***

**Especially dangerous wave heights and safety of the fishing fleet in the Northern Pacific**

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Big waves are more often the cause of vessel and cargo loss in the Northern Pacific. Especially dangerous heights of 8 m and more dampen the success of the trade fishery in the Northern Pacific. For successful fishing, it is necessary to know the distribution and the time of appearance of especially dangerous wave heights. Dangerous wave heights are observed during the cold season, especially from November to February. Two zones of maximum frequency for especially dangerous heights occur in the West and East of the Northern Pacific. Understanding the peculiarities in distribution and frequency of dangerous wave heights will allow us to provide security to fishery ships in the Northern Pacific.

***PICES XIV POC\_Paper-2383 Poster***

**Ice formation is especially dangerous for fishing boats in the Northern Pacific and for the safety of the fishing fleet**

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Ice formation (or icing) is especially dangerous to fishing boats in the Northern Pacific. Dangerous icing of the boats occurs when intensive accretion of ice results in more than 4 t/hour and occurs when:

- a) the speed of wind is higher than 15 m/s and the air temperature is lower  $-3^{\circ}\text{C}$ ;
- b) the wind speed is from 9 to 15 m/s and the air temperature is lower  $8^{\circ}\text{C}$ .

In the Northern Pacific especially dangerous icing is observed along the eastern seacoast of Kamchatka Peninsula, Kuril Islands and the extreme North East Pacific, and by the North American sea coast, mainly in winter. This ice formation (icing) on boats is the cause of boat loss, diminishes the effectiveness of Fishing Fleet activity, and decreases the fishery owing to the unfavourable conditions. The possible use of icing maps of the North Pacific by fishing boats to avoid dangerous zones is considered.

***PICES XIV POC\_Paper-2319 Oral***

**Ocean surface waves play an essential role in air-sea interaction from an atmosphere-wave-ocean coupled model**

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Previously, most ocean circulation models have overlooked the role of the surface waves, and thus have produced insufficient vertical mixing. As a result, nearly all the ocean circulation models face some common problems such as when the simulated summertime SST is overheated, the simulated mixed layer is too shallow and the strength of the thermocline is too weak due to insufficient mixing in the upper ocean compared with observations. As the ocean surface layer determines the lower boundary conditions of the atmosphere, this deficiency has severely limited the performance of the coupled ocean-atmospheric models and hence the numerical studies of climate. For example, the simulated cold tongue in the tropical Pacific is too cold for all atmosphere-ocean coupled numerical models. Recently we developed a 3-D wave-circulation coupled theoretical model, and set up a wave-circulation coupled numerical model and an atmosphere-wave-ocean coupled numerical model. With a third generation wave numerical model, the wave-induced vertical viscosity and diffusivity are calculated.

The wave-circulation coupled numerical model results indicate that the wave-induced vertical mixing can penetrate down to 100m depth. In boreal summer the wave-induced mixing is strong in the southern oceans

south of 30°S, and in boreal winter it is strong in the North Pacific and the North Atlantic north of 30°N, as well as in the southern oceans south of 40°S. The new scheme has enabled the mixing layer to deepen, the surface excessive heating to be corrected, and excellent agreement with observed global climatologic data has been achieved. For example, with the wave effect considered, the mean correlation coefficient between simulation and Levitus data in the upper 100m along a section of 35°N in the Pacific and Atlantic Oceans is raised to 0.93 from 0.68 without wave effect. In the southern hemisphere, similar results are achieved. The atmosphere-wave-ocean coupled numerical model results indicate that the too cold tongue in tropical Pacific is much improved, and the sub-arctic region may play a much more important role in climate change than previous understood.

All these results suggest that ocean surface waves can greatly improve the performance of numerical models in the upper ocean. Our study indicates that surface waves are essential for mixed layer formation, and that they are the primary drivers of upper ocean dynamics. Therefore, surface waves play a critical role in the climate studies.

