PICES/GLOBEC Symposium T1-2670 Poster

Interdecadal variation of the lower trophic ecosystem using a 3-D physical-biological coupled model '3D-NEMURO'

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Regime shifts, consisting of decadal-scale oscillations in atmosphere-ocean systems, have recently been the focus of many marine ecosystem studies. These ‘regime shifts’ alter sea surface temperature and mixed layer depth (MLD), changing the environment for marine ecosystems. The climate regime shift of the 1970s plays an important role in lower trophic ecosystem change, especially in the Northwestern Pacific and Bering Sea.

We investigated the interdecadal climate changes in dynamics of the lower trophic ecosystem related to climate regime shifts and ENSO, using data from 1948 to 2002 to drive a global three-dimensional physical - biological coupled model, ‘3D-NEMURO’. We analyzed the results for the Bering Sea, the Gulf of Alaska and Kuroshio-Oyashio transition water. Phytoplankton and zooplankton biomasses correlate positively with PDO in the Bering Sea, but have only slight negative correlations in the Gulf of Alaska.

PICES/GLOBEC Symposium T1-2637 Oral

Decadal variability in the North Pacific Ocean in a coupled physical-ecosystem model

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A basin-wide interdecadal change in both the physical state and the ecology of the North Pacific occurred near the end of 1976. Here we use a physical-ecosystem model to examine whether changes in the physical environment associated with the 1976-77 transition influenced the lower trophic levels of the food web and if so by what means. The physical component is an ocean general circulation model, while the biological component contains 10 compartments: 4 zooplankton, 3 nitrogen, 2 silicate and CO_2. The model is forced with observed atmospheric fields during 1960-1999. During spring, when the mean plankton biomass peaks in the model, there is a strong (~20%) reduction in plankton biomass after the 1976 transition. The epoch difference in plankton appears to be controlled by the mixed layer depth (MLD). The enhancement of Ekman pumping in the latter period caused the halocline to shoal, and thus the MLD could not penetrate as deep in the central Gulf of Alaska during winter. As a result, more phytoplankton remained in the euphotic zone and phytoplankton concentrations began to increase earlier in spring during 1977-88 relative to 1970-76. Zooplankton populations also increased but then grazing pressure lead to a strong decrease in phytoplankton by April followed by a drop off in zooplankton by May. Essentially the mean seasonal cycle of plankton biomass is shifted earlier in the year. Finally, there is a rebound in plankton concentrations leading to an enhancement in zooplankton biomass by mid summer after 1976 but the increase is much smaller than observed.

PICES/GLOBEC Symposium T1-2630 Oral

Shifts in trends in the dominance of Pacific salmon in the Strait of Georgia are related to life history strategies, regimes and climate warming

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The Strait of Georgia is a semi-enclosed marine ecosystem on Canada's Pacific coast that is the major rearing area for juvenile Pacific salmon (*Oncorhynchus* spp.). Profound changes in the rearing capacity for the various species of salmon have occurred over the past 40 years that are related to regimes and the life history strategies of each species. Chinook and coho salmon benefited from the ecosystem organization prior to the 1977 regime shift. Sockeye salmon productivity peaked in the 1977-1989 regimes, but was poor in the regime from 1990-1998. Chum and pink salmon production is at historic high levels following the 1998 regime shift.

In early summer 2005, survey catches of juvenile coho and chinook salmon were lowest in a nine-year study, while catches of juvenile chum salmon were the record highest. We propose that shifts in the dominance of species occur because of shifts in the timing of the spring bloom in relation to marine entry times. The mechanism regulating marine survival relates to the amount of growth in the early marine period and to the specific life history strategies of each species of Pacific salmon. A general warming trend and the use of hatcheries also affected the ability of a species to adapt to changes in the organization of the ecosystem.

PICES/GLOBEC Symposium T1-2659 Oral

Current status and historical trend indicators of climate effects on the Bering Sea and Gulf of Alaska ecosystems

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Climate variability has affected the production and distribution of marine organisms in the North Pacific. It is well known that a major climate shift occurred in the North Pacific around 1976/77, a minor climate shift was observed in 1988/1989, and another climate shift possibly occurred in 1998/99. These climate shifts are reflected in ocean conditions, such as sea surface temperature, ice cover, and wind-driven transport, which then affect the production and distribution of marine organisms. The Ecosystem Considerations section of the Stock Assessment and Fishery Evaluation of the North Pacific Fisheries Management Council provides a current and historical perspective on status and trends of ecosystem components and ecosystem-level attributes using an indicator approach. Past and present indicators of climate effects on the Bering Sea and Gulf of Alaska ecosystems are summarized. Various indicators include climate, oceanographic, production, species, community, and ecosystem-level indicators. For example, there are indices of zooplankton and jellyfish biomass in the eastern Bering Sea, seabird and marine mammal population trends, and annually surplus production of groundfish. These indicators, when examined together elucidate general productivity trends in the Bering Sea and Gulf of Alaska in response to climate change. Many indicators representing different trophic levels suggest the productivity of the Bering Sea and Gulf of Alaska has decreased or shifted to unmonitored trophic pathways in recent years. Examination of changes in groundfish diet composition over time may reveal potential causes of the decreased or shifted productivity.

