PICES XIII W4-2099 Oral
Consideration of spatial scale when assessing the influence of environmental variability on walleye pollock in the eastern Bering Sea

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Walleye pollock, *Theragra chalcogramma*, occupies a central position in the Bering Sea ecosystem. Attempts to understand linkages between climate and population dynamics of this species in the eastern Bering Sea (EBS) have generally focused on comparing fluctuations in indices of physical phenomena with dynamics of the management-scale stock. However, there is increasing recognition that management-scale stocks may be composed of sub- or meta-populations. We present evidence that the EBS stock is composed of at least two components that tend to occupy different geographic regions. We show how observed patterns in growth, maturity and distribution at the management scale result from fluctuations in the relative abundance of these two components of the EBS walleye pollock stock. These components are exposed to different physical conditions and recruitment of strong year classes often appears asynchronous between the two regions. Thus, the effects of physical phenomena on the population dynamics of walleye pollock may be better assessed at a scale smaller than the management stock, and perhaps by using regional physical indices. While separate management of these stock components may not be necessary, recognition of the components may enhance our ability to identify the response of EBS walleye pollock to climate variation.

PICES XIII W4-2110 Invited
The impact of Pacific climate forcing on marine ecosystem

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Pacific climate variability (*e.g.*, El Niño, La Niña and PDO-Pacific Decadal Oscillation) has a significant impact on ecosystems. In the tropical Pacific, the climate variability is primarily dominated by interannual fluctuations associated with El Niño and La Niña. In the midlatitude Pacific, the climate variability is dominated by the seasonal cycle and decadal fluctuations associated with the PDO.

This talk will describe the use of observational data in conjunction with the multi-scale coupled physical-ecosystem models in studying the Pacific climate variability and its impact on ecosystems. The multi-scale model consists of a relatively coarse resolution Pacific basin model and a finer resolution regional model to capture the regional amplification of the basin-scale climate phenomenon. Biological and chemical processes are modeled with a multi-component ecosystem model embedded in the physical models. Feasibility of using the coupled physical-ecosystem model for operational nowcasting and forecasting will also be discussed.

PICES XIII W4-1984 Invited
CLIVAR/CO_2 Repeat Hydrography Program in the North Pacific Ocean

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The primary goal of the CLIVAR/CO_2 Repeat Hydrography Program is to quantify the role of the ocean in sequestering anthropogenic CO_2. Information on shorter timescales is essential to determine any feedbacks of oceanic carbon sequestration due to climate change, and to determine the role of natural variability on the oceanic carbon system. The North Pacific Ocean plays a unique role in controlling the long-term fate of anthropogenic CO_2 because (1) the North Pacific is the final destination of circulation of the deep water that contains a high level of preformed nutrients and dissolved inorganic carbon (DIC), and (2) the North Pacific Intermediate Water stores dissolved CO_2 for more than a few tens of years. Discrete high-quality dissolved inorganic carbon and total alkalinity data were acquired as part of the WOCE/JGOFS Global CO_2 survey in the Pacific Ocean between 1991 and 1999 followed by repeat surveys in 2001 and 2004 as part of the Sub-arctic Gyre Experiment (SAGE) along the P17N line in the eastern North Pacific and the Repeat Hydrography Program east-west P2 cruise along 30°N. Water column integrated uptake rates ranged from 0.25 to 1.3 mol m^{-2} yr^{-1}, depending on location. Deep ventilation within the Kuroshio Extension and the subsequent circulation in the subtropical gyre generates a strong east-west gradient in the anthropogenic CO_2 penetration depth. The combined effect of the tilted density surfaces and the younger waters with higher anthropogenic CO_2 concentrations leads to higher total column inventories in the western North Pacific.