**PICES XIV POC\_Paper-2386 Oral**  
**Realtime monitoring of oceanic state variables in Kangjin Bay, South Sea, Korea**

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A realtime (RT) monitoring system for oceanic state variables was developed and has been operating since April, 2004 in Kangjin Bay, South Sea, Korea. The RT production of a data stream and display on an Internet web page is made possible in continuous functions of various system elements. Detailed technical information for the RT monitoring system is described in Ro *et al.* (2004). The water quality parameters, current and meteorological conditions are continuously monitored with very high sampling resolution (10 min) throughout the year and are being published on internet web pages (<http://oceaninfo.co.kr/kangjin>). This study focuses on the formation of the hypoxia in the shallow Kangjin Bay in the South Sea by understanding the oxygen supply and consumption processes in the water column and at the bottom sediment interface in connection to the pulse type Dam water discharge during the monsoon summer season. The occurrence of the hypoxia caused by water discharge in the Bay is suspected to cause the dramatic mass death of local shell-fish. This study will elucidate a series of physico-chemical processes and their implications for the local eco-system. We have found a very significant and striking mechanism for the formation of the hypoxia in Kangjin Bay which was driven by the abrupt dam water discharge with large volume. This has caused a strong halocline (pycnocline) which has then inhibited the supply of aerated surface water into bottom layer where consumption of oxygen is taking place by the organic sediment oxygen demand. The series of the physical processes were observed from field work records of vertical profiles of water quality, and tidal current and bottom sediment analysis.

**PICES XIV POC\_Paper-2452 Poster**  
**Structure of seawater properties profiled by the Argo floats in the Ulleung-do area (East/Japan Sea), 2003-2004**

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This study analyzed the temperature-salinity structure around Ulleung-do Island (UI) waters by using all CTD profiles obtained by Argo floats in the period of 2003. 10. to 2004. 9. The raw CTD data were calibrated and tested for error contamination and quality controlled data were then compared to Korean Oceanographic Data Center (KODC) data obtained in the same period and to the climatology dataset, Generalized Digital Environmental Model (GDEM) published by the U.S. Navy. The comparison between Argo profile data and KODC shows good agreement, while that between Argo and GDEM shows a salinity discrepancy up to 0.15 psu. The waterbody in the upper 800 m around Ulleung-do Island turned out to be composed of three major water masses, which is in accordance with traditional water characteristics. In the upper layer, there exists a water mass of higher temperature and lower salinity in the western part of the UI which is under the influence of summer-time Tsushima warm water diluted by the river runoff. The salinity below 300 m appears very homogeneous in all salinity profiles and is less than 34.1 psu, while the temperature shows larger variance of up to 9.0°C. The behavior of three Argo floats released in the western part of UI shows striking differences in that their fates and trajectories diverged into three different paths depending on the water masses they rode. The

CTD profiles obtained with the high sampling rate by Argo floats provides us with more information to understand the spatial-temporal variability of seawater properties in the study area.

**PICES XIV POC\_Paper-2470 Poster**

**Structure of an anticyclonic eddy in the southern Kuril Islands region and its influence on water dynamics and the saury fishery**

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The evolution of an anticyclonic eddy in the southern Kuril Islands region during the year 2000 is considered from satellite (infrared) IR and altimetry data. The eddy started to form off Cape Inubo in 1997 and disappeared at the end of 2000. Within the period of observations (January-November, 2000), the eddy had passed 260 miles northeastward with an average velocity 0.75-0.80 miles/day. The maximal velocity of its movement was observed in late April and in May (1.3 miles/day). The spatial scales of the eddy were 90-130 miles. The rotating current inside the eddy had a velocity up to 70 cm/s, according to the satellite altimetry data.

Oceanographic data from the R/V *Boso-maru* (Japan) obtained from 2 sections crossing the eddy in August 3-5, 2000 were used for analysis of the eddy structure. The eddy features were observed in the whole 1000-meter water column. Maximal geostrophic velocity inside the eddy (23-38 cm/s) was observed in the 70-120 m layer. The thermohaline structure of the eddy is described in detail.

Under the influence of the anticyclonic eddy, water dynamics of the southern Kuril Islands region essentially changed: water transport by the first branch of Oyashio decreased considerably and sometimes this branch disappeared; the main Oyashio flow shifted to the second branch of the Oyashio. These changes in water circulation are the reason for saury fishing grounds formation on the ocean side of the region (on the Subarctic front to the east from 148-149°E) and for the Russian saury fleet moving to the ocean in October–November of 2000.