PICES/GLOBEC Symposium T1-2682 Oral

The rise and fall of large medusae in the Bering Sea in relation to regime shifts

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A dramatic increase in jellyfish biomass (SCYPHOMEDUSAE) over the eastern Bering Sea shelf was documented throughout the 1990s using summer bottom trawl surveys conducted consistently since 1979. The biomass trend peaked in summer 2000, and during the last four years it has declined precipitously and stabilized at 1980s levels. The onsets of the outburst and decline coincided with transitions between climatic regimes. In particular, 1989 appears to have marked the beginning of a period of moderate temperatures in the Bering Sea, after the very warm conditions of the late 1970s through the 1980s. Relative warmth returned to the Bering after 2000, as expressed in terms of decreased ice cover in winter and increased total heat content and surface temperatures in summer. We estimated the effects of temperature, ice cover, atmospheric variables, current patterns, zooplankton biomass, and associated fish biomass on changes in jellyfish biomass in two regions of the Middle Shelf Domain. We found an interaction of the biomass in the two regions related to the flow regime and demonstrated a clear linkage between biophysical indices and the biomass of jellyfish in response to regime shifts that can be used to predict future trends in biomass. An important conclusion from our work is that increasing ocean temperatures associated with global warming may not necessarily result in higher biomass of gelatinous macrozooplankton in all systems and that a suite of biophysical factors may lead to changes in jellyfish observed in the world's oceans.

PICES/GLOBEC Symposium T1-2714 Poster

Analysis of coastal catches of Kamchatka River salmons for 1936-2004

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Coastal catches of several salmon species, (chinook salmon *Oncorhynchus tshawytscha*, sockeye salmon *O. nerka*, chum salmon *O. keta*, coho salmon *O. kisuttch*, pink salmon *O. gorbuscha* and char *Salvelinus alpinus complex*), reproducing in the Kamchatka River system have been analyzed (by the data pool intervals of one, three and five years) for the period 1936-2004.

Presence of correlation between the catches of particular species in this river system has been monitored most clearly for the pairs chinook-coho and sockeye-chinook (on annual, three-year, and five-years data pools). The correlation revealed for the chinook-coho catches was positive, whereas the correlation between sockeye-chinook catches was negative, *i.e.*, with increased sockeye salmon catches the catches of chinook salmon decreased. Otherwise, analysis by the data pool intervals of three and five years has also revealed a negative correlation between the catches of sockeye and coho salmons. The results suggest that abundances of some important commercial Pacific salmon species in the Kamchatka River work in anti-phases. This suggestion has an explanation in a rather similar juvenile ecology of chinook, coho and sockeye salmons (rival subpopulations) during their freshwater period of life. The analysis by three-years data pool intervals has revealed a positive correlation between the catches of sockeye salmon and pink salmon. The positive correlation also can be seen on the five-years data pool intervals. Analysis by the intervals of five years has revealed a nonlinear (parabolic) connection between chum and sockeye salmon catches: both catches demonstrate initial increases, but with even higher catches of sockeye the catches of chum salmon decline. This correlation has not been revealed from the analysis of annual and three-years data pools. A positive correlation has been revealed between the catches of sockeye salmon and char catches on the five-years data pool intervals.

PICES/GLOBEC Symposium T1-2713 Poster

Correlation between Kamchatka River sockeye salmon *Oncorhynchus nerka* freshwater and ocean growth rates and stock abundance (on the data for 1989-2004)

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The growth rate of the two largest structural components of sockeye salmon of the Kamchatka River system – Azabachye Lake sockeye salmon ("A" stock, 2.3 fishes) and Kamchatka River lower reaches tributaries sockeye salmon, using Azabachye Lake for feeding as underyearlings ("E" group, 1.3 fishes), has been studied from scale structure and body length of mature fishes that returned in 1989-2004.

The fishes of "A" stock (males and females separately) have demonstrated a highly significant correlation between yearly increment for 1-2 years of freshwater growth and sockeye salmon abundance of this stock, whereas there were no influences of the yearly increments during 1-3 years residence in ocean on the abundance.

The fishes of "E" group (males and females separately) have demonstrated a significant correlation between increments for the first summer of life (until underyearlings migrate to Azabachye Lake) and abundance of this group, whereas there were no correlations between the group abundance and scale increments from the periods spent feeding in Azabachye Lake or for 1-3 years in the ocean.

The exceptionally abundant runs and high catches of Kamchatka River sockeye salmon in 1995-1997 are demonstrated to be determined by a high abundance of the "A" stock, consequent after fertilization of the Azabachye Lake system with volcanic ash in the course of Klutchevskaya Sopka eruption in 1990. By analogy, the high catches of sockeye salmon in 1944-1947 are suggested to be of a similar nature, relating to ash fertilization of the Azabachye Lake system from Klutchevskaya Sopka eruption in 1937-1938.

PICES/GLOBEC Symposium   T1-2642   Oral

Regime shifts and lower trophic level phenology in the western North Pacific

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Since the start of the Ecosystem Change Research Program of the FRCGC in FY2000, we have been conducting a series of retrospective studies based on the historically collected observational data sets after the 1960s in the several domains of the western North Pacific. This presentation is to summarize the regional comparison of the lower trophic level responses to the decadal scale climatic forcing in the western North Pacific. As there is a growing recognition on the importance of functional/taxonomic breakdown of biological processes to better understand the mechanisms and consequences of the ecosystem changes, we have particularly focused on the plankton community structure rather than merely looking at the bulk biomass. One of our major findings was alternation of seasonal phytoplankton and zooplankton communities, which roughly coincided with the climatic regime shifts in 1976/77 and 1988/89. Those indicated phenological changes in the lower trophic levels. Both in the light-limited subarctic and nutrient-limited subtropical regions, the spring bloom season seemed to start later than usual after the mid 1970s although the average timing of the beginning of the bloom differed between the regions. During the same years, the blooming season seemed to end earlier due to strong stratification. Wintertime cooling coupled with rapid summertime warming might be responsible for the delayed initiation and the early termination of productive season. In the 1990s, on the contrary, warm winter and cool summer elongated the annual productive season. The majority of the past climate – ecosystem link studies have emphasized winter to spring processes. However, our study suggested that climatic forcing with a different decadal scale cycle worked in winter and summer to present seasonal and interannual variation of hydrographic conditions, and thus a combination of winter and summer processes determined the seasonal/interannual biological productivity.