PICES XIII W4-1851 Poster
Interannual variability of the diversity and ichthyoplankton community in the central Pacific off Mexico

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We examined larval fish diversity and assemblage structure in the central Pacific off Mexico (coast of Jalisco and Colima) from December 1995 through December 1998 using data from samplings collected with a Bongo net. A total of 132 taxa were recorded at 12 stations during 27 months. The dominant species were *Bregmaceros bathymaster* (90% of the total abundance), *Dormitator latifrons* (1.9%) and *Harengula thrissina* (0.8%). Only *B. bathymaster*, *D. latifrons* and *Gobionellus* sp. attained 100 % of occurrence. The effects of the El Niño event on ichthyoplankton diversity were significant, and the prevalence of the typical seasonality could be observed. Diversity null hypothesis models were used to determine structural changes in the assemblage due to El Niño effects; both species richness and evenness were highest during El Niño. The most parsimonious models of assemblage organization included the El Niño and seasonality as most significant environmental variability sources. The small-scale spatial variability expressed as the cross-shore gradient was not relevant. The average taxonomical distinctness, that could be considered as a measure of functional diversity was highly sensitive to the seasonal change of the assemblages independently of the El Niño. This index was reduced during tropical and transition periods characterized by warm and oligotrophic waters.

PICES XIII W4-2167 Invited
Implications of climate regime shifts on the management of marine resources

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It is possible to manage fisheries given climatic uncertainty. To do so requires a coordination of ecosystem assessment (knowledge of the state of the environment) and ecosystem-based management (the accounting of ecosystem processes when formulating management actions). Marine organisms have evolved life history strategies to cope with variability in their environment. In fish, these life history strategies range from short-lived species with highly variable stock dynamics which respond immediately to changes in the environment to extremely long-lived species whose population dynamics are not highly variable. Stock dynamics, *i.e.* levels of productivity, appear to be decadal in nature, corresponding to regimes and regime shifts. The timing of the impacts of environmental variability on the intrinsic rate of population growth varies across life history strategies but since most fisheries are conducted on mature fish, the response time of management actions to regime shifts can be lagged by a correspondence to the age of recruitment. Fisheries scientists should provide harvest recommendations that reflect a range of levels of risk to the stock under different assumptions of productivity or recruitment. Coupling ecosystem assessment with ecosystem-based management, would allow managers to select regime specific harvest rates. In all cases it would be crucial to maintain a critical spawning biomass to ensure that the population is able to withstand long periods of poor environmental conditions.

PICES XIII W4-2111 Oral
Climate impacts on OPI coho salmon, *Oncorhynchus kisutch,* production: Insights from a species sensitive to habitat change at daily to centennial time scales

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Effects of climate on ocean conditions in the California Current system are becoming well understood. In particular, relationships between marine conditions and coho salmon, *Oncorhynchus kisutch*, survival have received much attention. Interannual variability of OPI area coho salmon marine survival is related to winter sea surface temperature, spring transition, and upwelling. However, coho salmon spend half their life-cycle in freshwater. Interannual variability of coho smolt production is related to air temperature, timing of winter storms, and stream flow in the second freshwater winter and spring. Freshwater and marine environmental factors are largely concurrent and correlated; good marine survival is likely to occur in the same years as good freshwater smolt production. In addition to the interannual and decadal scale variation attributable to these factors, climate affects freshwater production through a second, unrelated mechanism; changes in the freshwater ecosystem through landscape processes of fire, mass wasting (landslides), and forest growth. Early modeling efforts indicate that these processes alone can result in a two-fold variation in smolt production with a 100-year cycle. There is likely to be a similar-scale effect in ocean ecosystems, with some components of the system (long-lived groundfish, pelagic predators) responding on decadal to centennial time frames, creating (primarily) top-down trophic effects. In the marine system we need to explore links between climate effects and long-term responses of biological systems. Such a long-term perspective could aid in developing ecosystem-level management in the California Current system.

PICES XIII W4-1992 Invited

The impact of environmental variability on the effectiveness of fisheries management strategies

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The effects of environmental variability on Alaska groundfish recruitment are well documented. In addition to correlative studies, process-oriented studies have elucidated the mechanisms by which environmental variability influences recruitment. AFSC scientists have applied the knowledge gained from these studies to develop stock assessments that incorporate information on environmental variability. Age-structured assessment models for Eastern Bering Sea flatfish utilize a relationship between survey catchability and bottom temperature. The assessment for Eastern Bering Sea pollock uses simulated surface drift patterns to forecast the size of recruiting year classes. Finally, a current-year recruitment forecast derived from data on precipitation, wind mixing, and advection is incorporated into the Gulf of Alaska pollock assessment. As the fisheries science community moves towards expanded use of environmental information in stock predictions, we will be faced with the question of what type of management measures we should take, given our understanding of environmentally-driven variability in stock production. For some stocks it might be most appropriate to vary biological reference points with each new stock production "regime". For other stocks, the best strategy might be to protect a portion of spawning biomass with no-take reserves. Yet other stocks might be best managed with a biomass-control rule that prohibits targeted fishing below a threshold stock biomass