**PICES XIV POC\_Paper-2523 Poster**

**Methane anomalies in the Okhotsk Sea**

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Research is aimed to explore the features of fossil methane emission and distribution induced by modern regional and local variable geological settings in the Okhotsk Sea. Tectonically generated pathways related with hydrocarbon sources (oil-gas deposits, gas saturated sediments, gas hydrates, coal bearing sediment complexes and others) are considered to be the main structures of methane leaking to the water column. Three basic geological patterns controlling methane emission are pointed out: sporadic single local vents/flares within the intersections of the disjunctives, wide areas of methane steady seepage through the grids of local faults over oil-gas deposits and methane emission via the abrasion zones of folded structures. Methane anomalies (up to 30,000 nl/l) were found in all water masses of the sea but their spatial varieties have genetic relations with different hydrocarbon sources which suggests a high permeability of active fault zones and geodynamic, seismic and geochemical activity in some areas, especially along the western Okhotsk Sea.

**PICES XIV POC\_Paper-2583 Poster**

**Monitoring of baroclinic circulation conditions and ice cover by GIS methods in the Far Eastern Seas**

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Applying methods of modern GIS technology, complex maps of atmospheric pressure distributions above the earth and their anomalies in January-February, as well as the localization of the ice edge in Japan/East, Okhotsk,

Bering seas in March of 1997-2003, were compiled. An analysis of baroclinic circulation processes above the Asian-Pacific region ( $60^{\circ}$  E –  $160^{\circ}$ W,  $20^{\circ}$  –  $80^{\circ}$  N) was carried out and the spread of the ice is assumed to clear up these inter-annual differences. They appear generally in the position and intensity of the Siberian anticyclone and Aleutian Low. Especially evident distinctions were found in the above-earth fields and location of the Siberian anticyclone, as well the Aleutian Low centers in the years of extreme ice cover. It was determined that extreme low ice cover in the Okhotsk sea during 1997, when the area of ice cover was 53,7 % in March, originated in the weak intensity of the Siberian anticyclone and a shift of the Aleutian Low to the East. The main cause of extremely high ice cover in the Okhotsk Sea during 2001, when area of ice cover equaled 97,6 %, was a shift to the north and sharp drop in pressure of the Aleutian Low in February, when the anomalies in a small area reached minus 11 gPa. In the Bering Sea, the year 2001 was featured by extremely low ice cover, in which the ice cover area totaled only 31 %. This phenomenon was due to the Bering Sea being under the influence of the front part of cyclones that are forming the Aleutian depression.

**PICES XIV POC\_Paper-2268 Oral**

**Seasonal variability of oceanological conditions in the southern part of the Okhotsk Sea from CTD surveying on standard section Cape Aniva – Cape Dokuchaev**

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Regular observations on a standard oceanological section give us excellent data for investigating seasonal and interannual variations of fish and other types of marine biota habitat. The section Cape Aniva–Cape Dokuchaev (AD), which crosses the southern part of the Okhotsk Sea from the southeastern end of Sakhalin Island to the northeastern end of Kunashir Island, is the most informative among sections of the Sakhalin shelf. This section also crosses zones of the East Sakhalin Current and Soya Warm Current. Multiyear mean temperature and salinity distributions on the AD section in May were analyzed to describe oceanological conditions in spring. We have found that the influence of the Soya Warm Current in May is relatively weak. The cold intermediate layer is well-expressed. Low salinity waters were found in the upper 50-meter layer being formed as a result of sea ice melting. The influence of Soya Warm Current is very significant in the southeastern part of the AD section in summer; the Japan/East Sea warm waters were observed in the upper 200-meter layer on the shelf of Kunashir Island. At the same time, we have found the cold intermediate waters with temperature  $-1.3^{\circ}\text{C}$  on the shelf of Sakhalin Island. The East Sakhalin Current transports relatively warm and fresh Amour River waters to the southern part of the Okhotsk Sea in the fall season. The cold intermediate layer is destroyed in November. At the same time, the influence of the Japan/East Sea warm waters is significant on the shelf of Kunashir Island. We have also analyzed ADCP current data that were measured near Cape Aniva and Cape Dokuchaev.