PICES/GLOBEC Symposium T1-2651 Poster

Ichthyoplankton samples as indirect indicators of the thermal regime of the ocean

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Living organisms are closely associated with their environment so they are effective indicators of its condition. Embryogenesis is the short period in a fish's life cycle when they are most sensitive to changes in salinity, concentration of oxygen and temperature. The last factor determines the rate of embryo development, duration of embryogenesis and the ratio of eggs at different stages of development in ichthyoplankton samples. Therefore, the quality of eggs can be an indication of the thermal regime of water and its changes. Ichthyoplankton samples of several species of fishes were examined from 1996 to 2004 in the Japan Sea (Peter the Great Bay). Samples were collected during summer - autumn seasons (spawning period of majority pelagic species of fishes). For each year (and for every species) common correlation eggs on the different stages of development were calculated. This ratio was very different from year to year. For explanation of these results, all dates were sorted taking into account (1) changes of the number of eggs in samples (for definition of active spawning period), (2) water temperature, (3) time of trawling and (4) egg development ratios. Based on this analysis, an algorithm was developed and used for interpretation correlation between quality of eggs samples and changes in environmental factors (initially water temperature).

PICES/GLOBEC Symposium T1-2709 Poster

Climate variability and phytoplankton dynamics in the Okhotsk Sea and Bering Sea investigated with satellite remote sensing and 1-D ecosystem modeling

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The temporal and spatial variability of surface phytoplankton are investigated in the Okhotsk Sea and Bering Sea from 1998 to 2004 using SeaWiFS ocean color datasets. The one-dimensional physical ecosystem model (PhEcoM) is applied in order to clarify the relationship between climate variability and phytoplankton dynamics. PhEcoM derives a plankton ecosystem into three subsystems: physical, environmental and biogeochemical. The model generally uses the POM (Princeton Ocean Model) as physical subsystems, which includes the sea ice functions. The biogeochemical components are a nitrogen-silica based model with 10 components. The phytoplankton bloom period varied from late April to late May from 1998 to 2004 in relation to wind-driven water column convection. In the eastern Bering Sea, wind forcing was high in 1998 and 2001 compared with other years. As a result, the mixing layer is relatively deeper compared with other years, and the timing of spring blooms delayed compare with normal years. Especially this late bloom pattern is dominant in May 1998. Sea ice is an important factor for phytoplankton variability too. Especially in the northern Okhotsk Sea, the timing of the spring bloom was affected by the timing of ice retreat. If sea ice melting occurs after mid May, the phytoplankton bloom is light limited by the presence of sea ice. The ENSO events were associated with strength and position of the winter Aleutian low and Siberian high. The light intensity, wind forcing and sea ice distribution are affected by position and strength of the Aleutian low and Siberian high in these regions. We will discuss relationships between the ENSO events and the phytoplankton dynamics in the two subarctic marginal seas from 1998 to 2004.

PICES/GLOBEC Symposium T1-2678 Oral

Ecosystem change in the western North Pacific associated with global warming obtained by 3-D ecosystem model

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We developed a 3-D ecosystem-biogeochemical model, with horizontal resolution of 1°×1°, and applied it to the western North Pacific in order to predict effects of global warming on ecosystem dynamics. Using dataset of simulated fields according to an IPCC global warming scenario, IS92a, as boundary conditions for our ecosystem model, we conducted a global warming experiment. Model results in the global warming experiment show increases in vertical stratification due to increased surface temperature. As a result, the predicted nutrient and chlorophyll-*a* concentrations in the surface water decrease at the end of the 21st century, and the dominant phytoplankton group shifts from diatoms to other small phytoplankton. Changes in seasonal variations of biomass in the subarctic-subtropical transition region associated with the global warming are large in all regions. The onset of the spring diatom bloom is predicted to occur a half-month earlier than in the present-day simulation due to the strengthened stratification. The maximum biomass in the bloom is predicted to drastically decrease from that in the present due to the decreases in nutrient concentration. In contrast, the biomass maximum of the other small phytoplankton at the end of the diatom spring bloom is the same as that in the present. Therefore, the change in transition of the dominant group appears notably at the end of spring bloom. We will also show the first results of the new global warming experiments in the same region, using a high resolution 3-D ecosystem model, which horizontal resolution is 1/4°×1/6°.

PICES/GLOBEC Symposium T1-2708 Poster

Interannual response of fish growth of Pacific saury to the 3-D global NEMURO output with realistic atmospheric forcing

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The bioenergetics model of Pacific saury, a part of NEMURO.FISH (North Pacific Ecosystem Model for Understanding Regional Oceanography for Including Saury and Herring), was driven by zooplankton densities and water temperature from 3-D global NEMURO. Since saury migrate from the Kuroshio area (KR) to the Oyashio area (OY) through the mixed water region (MW), three points were selected along 155 E from a 3-D global NEMURO run. Since the model zooplankton densities were smaller than the observed values, the saury's growth was underestimated by the model. To overcome this problem, an automatic calibration program PEST was applied. Using the calibrated parameters, the model was integrated from 1950 to 2002 and the wet weight of adult saury showed several distinctive shifts. To elucidate the key factors for wet weight change of saury, an additional 17 experiments were conducted. Two of the eight major shifts were controlled by temperature effects and the six others by zooplankton densities. The temperature effect was most important in OY. In MW, prey density was the controlling factor, with predatory zooplankton density playing the most important role. The direct temperature effect is closely related to the migration of saury. In the case of warmer conditions in OY, the saury's residence time in the OY is lengthened and, hence, the saury growth is accelerated. However, if the wintertime temperature in OY is high, the zooplankton density is decreased. In this sense, the large migration range of Pacific saury may be a strategy to stabilize their growth.