PICES XIII W4-2048 Invited

To upscale or downscale? Thoughts on bridging disparate scales of space and time in linking the planetary to the plankton

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A common and difficult problem in fishery oceanography lies in choosing informative methods for linking time series of *in-situ* or regionally aggregated fishery-related observations to seasonally averaged indices for very large scale climate phenomena like El Niño Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), or the North Atlantic Oscillation (NAO). All biophysical interactions must be local in nature, yet for some species single local environmental indicators are no better, or perhaps even worse, than very large-scale climate indices at explaining biological variations at local and regional scales. While directly comparing large scale indices to local/regional fishery data often yields statistically significant relationships, this approach rarely yields deep insights into the biophysical processes underlying the statistics. In contrast, "upscaling", wherein biophysically important local/regional environmental parameters are linked to larger scale climatic phenomenon, offers a promising route to better understanding both the local biophysical interactions and the ecological predictability that is tied to large scale climate phenomena. Creative approaches to linking high frequency observations from ships and moorings, to spatially rich but often temporally poor satellite observations and gridded global data sets has the potential to yield rapid advances in understanding the role of planetary scale climate changes in local/regional marine ecology.

PICES XIII W4-1811 Oral

Integrated adaptive management applied to the Gulf Ecosystem Monitoring and Research (GEM) Program

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The Gulf of Alaska Ecosystem Monitoring and Research Program (GEM), is focused on the northern Gulf of Alaska (GOA), one of the world's most productive ecosystems. One challenge is to develop a set of prioritized requirements for indicators of ecosystem status and health to guide GEM research and monitoring. Recently, the Integrated Management (IM) approach has been successfully applied elsewhere, *e.g.*, Canada. Using the IM methodology, Management, Community and Operational Objectives are defined and translated into ecosystem indicators and reference points that are critical to monitoring, modeling and managing the ecosystem. Although understanding ecosystem-fishery interactions is limited, in the IM approach the indicators and reference points work well while providing valuable information for researchers and management decision-makers. The IM approach allows each stakeholder group (commercial, recreational, environmental, subsistence, local government, educational and scientists) to have a voice in defining priorities, allows users to better understand and accept other group's priorities and facilitates community involvement in the development of the GEM program. The community requirements for each stakeholder group will be defined in detail at a series of workshops to be held beginning in 2005. The overall requirements for the GEM Program will result from adapting the newly developed stakeholder priorities to the constraints of the scientific and legal management framework under which the GEM Program operates. This will provide the GEM management team with the prioritized information needed to develop, implement and manage an effective GEM Monitoring and Research Program.

PICES XIII W4-2187 Invited

Regional impacts of large-scale climate variations on the Pacific Ocean ecosystem

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Large-scale climate variations in the Pacific Ocean wield a strong influence on the oceanic ecosystem. Two dominant patterns of large-scale decadal SST variability and one dominant pattern of large-scale decadal thermocline variability can be explained as a forced oceanic response to large-scale changes in the Aleutian Low. The physical mechanisms that generate this decadal variability are still unclear, but stochastic atmospheric forcing of the ocean combined with atmospheric teleconnections from the tropics to the midlatitudes and some weak ocean-atmosphere feedbacks processes are the most plausible explanation. These observed physical variations organize the oceanic ecosystem response through large-scale basin-wide forcings that exert distinct local influences through many different processes. The regional ecosystem impacts of these local processes are discussed for the Tropical Pacific, the Central North Pacific, the Kuroshio-Oyashio Extension, the Bering Sea, the Gulf of Alaska, and the California Current System regions in the context of the observed decadal climate variability. The physical ocean-atmosphere system and the oceanic ecosystem interact through many different processes. These include physical forcing of the ecosystem by changes in solar fluxes, ocean temperature, horizontal current advection, vertical mixing and upwelling, freshwater fluxes, and sea ice. These also include oceanic ecosystem forcing of the climate by attenuation of solar energy by phytoplankton absorption and atmospheric aerosol production by phytoplankton DMS fluxes. A more complete understanding of the complicated feedback processes controlling decadal variability, ocean ecosystems, and biogeochemical cycling requires a concerted and organized long-term observational and modeling effort.