**PICES XIV POC\_Paper-2411 Oral**

**Distribution and transport variations of source waters for North Pacific Intermediate Water formation revealed by multiple tracer analysis**

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In order to reveal time and spatial variations in the distribution and transport of the source waters for the North Pacific Intermediate Water (NPIW) formation, we calculated the source water components by multiple tracer analysis and examined their transports off the east coast of Japan. In each season of 2001, hydrographic observations were made on a repeat section called the Oyashio intensive observation line off Cape Erimo (OICE), which extends southeastward from the Hokkaido coast. A least square multiple tracer analysis using temperature, salinity, oxygen and potential vorticity was applied to calculate isopycnal mixing ratios at densities  $26.7 - 27.3 \sigma_{\theta}$  among three source waters, which are defined as the Okhotsk, East Kamchatka (EK) and Kuroshio waters, respectively. Combining the mixing ratios with geostrophic currents referred to 1500 dbar, we calculated their transports across OICE. In the mixing ratio distribution, it is clearly seen in any season in the Oyashio area that the EK component increases with depth/density while the Okhotsk component is almost confined at  $26.7-27.0$ , suggesting that they are mixed to form Oyashio water with a different mixing ratio at each density. In the transports contributing to NPIW formation, the Okhotsk and EK components commonly have a clear seasonal signal, with a maximum in winter and minimum in summer, whereas we cannot see any

significant seasonal signal in the Kuroshio component. In an annual average, the NPIW-contributing Okhotsk transport (3.5 Sv for 26.7 - 27.3  $\sigma_\theta$ ) is larger than the EK transport (1.5 Sv).

**PICES XIV POC\_Paper-2592 Poster**

**Daily variation of abnormal ocean conditions in the northwestern Pacific Ocean using NGSST satellite data**

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The New Generation Sea Surface Temperature (NGSST) Development Group (Leader: Hiroshi Kawamura) has been working on a new satellite-based SST product, which utilizes benefits of the modern satellite/*in situ*-based ocean observing systems and overcomes weaknesses of the present operational SST products since 2000 (Guan and Kawamura, 2004). Real-time generation and distribution of the new SST products for open oceans have started.

The daily variations of SST in the northwestern Pacific Ocean were studied in this paper. Spatio-temporal variations which have global and short-term changes were captured by NGSST, in particular with respect to the abnormal phenomena such as cold water extension in the Yellow Sea, local heating in the East China Sea, cold and warm water patches caused by typhoons in the East/Japan Sea, and huge tidal fronts in the Kuril Islands. Local heating occurred on the surface layer in the East China Sea for 15 days (August 4-18, 2004). The surface cooling of cold water lower than 10m suddenly extended from the coast of Shanghai-Qingdao in China to the southeastern part in the East China Sea for 5 days (March 25-28, 2005). A huge cold water mass lower than 10m temporally varied in the Kuril Islands for 6 days (August 26-31, 2004). Abnormal cold and warm water caused by typhoon Megi occurred in the East/Japan Sea for 7 days (August 19-25, 2004). The occurrence of daily abnormal ocean conditions are caused by typhoons, monsoons, sea surface wind, low salinity and tidal currents in the northwestern Pacific Ocean.

**PICES XIV POC\_Paper-2460 Oral**

**Spatial phytoplankton distributions affected by eddy dynamics in the Eastern Kamchatka Current and Oyashio regions during the spring between 1998-2004**