PICES/GLOBEC Symposium T1-2667 Poster

Interannual variation of squid, salmon and saury growth using NEMURO.FISH

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NEMURO.FISH is applied to typical nekton around Japan. It has previously been applied to Pacific saury and herring. We applied the same kind of bioenergetics model, coupled with NEMURO, to common squid and chum salmon. Model squid and chum salmon migrate from spawning areas to nursery areas and graze zooplankton, the concentration of which was calculated using the NEMURO lower trophic level ecosystem model embedded in a 3-D physical circulation model. The results of time dependent features of body weight of each nekton species show good agreement with observations. And this can explain the role of temperature and food density on their growth. Although there is no evident data to support, the simulation results show the inter-annual variations of fish growth corresponding to ENSO/PDO.

PICES/GLOBEC Symposium T1-2632 (Withdrawn)

Switches between bottom-up and top-down ecosystem control due to climate effects on predator populations: A route to alternate stable states?

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The role of predation in structuring oceanic communities has received much recent attention, but few studies have examined the effects of climatic variability on top-down ecosystem control. We used a time series of Gulf of Alaska small mesh trawl surveys conducted between 1972 and 2005 to examine the role of climate-mediated predation in the transition to an alternate community state following the 1976/77-climate regime shift. I compared catch rates of high and low trophic level taxa to test predictions of bottom-up control (positive correlations between trophic groups) and top-down control (negative correlations between trophic groups). I found evidence of initial bottom-up control (high shrimp and forage fish biomass, low groundfish biomass), followed by a period of negative correlation between trophic groups, indicating that top-down control played an important role in the transition to a post-regime shift community. Following the completion of this transition the abundance of the two trophic groups has been positively correlated, suggesting a reversion to bottom-up control in the new community state. I also used data from the time series on the abundance of a predator, Pacific cod *Gadus macrocephalus*, and three prey taxa (Pandalid shrimp, capelin *Mallotus villosus* and tanner crab *Chionoecetes bairdi*) to test the hypothesis that climate change regulates top - down ecosystem control by directly affecting predator abundance. These results should contribute to our understanding of the role of trophic interactions in climate-forced transitions between alternate community states.

PICES/GLOBEC Symposium T1-2666 Oral

An integration of the sardine-anchovy regime variation in the Pacific Ocean

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Sardine and anchovy population abundance has been shown to fluctuate out of phase in regions where large scale tropical-temperate current ocean currents mix. Such variation is essentially synchronous, although lags have occurred. While this phenomenon has been recognized in most upwelling areas and in the northwest Pacific (Kuroshio-Oyashio) region, no widely accepted mechanism has been as yet proposed. Part of the problem resides in the fact that apparently opposing processes occur between the eastern and the western north Pacific regions; for instance, while sardine high abundance periods have been coincident with warming of the eastern North Pacific, cooling has occurred at the western side. However, during the last decades various new developments have been proposed, and it becomes feasible to integrate a hypothesis that takes into account the observed discrepancies. The presentation brings together those pieces into an integrating hypothesis to explain the abundance fluctuations of sardine populations around the Pacific Ocean.

PICES/GLOBEC Symposium   T1-2697   Poster

A closer look of the 1998/99 change in Kuroshio/Oyashio extension region

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Detailed structures of the 1998/99 change in the Kuroshio/Oyashio extension region are investigated using recent high-resolution satellite datasets, such as AVHRR SST, VIRS SST by TRMM satellite, and absolute sea-level height (SLH). In this region, anomalous warming was observed from 1999 to 2001 (warming period) (see Minobe 2002 Prog. Oceanogr.). AVHRR SST reveals warming distributed in a region between the Kuroshio extension and the Oyashio extension (or subpolar front). In particular, the northern edge of the warming closely follows the Oyashio extension, suggesting that the dynamical response of the ocean plays an important role in the warming. VIRS SST and SLH indicate the northward migration of the Kuroshio extension caused the warming around the first northward meander just east of Japan (around 37°N, 143°E). However, the area of the warming region explained by the migration of the Kuroshio extension is much narrower than the overall warming region, and hence a mechanism other than the Kuroshio extension migration should be at work. SLH data generally indicates enhanced SLH standard deviation during the warming period between the Kuroshio and Oyashio extensions. This suggests strengthened eddy activities, which are mainly related to warm eddies detached from the Kuroshio extension. Thus, strengthened eddy activities might bring anomalous heat from the Kuroshio extension, and warm the region between the Kuroshio and Oyashio extension. If this is the case, not only the heat transport, but also material circulation and thus the marine ecosystem may be substantially influenced by the modulated eddy activities.

PICES/GLOBEC Symposium T1-2673 Poster

Spreading of warming signal of the Okhotsk Sea Intermediate Water to the North Pacific since the 50s

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We investigate long-term variations (> 5-yr period) of intermediate water in the North Pacific including the Okhotsk Sea, based on water temperature data on isopycnal surfaces. The data used in this study are derived from World Ocean Database 2001 and other available data from 1950 to 2004. A significant warming trend is found from the Okhotsk Sea to western subarctic gyre regions in the range of 26.8–27.2σ_0. The warming trend becomes maximum (0.12°C/decade) in the western part of the Okhotsk Sea and decreases to 0.08°C/decade in the western subarctic gyre region (40°–52°N, 145°–170°E). Considering that the Okhotsk Sea is the ventilation source of the North Pacific Intermediate Water and that the warming signal is larger in the area closer to the outflow origin of Okhotsk water, the warming trend of the western subarctic gyre region likely originates from the Okhotsk Sea. A possible cause of the warming of the intermediate water in the Okhotsk Sea is a decrease in production of cold, dense shelf water in the northwestern shelf of the Okhotsk Sea. Sea ice extent in the Okhotsk Sea has a decreasing trend according to the satellite data of 25-yr length. Wintertime surface air temperature in the easternmost Eurasia, which has significant negative correlation with the sea ice extent, has increased by 2.55°C during the last 50-yr. We propose that the 50-yr timescale decrease in sea ice production causes the warming trend of the intermediate water in the Okhotsk Sea and further the western North Pacific. The warming trend of the intermediate water implies weakened overturning in the western subarctic gyre region, which might give substantial impacts on biological and material cycles.