PICES XIII W4-2155 Invited
Global linkages of decadal variability over the North Pacific Ocean

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Linkages of Pacific variability to other regions are investigated on decadal timescales. The most prominent relation is found between the Atlantic and the Pacific Oceans associated with the quasi-decadal variability prominent in the North Atlantic Oscillation (NAO). Decadal filtered (7-yr < period < 17-yr) time series comparison of the NAO index and the North Pacific Index (NPI) in winter exhibits a close-relation after 1950 with one-year lag (NPI leads). Correlation map of Sea Level Pressure (SLP) onto the NAO and NPI suggests that the one-year before the maximal NAO, SLP anomalies in the Atlantic sector are centered in the Mediterranean Sea, from which an atmospheric Rossby wave is propagated to the North Pacific through northern Eurasia, resulting in large atmospheric circulation anomalies over the North Pacific. Consistently, coherency analysis of the wintertime NAO and NPI showed a 95% significant quasi-decadal peak after 1950. Correlation map of heat content (0-400 m) anomalies onto the NAO with the decadal filter exhibits strong correlations over the North Pacific centered 40°N with the one-year lag (NAO delayed) as well as the simultaneous correlation map onto the NPI. These results suggest that the NAO influenced the North Pacific Ocean in the region of sub-arctic front (40°N) on the quasi-decadal timescale after 1950, but the influence is the strongest one-year before the maximal NAO. For better understanding of the decadal variability of the subarctic front, which has attracted large attentions, we need to improve our understanding of the interactions between the Pacific and Atlantic Oceans.

PICES XIII W4-2067 Oral
Spatial scales and magnitudes of covariation among fish populations in the Northeast Pacific

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Climate effects on fish populations are most apparent in correlations between large-scale climate variables, such as the PDO or ENSO, and spatially aggregated measures of fish productivity. However, these large scales may not reflect the spatial scale at which climate affects fish populations. In order to better understand how and at what scales the underlying mechanisms operate it is important to understand the spatial scale of covariability among different populations. Therefore, we examined the magnitude of covariation among recruitment and survival rates of groundfish populations within and between the Eastern Bering Sea (EBS) and the Gulf of Alaska (GoA). Recruitment series of different populations were, on average, positively but very weakly correlated (EBS: $r = 0.07$; GoA: $r = 0.12$). However, multivariate analyses identified certain groups of species with strong positive covariation, particularly in the Eastern Bering Sea (up to $r = 0.8$), suggesting that this shared variability is controlled by similar mechanisms. In addition, we found strong negative covariation between survival rates of two groups of species in the EBS (up to $r = -0.6$), suggesting a common mechanism that affects their survival in opposite ways. Recruitment of different populations of the same species that occurred in both the EBS and GoA were relatively weakly correlated ($r = 0$ to 0.48). This implies that different species within each region share a larger proportion of recruitment variability than populations of the same species from different regions and suggests a need for explanatory variables at the spatial scale of these regions.

PICES XIII W4-1925 Invited
Tropical and extratropical modes of ecosystem variability

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The manifestation of physical climate forcing on ecosystem variability is well known in terms of the ENSO related variability or lower frequency PDO type variability. In this modeling study, we employ a coupled physical-biogeochemical model to seek physical mechanisms of these relations. The ENSO impact for *e.g.*, is assumed to be the reduced primary produciton through reduced upwelling in the eastern equatorial Pacific but the impact of ENSo on the western equatorial Pacific and in the off-equatorial regions remains less known. An eddy resolving and a non-eddy resolving simulation are used to study the impact of mesoscale variability of the tropical ecosystem response at interannual and longer time-scales. It is shown that the rectification of the lower-frequencies by the mesoscale variability is significant and needs to be considered in global modeling, especially in terms of climate change projections. The extratropical modes of variability are affected uniquely by biogeochemical and ecosystem responses to subsurface variability such as thermocline movements as opposed to much observed SST variability. The role of the ecosystem in indicating impending low-frequency changes in the physical system is explored in this context by analyzing the details beyond simple correlations of ecosystem variables with climatic indices. The scales at which ecosystems respond clearly have a consequence for our interpretations of climate variability such as regime shifts.