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In this study, we use satellite multi-sensor remote sensing to investigate the relationship between the eddy field and the distribution of phytoplankton biomass in the Eastern Kamchatka Current (EKC) region during the spring between 1998-2004. We employed ocean color (Chlorophyll-*a* (Chl-*a*), SeaWiFS), photosynthesis active solar radiation (PAR, SeaWiFS), sea surface temperature (SST, AVHRR), and sea surface height anomaly (SSHA, AVISO) datasets. Primary production was calculated using the vertically generalized production model (VGPM) of Behrenfeld and Falkowski (1997). Phytoplankton biomass in the EKC region was the highest in the western sub-arctic gyre region during the spring. The distributions of phytoplankton biomass were different for each year. On the other hand, a number of mesoscale eddies propagated from the western Bering Sea or the Aleutian chain. The positions of eddies affecting surface flow also differed for each year. Our results indicate that high chl-*a* regions would be transported to offshore by the anticyclonic eddy which is located along the south-eastern Kamchatka Peninsula. While the anticyclonic eddy was identified near shore during spring in 1998-2002 and 2004, its location was offshore in 2003. Therefore high chl-*a* distributions show different spatial patterns reflected by the eddy field. These results suggest that the spatial eddy field should affect high chl-*a* regions. Further analysis may be achieved to clarify the spatial relationships between high chl-*a* regions and the eddy field.

**PICES XIV POC\_Paper-2361 Oral**

**A review of the investigation and study on Yellow Sea circulation**

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The Yellow Sea is a shallow semi-closed shelf sea, which is adjacent to the East China Sea on the south and connected to the Bohai Sea on the north. The bottom topography of the Yellow Sea is characterized by the Yellow Sea trough stretching from southeast to north with a water depth of 70m to 100m, on both sides of which the isobaths are basically parallel to the coastline with quite a slope on the east side and a wide shallow water area on the west side. The Yellow Sea is affected little by the Kuroshio. In the Yellow Sea, the tidal current is dominant and the residual current is very weak with a speed of less than 5cm/s and quite unstable in direction. Thus, it provides difficulties for observing and studying the Yellow Sea circulation. As well, there are many fisher-boats and very active fishing activities all year round in this region and this brings lots of risks to long-term continuous observational moorings. Up to now, Yellow Sea circulation is not well understood due to limited of current-observing data. There are still serious controversies remaining on Yellow Sea circulation. In this paper, the investigation and study on Yellow Sea circulation are reviewed and some argued questions will be put forward.

**PICES XIV POC\_Paper-2431 Oral**

**Interannual variability of cold and warm seasons and their duration in the North West Pacific**

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The important factors determining the development of production processes in the ocean are the beginning, duration and ending of the phenological seasons. These characteristics vary from year to year. The sea surface temperature (SST) is a well illustrated characteristic for them, as it is the parameter resulting from ocean-atmosphere interaction. The analysis of weekly SST maps for the North West Pacific (including the Okhotsk and the Bering Seas) allowed us to reveal some essential interannual differences in the character of winter cooling and summer warming. An important regularity was found: interannual variability of seasonal dates at the beginning is opposite in sign to the variability of their duration. Thus, the earlier a season begins, the longer it will stay (and *vice versa*). This regularity allows a rather early prediction of the end of the current season. The beginning of a season was considered as the crossing of a chosen latitude or longitude by a chosen isotherm. The persistent duration of this isotherm was chosen to estimate the seasonal duration. Variability of ice conditions in some regions of the above-mentioned seas follows the same regularity. Therefore, it can also be used to predict the time of ice edge retreat for such regions as the West Kamchatka and South Kuril Islands (Sea of Okhotsk), St. Mathew Island and 62°N (Bering Sea). For the Bering Sea a trend to shortened cold seasons was detected.

**PICES XIV POC\_Paper-2225 Poster**

**Water mass transformation in the Japan/East Sea**

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The changing of climate influences the thermohaline structure and ecosystem of the Japan/East Sea. The idea for this study is that by calculating the vertical mass flux as a function of the density of the surface water rather than as a function of location, it is possible to deduce the amount of water mass formed or modified in any given density range by air-sea fluxes of heat (H) and fresh water (E-P). Our aim is to estimate the formation rate of water with density similar to intermediate water.

