

PICES / GLOBEC Symposium

**Climate Variability and Ecosystem
Impacts on the North Pacific:
A Basin-Scale Synthesis**

**April 19-21, 2006
Honolulu, USA**

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- Theme 1: Regime shifts, especially, examination of the ocean and ecosystem responses to known strong, infrequent changes in the North Pacific, such as those that occurred in 1977, 1989, and 1998;
- Theme 2: Ecosystem productivity and structural responses to physical forcing, with an emphasis on shorter than inter-decadal time-scales; interannual (El Niño-La Niña), seasonal and event scales;
- Theme 3: Pan-Pacific comparisons, with an emphasis on comparisons of similar species or processes from multiple coastal ecosystems and of open ocean-coastal linkages and climate connections

Abstracts are sorted first by session and then alphabetically by presenter's last name. Presenters' names are in bold and underlined print. The Index of Authors lists all authors, including co-authors, in alphabetical order. Paper numbers and page numbers are also listed in the Index of Authors. Some abstracts in this collection have not been edited and have been printed in the condition that they were received.

Schedule

Day 1 (April 19, 2006)		Day 2 (April 20, 2006)		Day 3 (April 21, 2006)	
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08:50	Overland, J.	09:05	Hermann, A.	09:05	Francis, R.
09:25	Schwing, F.	09:30	Agostini, V.	09:30	Thomas, A.
09:50	Rogachev, K.	09:55	Little, J.	09:55	Rodriguez-Sanchez, R.
10:15	Break	10:20	Break	10:20	Break
10:45	Hashioka, T.	10:45	Doyle, M.	10:45	Takasuka, A.
11:10	Alexander, M.	11:10	Pinchuk, A.	11:10	Yatsu, A.
11:35	Beamish, R.	11:35	Kline, T.	11:35	Hay, D.
12:00	Lunch	12:00	Lunch	12:00	Lunch
13:15	Peterson, W.	13:15	Kang, S.	13:15	Rose, K.
13:40	Zavarina, L.	13:40	Megrey, B.	13:40	Perry, R.I.
14:05	Boldt, J.	14:05	Orlov, A.	14:05	Peterman, R.
14:30	Tian, Y.	14:30	Polovina, J.	14:30	Varnavskaya, N.
14:55	Break / Poster Session	14:55	Break	14:55	Break (Posters down by noon)
16:30	Chiba, S.	15:25	Kim, Eun	15:25	Sydeman, W.
16:55	Brodeur, R.	15:50	Baker, J.	15:50	McKinnell, S.
17:20	Lluch-Belda, D.	16:15	Aydin, K.	16:15	Closing Perspective Talk 1 (Kashiwai)
17:45	Adjourn	16:40	Discussion	16:40	Closing Perspective Talk 2 (Davis)
18:00	Welcome Reception	17:15	Evening Poster Session	17:05	Closing Panel Discussion
20:00	Adjourn	20:00	Adjourn	17:40	Closing Session
				18:00	Adjourn

Theme 1 Regime shifts, especially, examination of the ocean and ecosystem responses to known strong, infrequent changes in the North Pacific, such as those that occurred in 1977, 1989, and 1998

Wednesday, April 19, 2006 8:30-20:00

08:30-08:50 **Introduction by Convenors**

08:50-09:25 **James Overland, Shoshiro Minobe and Sergei Rodionov**
(Invited)
North Pacific regimes shifts: Semantics and indicators
(T1-2676)

09:25-09:50 **Franklin B. Schwing, P. Ted Strub, Steven J. Bograd, Roy Mendelsohn, Andrew Thomas and Christopher S. Moore**
Interannual variability in the bifurcation of the North Pacific Current: Co-variability of California Current and Gulf of Alaska ecosystems (T1-2695)

09:50-10:15 **Konstantin Rogachey and Natalya Shlyk**
The role of Alaskan stream eddies in the dynamics of the Kamchatka Current and Western Pacific Subpolar Gyre
(T1-2629)

10:15-10:45 **Coffee Break**

10:45-11:10 **Taketo Hashioka, Yasuhiro Yamanaka, Fumitake Shido and Takashi T. Sakamoto**
Ecosystem change in the western North Pacific associated with global warming obtained by 3-D ecosystem model (T1-2678)

11:10-11:35 **Michael Alexander, Antonietta Capotondi, Art Miller, Doug Neilson, Fei Chai and Richard Brodeur**
Decadal variability in the North Pacific Ocean in a coupled physical-ecosystem model (T1-2637)