PICES XIII W4-1964 Oral
Relationship of different scales of climate variability in the Asian Pacific

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The major patterns of the climatic oscillations and trends in the monthly mean surface air temperature and precipitation for the Northeast Asia and Alaska Peninsula, as well as, in the sea surface temperature (SST) for the Northwest Pacific are revealed from the observational records. The methods of linear trend estimation, EOF decomposition and wavelet analyses are applied to reveal major patterns of the different scale climate variability the area studied. Regional features and seasonality of trends and dominating oscillations associated with high positive or negative anomalies, are related to the global scale anomalies. It is shown that the semi-centennial summer cooling during second half of the 20th century in some offshore continental areas of Asia accompanies the semi-centennial negative SST anomaly dominating during summer in the western subarctic pacific gyre. At the same time, the winter warming in the continental and marginal area of the North East Asia and Alaska Peninsula accompanies the positive SST trend predominated in the Kuroshio and Aleutian current systems in winter. Wavelet transformations show the evolution of frequency, amplitude and phase of the climate oscillation of the ENSO (3–7 years), decadal (8–13), and interdecadal (18–30 years) time scales. The bi-decadal (18–26 years) oscillation both in the air temperature and precipitation is most evident in the subarctic marginal Northwest Pacific zone, particularly, in the Kamchatka Peninsula and Okhotsk Sea area. The decadal scale (8–13 years) oscillation is most evident in the arctic marginal zone including western Bering Sea all year round, as well as over land in the latitude band of Kuroshio-Oyashio Extension area mainly in months of the cold period of a year. The period of interdecadal variability in some large scale areas shifts to the red spectrum and comes to about 30–40 years band. The long-term oscillations with a period of 50–60 years (Minobe 1997) is typical for the Chukotka Peninsula where the winter anomalies of this scale both in the air temperature and precipitation have an opposite sign in comparison with the summer. It is also related to estimation of the negative winter air temperature trend and the positive summer air temperature trend in this area for the second half of the 20th century. Due to the nonlinear dynamics in the ocean-atmosphere system, the frequency of the prevailing variability in the joint decadal-interdecadal band drifts from the decadal to interdecadal scale or from the interdecadal to decadal scale. Similarly, the frequency of the dominating oscillations in the air temperature, precipitation, and SST can drift in some areas from ENSO to decadal scale and back. The ENSO scale variability with period of about 3–7 years in the air temperature, precipitation, and sea surface temperature is one of the prevailing oscillations both in subtropic and subarctic regions of the Northwest Pacific, its marginal seas, and adjacent land area of the Northeast Asia. Winter El Niño accompanies the warming in

the subtropic Northwest Pacific and the adjacent land, and the cooling in the subarctic ocean/land area during winter. It seems to be that the alternating patterns and seasonality of positive and negative temperature anomalies of ENSO time scale in the Northwest Pacific Region are similar to patterns and seasonality of the semi-centennial climatic trend in the Northwest Pacific SST. The features of biennial oscillation and extreme event recurrence in the Russian Far East is related to phases of the ENSO and decadal oscillations.