NCEP/NCAR reanalysis data are used to estimate the rate water mass transformation in the Japan/East Sea from 1948 to 2002. The amount of surface water that sinks and forms the intermediate mass is defined. We found

that the formation rate of water with the density of High Salinity Intermediate Water ( $\sigma_\theta > 27,3$ ) decreased and the formation rate of water with density  $26.9\text{--}27.3\sigma_\theta$  increased. Some of this water sinks to form Low Salinity Intermediate Water. The total formation rate of intermediate water has not changed considerably from 1948 to 2002. Comparison of the formation rate with atmospheric indices shows that the formation of the High Salinity Intermediate Water is primarily influenced by the Siberian High, which is associated with the Arctic Oscillation, and, secondarily influenced by the Aleutian Low.

**PICES XIV POC\_Paper-2273 Oral**

**Seasonal and interannual variation of currents in the western Japan/East Sea: Numerical simulation in comparison with infrared satellite imagery**

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The Japan/East Sea is a mid-sized East Asia marginal sea, while its current system is similar to that of large-scale oceanic circulation. In particular, the Sea has its own system of western boundary currents (WBC), the northward East Korean Warm Current (EKWC) and southward cold Primorye (Liman) Current and its continuation, North Korean Cold Current. After the separation from the western coast, the WBCs converge, forming a zonal Subarctic Front. The circulation in the northwest Japan/East Sea, where the separation occurs, is highly variable both on seasonal and interannual timescales (Zuenko, 1996, 1999; Danchenkov *et al.*, 1997; Lobanov *et al.*, 2001; Nikitin and Kharchenko, 2002). In this study, the focus is on the seasonal variation of the separation latitude and Subarctic Front and on seasonal and interannual variation of currents off Vladivostok and North Korea (in the area north of the separation latitude). Numerical simulations are performed with the use of the Marine Hydrophysical Institute (MHI) oceanic model (Shapiro and Mikhaylova, 1992). Monthly buoyancy and 1998-2000 wind forcing is applied, based on data from NCEP Reanalysis and Global Precipitation Climatology Projects. The simulated EKWC intensifies in late summer–autumn when the increased non-linearity facilitates the onset of separation and the separation latitude shifts southward. Simulation results suggest that variations in currents off Vladivostok and North Korea can be associated, to a considerable extent, with the change of wind. The simulation results are confirmed by patterns derived from the A-Highers SST (Sakaida *et al.*, 2000) and New Generation SST (Kawamura *et al.*, 2005).

**PICES XIV POC\_Paper-2284 Poster**

**Analysis of seasonal variability of hydrodynamic structures in the Sea of Okhotsk and their dependence on baric systems in the atmosphere**

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In the given study an attempt has been made to analyze hydrodynamic structures in the Okhotsk Sea on the basis of numerical experiments using a quasistationary baroclinic model (Vasiliev, 2002) and a classification of the baric systems (Polyakova, 1999). In brief, the essence of the method is in the following: a prognostic model is created using the principles of self-similarity or vertical similarity, *i.e.* it is just a function of their stratification. The input information for the model is a global array of the monthly averaged climatic data of surface temperature and salinity in the nodes of a regular  $1^0 \times 1^0$  grid, and average monthly fields of the atmospheric pressure, corresponding to certain types of the baric systems. Bottom topography, coast-line framework, water-exchange on the liquid margins,  $\beta$ -effect, coefficients of the vertical and horizontal turbulent exchange are also considered. This classification of synoptic processes is based on the dislocation of the main trajectories of cyclones over Far Eastern Seas and the North Pacific.

Analyses of charts for the transport streamfunctions have shown that the study areas are characterized by quasi-stationary hydrodynamic characteristics not dependent on atmospheric circulation, and specific hydrodynamic features dependent on atmospheric baric systems originating over the ocean surface. The common feature for all charts is the cyclonic activity in the Okhotsk Sea with a mosaic of anticyclonic whirls near the South Kuril Islands. The specified hydrodynamic regime creates optimum conditions for active fishery development in the investigated water area.