11:35-12:00 **Richard Beamish, R. Sweeting, C. Neville and K. Lange**
Shifts in trends in the dominance of Pacific salmon in the Strait of Georgia are related to life history strategies, regimes and climate warming (T1-2630)

- 12:00-13:15 **Lunch**
- 13:15-13:40 **William Peterson, Cheryl Morgan, Hongsheng Bi, Edmundo Casillas, Joe Fisher, Jen Zamon and Robert Emmett**
 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 (T1-2688)
- 13:40-14:05 **L.O. Zavarina and E.A. Shevkyakov**
 About the influence of pink salmon on the dynamics of chum salmon abundance in the west and north-east coasts of Kamchatka (T1-2712)
- 14:05-14:30 **Jennifer L. Boldt and Kerim Aydin**
 Current status and historical trend indicators of climate effects on the Bering Sea and Gulf of Alaska Ecosystems (T1-2659)
- 14:30-14:55 **Yongjun Tian, Hideaki Kidokoro, Tatsuro Watanabe and Naoki Iguchi**
 The late-1980s regime shift in the ecosystem of Tsushima Warm Current in the Japan/East Sea: Evidence of historical data and possible mechanisms (T1-2663)
- 14:55-16:30 **Break / Poster Session**
- 16:30-16:55 **Sanae Chiba, Kazuaki Tadokoro, Toshiro Saino and Hiroya Sugisaki**
 Regime shifts and lower trophic level phenology in the western North Pacific (T1-2642)
- 16:55-17:20 **Richard D. Brodeur, Mary Beth Decker, Lorenzo Ciannelli, Jennifer E. Purcell, Nicholas A. Bond, Phyllis J. Stabeno, George L. Hunt, Jr. and Erika Acuna**
 The rise and fall of large medusae in the Bering Sea in relation to regime shifts (T1-2682)
- 17:20-17:45 **Daniel Lluch-Belda**
 An integration of the sardine-anchovy regime variation in the Pacific Ocean (T1-2666)
- 17:45-18:00 **Adjourn**

Posters

Maki Nuguchi Aita, Kazuaki Tadokoro, Yasuhiro Yamanaka and Michio J. Kishi

Interdecadal variation of the lower trophic ecosystem using a 3-D physical-biological coupled model '3D-NEMURO' (T1-2670)

V.F. Bugaev, B.B. Vronsky, L.O. Zavarina, Z.Kh. Zorbidi and I.V. Tiller

Analysis of coastal catches of Kamchatka River salmon for 1936-2004 (T1-2714)

V.F. Bugaev

Correlation between Kamchatka River sockeye salmon *Oncorhynchus nerka* freshwater and ocean growth rates and stock abundance (on the data for 1989-2004) (T1-2713)

Svetlana V. Davidova

The ichthyoplankton samples as indirect characteristic of the thermal regime of the ocean (T1-2651)

Takahiro Iida, Sei-Ichi Saitoh, Meibing Jin and Jia Wang

Climate variability and phytoplankton dynamics in the Okhotsk Sea and Bering Sea investigated with satellite remote sensing and 1-D ecosystem modeling (T1-2709)

Shin-ichi Ito, Kenneth A. Rose, Maki Noguchi Aita, Bernard A. Megrey, Yasuhiro Yamanaka, Francisco E. Werner and Michio J. Kishi

Interannual response of fish growth of Pacific saury to the 3-D global NEMURO output with realistic atmospheric forcing (T1-2708)

Michio J. Kishi, Ippo Nakajima, Yasuko Kamezawa, Daiki Mukai, Maki Aita-Noguchi and Yasuhiro Yamanaka

Interannual variation of squid, salmon and saury growth using NEMURO.FISH (T1-2667)

Shoshiro Minobe and Asakawa Shogo

A closer look of the 1998/99 change in Kuroshio/Oyashio extension region (T1-2697)

Takuya Nakanowatari, Kay I. Ohshima and Masaaki Wakatsuchi

Spreading of warming signal of the Okhotsk Sea Intermediate Water to the North Pacific since the 50s (T1-2673)

Vadim V. Navrotsky

Climate and ecosystems: Mechanisms of their changes and interrelations (T1-2644)

Konstantin Rogachev

Nodal modulation of air temperature in the Sea of Okhotsk (T1-2624)