PICES/GLOBEC Symposium T1-2644 Poster

Climate and ecosystems: Mechanisms of their changes and interrelations

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Ecosystem regime shifts in most studies are supposed to be a direct consequence of climate regime shifts. There is no doubt of climate influence on ecosystems, but regime shifts are not evolutionary changes, they are bifurcations at some threshold values in these highly nonlinear systems. Supposing that we know objective criteria for regime shifts in both systems (climate and ecosystem), there is no necessity for their threshold values to coincide in space and time. It means that regime shifts in ecosystems can lag far behind the climate shifts or can arise independent of climate shifts due to internal processes.

Nevertheless rather high correlations between climatic and ecosystem parameters are reported, and sometimes ecosystem changes take the lead over climate changes. To explain these facts we should suggest the existence of some external common forcing that affect them simultaneously in time, but differently in space. The evident common factors are 1) fluctuations of solar and secondary cosmic radiation, and 2) fluctuations of the sun caused and terrestrial magnetic fields. Electromagnetic waves in the range 10 – 100 billions Hz have considerable influence on biochemical processes in highly polarized cells through resonances with the membrane elasticity, and nonlinear interactions lead to generation of low-frequency waves in large groups of cells. Waves of lower frequencies and weak electric currents, caused by moving water in fluctuating magnetic fields, can influence behavior and migration of populations.

A review of published investigations on solar-terrestrial linkages and their role in climate and ecosystem changes is given. A scheme is proposed for external and internal climate-ecosystem interactions at different space-time scales and at different trophic levels.

North Pacific regimes shifts: Semantics and indicators

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Whether regime shifts are a credible description of low frequency variability for the North Pacific is an important issue, as ecosystems may reorganize in response to physical shifts. A strict interpretation of “regimes” and “regime shifts” involves the notion of *multiple stable states* with a tendency to remain in such states and transition rapidly to another state. Several authors have suggested that N. Hemisphere climate has a tendency to be found in multiple preferred patterns. An alternate empirical interpretation has been to refer to regime shifts as simply interdecadal fluctuations. Even in 100 year long records for the N. Pacific, a definition of regimes based solely on distinct multiple stable states is difficult to prove or disprove, while on interdecadal scales there are apparent local step-like features and multi-year intervals where the state remains consistently above or below the long-term mean. The terminologies *climatic regime shift, statistical regime shift* or *climatic event* has been suggested for distinguishing the second interpretation from the first.

A number of methods can detect a discontinuity or “shift” of the second kind; unfortunately, many suffer a common problem — their performance diminishes at the ends of time series just when they are of particular interest. An alternate probabilistic method called STARS checks whether a new observation represents a statistically significant deviation from the mean value plus red noise of the previous regime. If it does, this year is marked as a potential shift, and subsequent observations are used to confirm or reject this hypothesis. The method assesses the relative strength of each shift. STARS is easily used for automatic calculation of shifts in large sets of variables. It has been successfully tested for North Pacific time series, showing that physical and biological indicators can either reinforce or contrast with each other in indicating regime shifts.

PICES/GLOBEC Symposium T1-2688 Oral

Relationships between interannual and decadal changes in the Pacific Decadal Oscillation (PDO), ocean conditions, and survival of coho and chinook survival in the coastal ocean off the Pacific Northwest

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We have been sampling juvenile salmonids off the coast of Washington and Oregon for eight years, from 1998-present using a large pelagic trawl. Cruises are conducted three times per year, in May, June and September. Oceanographic data are also collected including CTD profiles, secchi depths, nutrients, chlorophyll-*a* and zooplankton biomass and species composition. Pronounced interannual variations in salmonid abundance are observed and they follow changes in sign of the Pacific Decadal Oscillation. Low (high) abundances are observed in years when the PDO is positive (negative). For example, the lowest abundances were observed in 1998 (El Niño year) and 2005 (a year characterized by very warm ocean temperature anomalies); highest abundances were during years of cool ocean conditions (2000-2003). In this talk, we will attempt to provide a definition for the often-used term "ocean conditions" in terms of physical and biological oceanographic variables, we will show that survival of coho salmon is correlated with several measure of climatic variability and "ocean conditions", and we will discuss mechanisms through which climate signals move through the food chain to salmon. Two mechanisms will be presented: a bottom-up control hypothesis whereby energy density of prey may control salmon growth and survival through lipid content of prey organisms; and top-down control by Pacific whiting and seabird (murre) predation.

PICES/GLOBEC Symposium T1-2629 Oral

The role of Alaskan stream eddies in the dynamics of the Kamchatka Current and western pacific subpolar gyre

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The waters off Kamchatka are a key component of the Pacific Ocean circulation. The region contains the Alaskan Stream, flowing along the Aleutian Island. An important aspect of the Alaskan Stream is that it sheds large anticyclonic eddies ~ 300 km in diameter. These eddies propagate westwards, taking warm saline water westward. These eddies keep their distinctive thermal characteristics and warm core up to the Kamchatka Current, and they drift into the western subarctic Pacific at approximately ~ 1.2 km day^{-1}. This warm-water link between the eastern and western subarctic is likely to have strong affects on the Kamchatka Current and Oyashio.