**PICES XIV POC\_Paper-2503 Invited**

**A first look at the new IPCC AR4 climate model simulations over the North Pacific**

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The 20<sup>th</sup> century and future climate system are assessed based on 56 ensemble runs from 19 coupled atmosphere–ocean general circulation models (AOGCMs) and their corresponding control runs. All models simulated the late 20<sup>th</sup> century warming to various degrees and 60 % of the models produce about the right level of variance for wintertime surface temperature anomalies. Models with the best simulations generally have better resolution of surface land and sea ice processes. Spatial and temporal distributions of warm anomalies are different among the ensemble members, but similar to observed intrinsic variability. For future scenarios two approaches are taken. We first look at the large scale patterns of SST and climate indices such as the Pacific Decadal Oscillation, the Pacific North American pattern and the Aleutian Low relative to the background variability from their control runs. In the second approach we investigate upscaling of parameters important to the ecosystem for the Bering Sea; these include surface radiative, sensible and latent heat fluxes, wind speed cubed, sea ice parameters, north-south wind components and the curl of the wind stress.

**PICES XIV POC\_Paper-2254 Oral**

**Seasonal hypoxic zone adjacent to the Changjiang Estuary**

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There is a large south-northward hypoxic zone adjacent to the Changjiang Estuary during the warm season, similar to other large runoffs in the world. Dramatic low dissolved oxygen (DO) concentrations, less than 0.8mg/l, were found during the cruise of September 2003. The hypoxic zone (DO<2mg/l) was about  $2 \times 10^4$  km<sup>2</sup> along the 20-50m isobaths. SBE 911<sup>+</sup> CTD casts were carried out at 32 stations and Chl-*a*, turbidity, and DO concentrations were measured at the same time as temperature and salinity in order to examine the relationship between the hydrological environment and the hypoxia. There is a complex water mass system in this area: the Changjiang discharge plume, with high nitrate and ammonia concentrations, runs to the north-east of the estuary in a 5m surface layer. Water with salinity less than 30 can have an influence on Cheju Island. Under this water mass lies cold water (sal<32, temp<16<sup>o</sup>C) from the Yellow Sea that intrudes to the inner shelf along the 50-m isobath. High salinity water (sal>34) from Taiwan Strait runs to the north along the coastal side of the 50-m isobath at the bottom. It returns to the south-east when it reaches the 32<sup>o</sup>N latitude. A high Chl-*a* concentration band was found but did not match the hypoxic zone very well. Lowest turbidity is found in the isopycnocline and resuspended particulate material can almost not cross the isopycnocline. Particulates of dead algae in the upper layer were transported to other areas rather than being deposited and decomposing locally. The hypoxia occurred at the strong isopycnocline where the density difference is large due to the large salinity difference between Changjiang discharge (sal<24) and salty water from Taiwan Strait (sal>34). Strong stratification prohibits the mixing down of DO in the upper layer, that was obtained from the atmosphere or produced by algae growth. Particulate organic carbon (POC) in the lower water layer is advected by Taiwan Strait Water or decomposes in the sediment and consumes the DO to produce a hypoxia condition. It is so sensitive to meteorological conditions that no hypoxia was found after 3 days of the onset of north winds.

**PICES XIV POC\_Paper-2255 Oral**

**Changes in ecosystem in the western North Pacific associated with global warming**

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To predict the effects of global warming on ecosystem dynamics and the effects of those changes on biogeochemical cycles, oceanic CO<sub>2</sub> uptake, and fishery resources, we need to develop 3-D global models which explicitly represent dynamics of oceanic circulation, ecosystems and fishes. We developed a global 3-D ecosystem model extended from NEMURO (North Pacific Ecosystem Model Used for Regional Oceanography)

of PICES (North Pacific Marine Science Organization), which includes phytoplankton and zooplankton divided into two and three groups, respectively, and coupled with carbon and nutrients cycles. NEMURO has also been coupled with a fish bioenergetics and a population model for two species of pelagic fish. Using data sets of observed climatology and simulated fields (COA-GCM developed by CCSR/NIES) as boundary conditions for our ecosystem model, we conducted experiments for demonstrating the effects of global warming on ecosystems and pelagic fish. The model results show increased vertical stratification in the subtropic-subarctic transition zone associated with global warming. As a result, in the transition zone, primary production and diatoms as percentage of total phytoplankton drastically decrease at the end of the 21<sup>st</sup> century. In the biogeochemical cycles, rain ratio and e-ratio, a ratio of export production to primary production, are also drastically changed due to transition of plankton groups and warming. For Pacific saury, a popular fish in Japan, global warming leads to a decrease in its body length and change in its migration route.