Hyunju Seo, Suam Kim, Sukyung Kang and Kibeik Seong

Variability in growth and survival of Korean chum salmon in relation to climate changes during the 1980s-1990s (T1-2671)

Tatyana A. Shatilina and Galina I. Anzhina

Climate shifts in center parameters of the Asian and Far Eastern depressions during the second half of 20th century (T1-2650)

Jie Shi and Hao Wei

Variations of the Yellow Sea environment and the response to the climate events (T1-2720)

Yao Sun

Research progress on dynamic processes of higher trophic food chain/webs in national GLOBECs of China (T1-2719)

Dinh Van Uu and Pham Hoang Lam

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 (T1-2705)

Tatsuro Watanabe, Hideaki Kidokoro and Yongjun Tian

Influence of the late-1980s regime shift to the Japanese continental slope area in the Japan Sea (T1-2675)

PICES/GLOBEC Symposium T1-2670 Poster
**Interdecadal variation of the lower trophic ecosystem using a
3-D physical-biological coupled model '3D-NEMURO'**

Maki Noguchi [Aita](#)¹, Kazuaki Tadokoro^{2,3}, Yasuhiro Yamanaka^{1,4} and Michio J. Kishi^{1,5}

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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

Michael **Alexander**¹, Antonietta Capotondi¹, Art Miller², Doug Neilson², Fei Chai³ and Richard Brodeur⁴

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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 CO₂. 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 led 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

Richard Beamish, R. Sweeting, C. Neville and K. Lange

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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**

Jennifer L. **Boldt**¹ and Kerim Aydin²

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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

Richard D. **Brodeur**¹, Mary Beth Decker², Lorenzo Ciannelli³, Jennifer E. Purcell⁴, Nicholas A. Bond⁵, Phyllis J. Stabeno⁶, George L. Hunt, Jr.⁷ and Erika Acuna⁸

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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 salmon 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. kisutch*, 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 salmon. 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 salmon (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)

V.F. **Bugaev**

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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 $1^{\circ} \times 1^{\circ}$, 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 $1/4^{\circ} \times 1/6^{\circ}$.

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 $26.8\text{--}27.2\sigma_\theta$. The warming trend becomes maximum ($0.12^\circ\text{C}/\text{decade}$) in the western part of the Okhotsk Sea and decreases to $0.08^\circ\text{C}/\text{decade}$ in the western subarctic gyre region ($40^\circ\text{--}52^\circ\text{N}$, $145^\circ\text{--}170^\circ\text{E}$). 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.

PICES/GLOBEC Symposium T1-2676 Invited
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 effects 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 CGOA. 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 13-35°N, 60-100°E; for SFD were 40-55°N, 115-135°E.

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 are stronger 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

Yongjun Tian, Hideaki Kidokoro, Tatsuro Watanabe and Naoki Iguchi

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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 planktivorous 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 25°C isotherm extending to 8th parallel of latitude. In the summer, there is often no horizontal variation in the surface temperature field, which remains near 29°C as characterized for tropicalocean. However, we focus on the upwelling phenomenon near the Vietnam coast, where the minimum temperature can be as low as 24°C. 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.

PICES/GLOBEC Symposium T1-2675 Poster
Influence of the late-1980s regime shift to the Japanese continental slope area in the Japan Sea

Tatsuro Watanabe, Hideaki Kidokoro and Yongjun Tian

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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 ($> 40^{\circ}\text{N}$) 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 ($< 40^{\circ}\text{N}$), 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.

Theme 2 Ecosystem productivity and structural responses to physical forcing, with an emphasis on shorter than inter-decadal time-scales; interannual (El Niño-La Niña), seasonal and event scales

Thursday, April 20, 2006 8:30-20:00

- 08:30-09:05 **Sinjae Yoo and Harold Batchelder** (Invited)
Seasonal, inter-annual and ENSO scale changes in the North Pacific ecosystems (T2-2701)
- 09:05-09:30 **Albert J. Hermann, Thomas M. Powell, Elizabeth L. Dobbins, Enrique N. Curchitser and Dale B. Haidvogel**
A model-based investigation of lower trophic level covariance across the Northeast Pacific on interannual time scales (T2-2692)
- 09:30-09:55 **Vera N. Agostini, Jodie E. Little, J.C. Field, Robert C. Francis and Anne B. Hollowed**
Hake habitat in the California Current System: Distribution, dynamics and ecosystem implications (T2-2707)
- 09:55-10:20 **Jodie E. Little, R.C. Francis, M.G. Dalton and J.C. Field**
Quantifying tradeoffs between ecology, economy and climate in the northern California Current ecosystem (T2-2694)
- 10:20-10:45 **Coffee Break**
- 10:45-11:10 **Miriam J. Doyle, Susan J. Picquelle, Kathryn L. Mier and Mick Spillane**
Climate-ecosystem connections in the Northeast Pacific Ocean: Linkages between Gulf of Alaska ichthyoplankton and physics at the local and basin scales (T2-2652)
- 11:10-11:35 **Alexei I. Pinchuk, Kenneth O. Coyle and Russell R. Hopcroft**
Climate-related changes in abundance and reproduction of dominant euphausiids in the northern Gulf of Alaska in 1998-2004 (T2-2661)