PICES XIII W4-2154 Oral
Coincidence of pink salmon catch trends among the odd-years and even-years populations: Regional and basin scale views

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A biannual spawning cycle is inherent for most pink salmon (*Oncorhynchus gorbuscha*) stocks due to the separation of odd-years and even-years populations. In our study, catch dynamics trends of pink salmon were calculated as the arithmetical difference of "expected" catch (mean value of four previous years in the odd-years or even-years cycle) and actual catch. Singular coincidence of catch dynamics among the almost independent odd-years and even-years populations was found for three coastal fishery regions of the Sea of Okhotsk. In the Sakhalin – Kurile Islands region, increasing and decreasing trends of abundance coincided with 22-years (double solar) cycle. Coincidence of peaks of the odd-years trend curve occurred with the generally recognized years of climate-ocean "regime shifts" in 1950, 1976, and 1989. Coincidence of trend curves for the odd-years and even-years population has become more apparent in the second half of 20th century ($r2 = 0.70$) than for all data series since 1907. Among smaller regions, the Aniva Bay catch series demonstrated the highest coincidence of the trend curves ($r2 = 0.84$) while dependence was not reliable for the Iturup Island. Observed relation between the pink salmon catch trends of even and odd years supposes an existence of the strictly determined internal response of populations to the periodic dynamics of global factor or the complex of factors, that affect the determining conditions for salmon reproduction and survival. However, this response has regional features that are determined by anthropogenic local factors as well as natural ones.

PICES XIII W4-1997 Invited
Temporal and spatial variability of phytoplankton biomass and productivity in the Bering Sea in relation to climate variability

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Interannual and seasonal variability of surface chlorophyll-a concentrations (Chl-a) and primary production (PP) were examined in the Bering Sea for the period of 1997-2002, using Empirical Orthogonal Function (EOF) analysis of Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and Ocean Color Temperature Scanner (OCTS) datasets. The results of EOF analysis on normalized monthly fields in spring showed the east – west seesaw pattern Chl-a in the spring bloom period (April - June). The first EOF mode explained about 31% of temporal and spatial variability, indicating that the outer shelf region and the Off Kamchatka Peninsula has a different phase in the spring bloom. The second EOF mode showed the costal and offshore variability. The third EOF mode describes phase difference in the continental shelf and the Off Kamchatka Peninsula. This strong east - west signal is linked by ocean surface wind. The wind speed anomaly derived from Special Sensor Microwave Imager (SSM/I) shows a similar east – west pattern related to the Aleutian low position. Where the Aleutian low shifted from westward to eastward, weak wind stress facilitated the development of stratification, resulting from enhancement strong spring bloom in the off Kamchatka. The position and strength of the Aleutian low correspond to the North Pacific Index, hence atmospheric forcing modulation would have a connection with the Bering Sea spring phytoplankton biomass variability through a teleconnection of the ENSO event of 1997-2002.

PICES XIII W4-1996 Oral
Relationships between environmental variability and eastern Bering Sea flatfish population distributions

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Little research has been conducted examining temporal changes in distributions of eastern Bering Sea (EBS) flatfish and their relation to environmental variability, despite several aspects of flatfish life-history, such as spawning migrations and larval drift, which are potentially affected by environmental variation. Additionally, the range of environmental variability recently observed in the EBS provides opportunity to examine such relationships. For example, temperature data from the EBS trawl survey indicate that 1999 was one of the coldest years since 1982, and the distribution of several flatfish species in 1999 appear to show a southward shift. In contrast, since 1999 a warming trend has occurred such that 2003 was one of the warmest years observed in the EBS trawl survey. In this research, the relationships between flatfish distributions and a variety of factors, including temperature, sediment size, depth, prey abundance, and population density are examined with a variety of methods, including time-series analysis and generalized additive models. Additionally, the effects that environmental variability and/or temporal changes in flatfish distributions may have on fishery stock assessments is discussed, such as populations potentially moving out of surveyed areas and temperature- induced behavioural changes. Finally, current efforts of incorporating environmental variability into EBS flatfish assessments are described, including estimation of temperature-dependant survey catchability coefficients.