**PICES XIV POC\_Paper-2487 Oral**

**Possible mechanism of bi-decadal North Pacific ocean/climate variability in relation to the 18.6-year period nodal cycle**

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Bi-decadal oscillation is known to be dominant in inter-decadal mid-latitude North Pacific climate variations, and influences the ocean as well as marine ecosystems. Osafune and Yasuda (2005) discovered bi-decadal oceanic fluctuations in the intermediate waters in the Oyashio and Okhotsk Sea around the Kuril Islands where strong diurnal tides enhance diapycnal mixing that could be modulated with the 18.6-year period tidal cycle. Sea-surface temperature and salinity around the Kuril Islands and the body lengths of the C5-stage *Neocalanus cristatus* and *N. flemingeri* in the Oyashio also change during the 18.6-year cycle. These bi-decadal oceanic signals precede the bi-decadal component of climate indices such as North Pacific, Pacific Decadal Oscillation and East-Asian Monsoon by a few years. A new hypothesis is here proposed, linking the 18.6-year tidal cycle with the North Pacific climate variability through the changes of North Pacific Intermediate Water circulation and poleward heat transport by the oceanic western boundary currents. Waters with higher salinity around the Kuril Islands during the time when the diurnal tide is stronger could be transported northward to enhance dense shelf water formation. This might change the oceanic heat transport and fronts along the Oyashio and the Kuroshio, and lead to bi-decadal climate variability.

**PICES XIV POC\_Paper-2322 Oral**

**Typical distribution of interannual variations of water temperature in the active layer of the Okhotsk Sea and their possible prediction**

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Fluctuations in oceanographic parameters can generate either favorable or adverse conditions for the living organisms. Knowing the features and regularities of the long-term variability of oceanographic conditions is the urgent topic of the sea ecosystem study. While studying interannual variability of the Okhotsk Sea thermal conditions and possibility of their prediction we used a hypothesis that water temperature anomalies in the active layer of the sea form in winter time. We also assumed water temperature anomalies (at subsurface horizons) to be traced for a long time within a year and spread over extended area. We used all available oceanographic data obtained by research institutes of Russia, Japan and USA (more than 95,000 oceanographic stations carried out from 1930 to 2004).

Based on the prior EOF decomposition of water temperature fields at a 50m horizon (Luchin, Zhigalov, Plotnikov, 2003), we estimated anomalous thermal conditions between 1950 and 2001. According to estimations, 1951, 1955, 1958, 1959, 1966, 1967, 1973, 1976-1978, 1999-2001 might be attributed to cold years; 1950, 1952-1954, 1957, 1960, 1962, 1965, 1969-1971, 1975, 1979, 1980, 1982, 1983, 1985, 1986, 1988-1990, 1992, 1993, 1995, 1996, 1998 – to normal years; and 1956, 1961, 1963, 1964, 1968, 1974, 1981, 1984, 1987, 1991, 1994, and 1997 might be attributed to warm years. Normal years are the ones that meet correlation

$|\Delta T| < 0.674\sigma$ , where  $\Delta T$  is the product of the first temporal and spatial functions of water temperature decomposition by EOF and  $\sigma$  is the standard deviation. Cold years are the ones that meet correlation  $\Delta T < -0.674\sigma$ , while warm years shall meet  $0.674\sigma < \Delta T$  correlation.

Then we compiled files of cold, warm and normal years and drew charts of average multi-year water temperature typical for every type of thermal condition. We used indices of macro-scale climatic changes in the Northern Hemisphere atmosphere and hydrosphere, ten-day and monthly ice conditions in the Okhotsk Sea, surface water temperature near the northern and central straits of the Kuril Ridge as the factors that might influence interannual variability of the active layer thermal conditions. We also analyzed correlation between multi-year variability of the Okhotsk Sea thermal conditions and biological parameters that characterize fluctuations of some of the hydrobionts (pollock, herring, euphausiids).