The Alaskan Stream eddies are large and therefore their volume is significant in comparison with inflow to the Near Strait and Kamchatka Current volume transport. There were prominent anomalies of number, size, and route of Alaskan Stream eddies in 1991-2005. The Alaskan Stream did not shed a large eddy in 1994-95 west of Near Strait. This substantially affected the Kamchatka Current and its sea level. This phenomenon shows the significant effect of the Alaskan Stream eddy spawning on variability in the Kamchatka current. This study reveals a plausible cause of the warming in intermediate layers in western subpolar gyre.

The observed increase of dynamic height near Kamchatka is due to deepening of the halocline. This deepening is particularly well pronounced in anticyclonic eddies. Therefore the change of halocline depth depends on the volume of water transported from the Alaskan Stream into the interior of the western subpolar gyre. This may explain the rise of sea level observed in the Kamchatka Current in 1994-1997.

PICES/GLOBEC Symposium T1-2624 Poster

Nodal modulation of air temperature in the Sea of Okhotsk

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Bi-decadal climate variations with possible lunar influences attracted the interest of oceanographers for many centuries. Here, I present evidence of air temperature variability in the Sea of Okhotsk associated with the 18.6-year nodal cycle.

Nodal modulations of tidal amplitude in the Sea of Okhotsk are high. There are bi-decadal variations of temperature at coastal stations of the Sea of Okhotsk. From values of tidal harmonics it appears that K1+O1 elevations should be as large as M2 and their 18.6-year modulation will be significant. K1 varies by +/-13% and O1 by +/-18% over that time period so they may play a large role in the temperature variations.

Monthly mean temperature range for these bi-decadal oscillations is ~1.5-2.0°C. The mechanism of these bi-decadal variations of temperature is not well determined, but is conceivably linked to nodal modulations of amplitude of tidal currents. The dissipation of tidal energy in shallow and coastal regions and attendant mixing is an important process that affects the sea surface temperature of vast areas. The Sea of Okhotsk is an area of particularly strong tidal dissipation.

Examples of the impact of tidal currents and tidal mixing on water temperature and sea ice are the persistent polynya above Kashevarov Bank in the western Sea of Okhotsk and a polynya off Shantar Bay. At Kashevarov Bank, fortnightly variations in the amplitude of diurnal currents dominate water motion over the bank. In winter, tidal mixing draws relatively warm water upward from mid-depth to maintain a sensible heat polynya that cyclically opens and closes in response to fortnightly variation in vertical heat flux. In summer, fortnightly modulation of the tidal mixing creates temporal variations in water column stratification, a critical factor in the joint supply of nutrients and light required to sustain phytoplankton growth.

PICES/GLOBEC Symposium T1-2695 Oral

Interannual variability in the bifurcation of the North Pacific Current: Co-variability of California Current and Gulf of Alaska ecosystems

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It is widely believed that there is an out-of-phase variation between transports in the California Current System (CCS) and coastal Gulf of Alaska (CGOA), which is reflected in the biological production of the two ecosystems. This idea is based on low-frequency fluctuations in coastal physical variables (*e.g.*, sea level) as well as fish stock abundances, most notably salmon. However, large-scale coastal chlorophyll variability in the two systems appears to have varied in phase in recent years. Heat, momentum and material transported by the North Pacific Current (NPC) enter both coastal ecosystems, so basin-scale climate-induced variations in the NPC may have downstream impacts on the CCS and GCOA. Here we use satellite data, model output, and *in situ* observations to contrast the variability in the CCS and CGOA transport on seasonal to decadal time scales and its ecosystem impacts. We compare model, and altimeter- and wind-derived volume transports within the NPC to similar estimates of relative transport within the Alaska Current and California Current Systems, and derive a NPC bifurcation index that quantifies recent and historical changes in the strength and bifurcation latitude of the NPC. Hydrographic data from the GLOBEC LTOP and process surveys are examined for changes in water properties (spiciness, oxygen, nutrient content) that may reflect the source waters, and their resident plankton populations, entering the CCS and CGOA. These detailed comparative analyses allow for a qualitative comparison of the regionally distinct responses of the CCS and CGOA to large-scale climate forcing.

PICES/GLOBEC Symposium T1-2671 Poster

Variability in growth and survival of Korean chum salmon in relation to climate changes during the 1980s-1990s

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A relationship between chum salmon growth, homing success, and environmental conditions in the subarctic Pacific Ocean was investigated. Assuming proportionality between scale size increments and fish length, distances between scale annuli were regarded as the growth conditions in different habitat areas with respect to the life stages of chum salmon during 1984-1998. In estuarine and coastal areas, growth rates of fingerling salmon were higher in the 1990s than in the 1980s. Concurrently, zooplankton abundance off the east coast of Korea increased after the late 1980s. Growth of juvenile chum salmon during the first summer in the Okhotsk Sea was relatively stable, and neither SST nor zooplankton biomass fluctuated significantly during the study period. Especially, the early growth during summer through winter and the return rate to the hatchery for spawning seem to fluctuate in same manner. And, the correlation coefficients between growth at old ages and the return rate become smaller, which suggest that early growth of Korean chum salmon during summer through winter is more important than later growth for the survival of cohort. On the other hand, in the Bering Sea, salmon growth rates between age-2 and age-4 (*i.e.*, ocean-phase immature salmon) were higher in the 1980s than in the 1990s. Variability in salmon growth in the Bering Sea was correlated to zooplankton biomass. These results suggest that the climate regime shift of 1988/89 in the subarctic North Pacific affected salmon growth mediated by changes of zooplankton biomass, revealing a bottom-up process.