PICES XIII W4-2141 Invited
Temporal variability of sea surface chlorophyll and biophysical coupling in the Pacific

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Aug. 2004 marks the end of the 8th year of data from the SeaWiFS ocean color sensor. The spatial and temporal resolution provided by satellite data have greatly improved our understanding of both biological variability in the surface ocean on both seasonal and interannual scales, and of biophysical coupling by analyzing satellite chlorophyll data in conjunction with satellite measurements of sea surface height (SSH) and sea surface temperature (SST). SeaWiFS recorded the chlorophyll changes in the Pacific brought on by the intense El Niño of 1997/1998 and the subsequent La Niña. Changes in the thermocline structure across the Pacific associated with the El Niño had a wide-scale impact on biology, reducing chlorophyll levels throughout the tropical Pacific. Dynamics are different between the equatorial and off-equatorial regions, with the chlorophyll recovery after the El Niño occurring earlier along the equator. While the SeaWiFS record is too short to discern low-frequency biological variability associated with the PDO or other regime shifts, some inferences can be made by comparing chlorophyll patterns from SeaWiFS with those obtained by the Costal Zone Color Scanner (CZCS) during 1979-1985. For example, the average winter position of the Transition Zone Chlorophyll Front (TZCF) from CZCS data was about 5° further south than its current position, indicating that there was a larger extent of productive waters in the early 1980s. Since the TZCF is an important migratory and foraging habitat, interannual variations in its position could have significant ecosystem implications.

PICES XIII W4-1867 Oral
Low frequency environmental fluctuations and Main Chilean Pelagic Fisheries

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Environmental changes at inter-annual and inter-decadal scales can be observed from the Pacific Southern Oscillation Index (SOI) and local indicators such as sea surface temperature and an upwelling index deduced from wind stress. Data from 1950-2003 were analyzed together with yields of key commercial fishes to study patterns of system variability.

Common sardine (*Strangomera bentinki*) and anchovy (*Engraulis ringens*) yields, showed negative anomalies associated with the El Niño events. The non-recovery of these fisheries after 1976 coincides with a drop in the long-term variability of the SOI, associated to the development of a warm long-term period affecting the region, and with the expansion of the sardine (*Sardinops sagax*) and jack mackerel (*Trachurus murphyi*) fisheries. The yields of sardine, jack mackerel, and also swordfish (*Xiphias gladius*), showed a clear decrease after the mid-1980s. At the same time, a remarkable recovery of landings of common sardine, anchovy, and of common hake (*Merluccius gayi*) was observed, associated to the development of a cooling trend in the environment, in spite of the El Niño 1987, 1991-92 and 1997-98 events. The El Niño events represent an interannual scale of the environmental variability, producing effects on the abundance and distribution of the fisheries resources. In addition to these events, interdecadal climatic regime shifts must be considered in the analyses of these fisheries.

PICES XIII W4-2026 Oral
Tide-induced North Pacific Intermediate Water circulation and impacts on climate

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Recent observations and modeling reveal that the circulation forming North Pacific Intermediate Water (NPIW) is related to the tide-induced diapycnal upwelling around the Kuril Islands. This relationship enhances the Oyashio and cross-gyre transport from the subarctic to subtropical gyres across the wind-driven gyre boundary. This circulation weakens the Kuroshio and the Kuroshio Extension and reduces the poleward heat transport along the western boundary currents. These changes of the western boundary current and heat transport are formulated as a function of the diapycnal upwelling transport. Simple three-layer numerical models confirm the validity of the formulation. Poleward heat transport changes are estimated to be about 0.1PW, corresponding to the diapycnal upwelling transport of 3 Sv. This change possibly has impact on climate, considering that the poleward heat transports across 24ºN were estimated to be 0.45-0.8PW.

PICES XIII W4-2156 Invited
Variability of Chl-a in the North Pacific marine ecosystems

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Satellite chlorophyll-a data from 1998 through 2003 were analyzed to understand the characteristics of interannual variability in phytoplankton dynamics in the North Pacific marine ecosystems. The study describes a response of phytoplankton to ENSO events as there were one large and one moderate El Niño, and one large La Niña during the period. Regional chlorophyll-a dynamics showed diverse patterns of seasonal cycles: unimodal, bimodal, or irregular cycles with high amplitudes or low level of chlorophyll-a. The phase and amplitude of chlorophyll-a cycles in each region showed high interannual variability. Despite such diverse patterns in seasonal cycles, EOF analysis indicates that a large portion of chlorophyll-a variability corresponded to basin-scale SST anomaly pattern in the North Pacific. We concluded that the SST pattern is symptomatic of complex physical regime rather than the causal factor to the chlorophyll variability. We to proposed hypotheses to explain the mechanisms relating to our conclusions.