PICES/GLOBEC Symposium T1-2650 Poster

Climate shifts in the parameters of the Asian and Far Eastern depressions centers during the second half of 20th century

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Data for determining the locations of the Asian depression (At) and in summer Far Eastern depression (SFD) were obtained from archives of average monthly NCEP/NCAR (National Center for Environmental Prediction, Washington DC, National Center for Atmospheric, Boulder CO) fields of Northern Hemisphere atmospheric sea level pressure, gridded at 2.5 degrees from 1954 to 1999. For location estimate of the centers of these depressions there were chosen next were boundaries of territory, namely, for At 13-35ºN, 60-100ºE; for SFD were 40-55ºN, 115-135ºE.

This work is aimed at researching climate changes in pressure dynamics, as well as changes in the latitude and longitude in the Asian atmospheric forcing centers: At and SFD. The positive trend was surveyed over the pressure variability in At center during all seasons. It was observed that anomalies of the above-earth pressure being calculated for wide areas embraced by at were similar to pressure anomalies variability in the center of the Asian depression. During 1954-1976, the location of the center of the SFD was further to the south, while during 1977-1999, the depression was further north. According to longitudinal shift of the center such observed temporal "break" was exposed even more evidently. The shifts in regime of the above-earth pressure in the SFD enter was surveyed too. Such alterations in the At and SFD regimes were forcing to other climate parameters of the Far Eastern district. So, the drier periods in the Amur river regime were marked depending on the shifts, they were one of the reason in catastrophic drop of the Amur salmon catches

PICES/GLOBEC Symposium T1-2720 Poster

Variations of the Yellow Sea environment and the response to the climate events

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The Yellow Sea is a semienclosed sea between the mainland of China and the peninsula of Korea. Its average depth is 44 m. The aim of this paper is to make clear the long-term variations of the environment and its responses to the climate events. The changes in environmental features of the Yellow Sea from 1976 to 1999, especially in winter and summer, are studied using seasonally observed data of the region west of 124.5°E and north of 34°N. The data includes the ocean temperature, salinity, biogenic elements, such as phosphorus (P), silicon (Si), dissolved inorganic nitrogen (DIN) (from 1985), and dissolved oxygen (DO). The analyses of the data show the following results. (1) The long-term sea surface temperature (SST) and sea surface salinity (SSS) show positive trends. (2) In winter, the average temperature of bottom water is about 0.1°C higher than that of the surface, indicating that the warm, salty Huanghai Warm Current (HWC) intrudes into the Yellow Sea at the bottom. Moreover, the inter-annual changes of the northern location of the 8°C isotherm suggest that in El Niño years, the HWC more greatly extends into the Yellow Sea. SST and SSS all show positive anomalies in El Niño years. (3) In summer, SST shows negative anomaly while SSS shows positive anomaly in El Niño years. The Yellow Sea Cold Water Mass (YSCW) is dominant at the bottom. The minimum temperature of YSCW is higher in El Niño years, *i.e.* YSCW is weak. (4) Time series of DIN exhibits a positive trend which is attributed to anthropogenic activities, while those of P (except the adjacent regions of some coastal cities) and Si exhibit negative trends which are mainly caused by the decrease discharge of the rivers. (5) Some important responses of the ecosystem to the environmental changes arestronger nutrient limitation, changes in primary production and phytoplankton abundance, and the decreasing ratio of diatoms to small phytoplankton.

PICES/GLOBEC Symposium   T1-2719   Poster

Research progress on dynamic processes of higher trophic food chain/webs in national GLOBECs of China

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So far, both of the Chinese national GLOBECs have been accomplished and another one was begun in 2006, which were separately supported by the natural science fund committee and the national science and technology ministry of China. There are similar species in the trophic food web of these three projects since the regions of study are adjacent each other. In these studies, sustainable utilization of fisheries resource was a high national priority. It is apparent that research on dynamic processes of species at high trophic levels needed to be an important component of this research. There have been trophic dynamic studies of 16 fish species, which play important roles in the food web. Because quantification of trophic dynamic processes between higher trophics, especially pelagic fish species, is difficult, three methods were adopted: *in situ* studies, *in situ* experiments, and laboratory experiments. The laboratory experiments were generally used to determine energy budget components and energy budget models under different ecological factors, such as temperature, feeding level, body weight and social behavior *etc.*, of fish species that could be easily captured and domesticated under individual condition. The *in situ* experiments were used to determine food consumption, growth and ecological conversion efficiency under different ecological factors, such as temperature, body weight and food granularity *etc.*, of fish species that could be domesticated under colony condition but hardly sampled in the same colony at strictly decided time and area. The *in situ* studies were mainly used to determine feeding level and pressure to prey. The results determined by different methods were compared and the mechanisms responsible for any observed the differences were discussed. In conclusion, many new results were obtained, which should help to quantify the relationship between predator and prey, understand the function of top-down and bottom-up control in marine food chain and inquire into the replacement pattern and supplement mechanism of dominant resources species in high trophic food chain/web of the researched waters.

PICES/GLOBEC Symposium T1-2663 Oral

The late-1980s regime shift in the ecosystem of Tsushima Warm Current in the Japan/East Sea: Evidence of historical data and possible mechanisms

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An oceanic regime shift as indicated as an abrupt change from colder to warmer water in the Tsushima Warm Current (TWC) is identified in the late-1980s in the Japan/East Sea (JES). Using various environmental and biological time series from plankton to top-predatory fishes including warm-water pelagic and cold-water demersal species, we investigated their response patterns to the late-1980s oceanic regime shift in the TWC.

Cell number of total diatoms in spring from the PM line located in the central part of JES showed decadal variations with an abrupt change from positive to negative anomalies around 1990; zooplankton biomass declined during the 1980s but increased during the 1990s. The catch of plantktivorous Japanese sardine increased to its peak in 1989 and then tended to decrease abruptly. On the other hand, both the small pelagic species (excluding Japanese sardine) such as anchovy and common squid, and large predatory species such as yellowtail and tunas increased since the late-1980s. Demersal fish assemblages also changed around the late-1980s accompanied with a shift both in the abundance and distribution of major indicator species: the cold- (warm-) water species such as walleye pollock (pointhead flounder) decreased (increased) their abundances and reduced (expanded) their distributions during the warm regime since the late - 1980s. Principal component analysis for pelagic and demersal fish assemblages, and/or for warm-water and cold-water assemblages showed decadal variation patterns with an evident change around the late-1980s. Mean trophic level estimated from 55 fisheries time series decreased sharply during the 1980s indicating that the fish community structure in the TWC changed around the late-1980s. Shifts found not only in plankton and small pelagic species at lower trophic level but also in large predatory species at higher trophic level and fish community base, strongly suggest an ecosystem regime shift occurred in the TWC region as a result of the late-1980s oceanic regime shift.

PICES/GLOBEC Symposium T1-2705 Poster

Seasonal to decadal variability of the sea surface temperature, water circulation and ecosystem in the west part of the Bien Dong (South China Sea) and the activity of the Indian-Pacific warm pool

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The sea surface temperature structure including warm pool and tropical cyclone activity in the West Pacific and Bien Dong Sea is subject to pronounced seasonal and year-to-year variations. These variations are connected with the local and remote forcing in the tropical Pacific Ocean; some of these are caused by local forcing as monsoon wind variation. Analyzing these interactions is important for improved understanding of their physics and initializing prediction models.

Due to monsoon activity there is strong seasonal variations of the SST and water circulation in the Bien Dong Sea. In the winter, there is deep trespassing of cool tongue to the south, with the 25ºC isotherm extending to 8th parallel of latitude. In the summer, there is often no horizontal variation in the surface temperature field, which remains near 29ºC as characterized for tropicalocean. However, we focus on the upwelling phenomenon near the Vietnam coast, where the minimum temperature can be as low as 24ºC. Offshore phytoplankton blooms appear in the southwest monsoon season.

We show SST anomalies (SSTA) during summer and winter. The strong effect of ENSO from May 1997 to May 1998 made SST increase significantly in the 1998 summer period compared with the SST at the same period of 1997. However, the ENSO probably affected SST in the Bien Dong area 3 to 4 months later. The reason for this lag may be due to the complexity of atmosphere-ocean interactions in Bien Dong, that need to be examined with longer series of data.

Preliminary results of climatic and remote sensing SST data and its environmental impacts (the variation of the summer offshore phytoplankton bloom and fishing ground) show that there are evident synoptic variations associated with seasonal and climatic oscillations, as ENSO and PDO, in the thermohaline structure of the sea water.

Influence of the late-1980s regime shift to the Japanese continental slope area in the Japan Sea

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The influence of the late 1980s regime shift on the Japanese continental slope region of the Japan Sea, which was defined as the depths shallower than 500m, was examined using historical temperature data. The largest temperature change was observed in spring and at depths of 200-500m. As for the interannual variability, three patterns of interannual variability of temperature change were observed. In the northeastern continental slope (> 40°N) the intermediate water, which was formed in the northwestern Japan Sea off the Russian coast in winter, was advected to the Japanese continental slope directly by the subarctic gyre. Thus, the relationship between the temperature change in this region and the regime shift was clear; the water temperature was decreasing until approximately 1986, and then large abrupt temperature increases started in 1987. In the southwestern continental slope (< 40°N), where the Tsushima Warm Current and the isolated warm/cold eddies were dominant factors for the offshore circulation, the relationship between the temperature change and the regime shift was weak; before the regime shift in the late 1980s the decrease of the water temperature was small, and after the regime shift the temperature jump was also small. On the other hand, in the southwestern corner of the Japan Sea, inside of the Tsushima Strait, most temperature changes occurred independently. It is suggested that the quantitative change of the Tsushima Warm Current was a dominant factor in this region.

PICES/GLOBEC Symposium T1-2712 Oral

About the influence of pink salmon on the dynamics of chum salmon abundance in the west and north-east coasts of Kamchatka

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Pink salmon is the most abundant Pacific salmon species and has the shortest life cycle, what is determinative for abundance dynamics and growth of the other Pacific Salmon species. Chum salmon is the next most abundance commercial species behind pink salmon, or may even dominate in particular years. We analyzed the data on the abundance of chum and pink salmon in spawning grounds of the west and north-east coasts of Kamchatka. The analysis has demonstrated a synchronicity between pink salmon abundance in spawning grounds and chum salmon generation abundance. In West Kamchatka the fluctuations of chum salmon abundance were similar to the fluctuations of pink salmon abundance until 1983-1984, when pink salmon generation dominance changed. The changed even–odd dominance caused a transformation of chum salmon abundance dynamics for more than 7 years. Afterwards chum salmon generation abundance cycles were restored.

At the same time the 2-year cyclic pink salmon run has also got broken in North-East Kamchatka. The tendency of dominant line change appeared to breach alternation order of abundant and poor chum salmon generations. Cyclic dynamics of chum salmon generations was restored in 1987-1988. Since restoration the relation between pink salmon abundance in spawning grounds and chum salmon generation abundance for the same years of spawn (r=+0.72) was restored.

This interspecific relation was determined presumably by increased production of oligotrophic river ecosystems in Kamchatka as a result of organic input to the trophic web from carcasses of postspawning pink salmon. The large organic input did not directly influence returning chum salmon abundances, but rather influenced the chum abundance dynamics indirectly through food supply to juvenile chum salmon during down stream migration and provides better physiological condition at smoltification and lower mortality at the time of transfer from freshwater to marine habitat.