- 11:35-12:00 **Thomas C. Kline, Jr.**
Salmon meta-population response to oceanic carbon subsidies during early marine feeding: Climate change implications (T2-2656)
- 12:00-13:15 **Lunch**
- 13:15-13:40 **Sukyung Kang, Ki Baik Seong, Chae Sung Lee, Young Hee Hur and Cheul Ho Lee**
The impacts of environmental variations on long-term changes of biological characteristics and run timing of Korean chum salmon (*Oncorhynchus keta*) (T2-2702)
- 13:40-14:05 **Bernard A. Megrey, George L. Hunt, Jr. and Jeffrey M. Napp**
Do pollock have an impact on planktivores in the eastern Bering Sea? (T2-2689)
- 14:05-14:30 **Alexei M. Orloy and Vasily A. Ul'chenko**
Multi-annual changes of bottom temperatures in the Pacific off the North Kurils and South Kamchatka and demography of selected groundfish species (T2-2638)
- 14:30-14:55 **Jeffrey J. Polovina, Fei Chai, Donald Kobayashi, Lei Shi and Yi Chao**
North Pacific ecosystem dynamics investigated with satellite remotely sensed oceanographic data and a coupled physical-ecosystem model, 1990-2004 (T2-2636)
- 14:55-15:25 **Coffee Break**
- 15:25-15:50 **Eun Jung Kim, Suam Kim and Dae-Yeon Moon**
The responses in distribution and biology of tropical tuna species in relation to ENSO (T2-2669)
- 15:50-16:15 **Jason D. Baker, Jeffrey J. Polovina and Evan A. Howell**
Apparent link between survival of juvenile Hawaiian monk seals and ocean productivity (T2-2635)
- 16:15-16:40 **Kerim Aydin and the CCCC CFAME Task Team**
Redefining carrying capacity ten years onward? CCCC research on a moving target (T2-2686)

16:40-17:15 **Discussion**

17:15-20:00 **Evening Poster Session**

Posters

Harold P. Batchelder, Enrique Curchitser, Leah R. Feinberg, C. Tracy Shaw and William T. Peterson

Influence of currents, topography and behavior in controlling euphausiid distributions in the northern California Current (T2-2677)

Tatyana A. Belan and Ludmila S. Belan

Long-term changes of marine environment in the coastal zone of Peter the Great Bay (Sea of Japan) (T2-2634)

Nicholas A. Bond, D.V. Holliday, Calvin W. Mordy, Jeffrey M. Napp and Phyllis J. Stabeno

Linkages between physical conditions in the coastal Gulf of Alaska and zooplankton biomass and size composition during 2002-04 (T2-2684)

Hyo Choi

Effect on typhoon Songda (2004) influenced upon the variation of sea surface temperature in the eastern coastal sea of Korea (T2-2716)

K. David Hyrenbach, David J. Anderson, Yann Tremblay, Scott A. Shaffer, Michelle Antolos, Daniel P. Costa, Steven J. Bograd, Dave Foley, Daniel M. Palacios, Elizabeth N. Flint and Maura B. Naughton

North Pacific albatross response to a dynamic oceanic habitat: Interannual variability in the Transition Zone Chlorophyll Front (T2-2703)

Gail V. Irvine, Scott J. Carpenter and Jeff Barnhart

Stable isotope ratios of modern Alaskan bivalve shells: Monitoring Gulf of Alaska coastal ocean dynamics during recent El Niño-La Niña events (T2-2696)

Jaime Jahncke, Benjamin L. Saenz, Chris Rintoul, Russell Bradley and William J. Sydeman

Krill and krill-predator responses to short-time scale variability in wind-driven upwelling in the Gulf of the Farallones, California (T2-2687)

Gennady A. Kantakov

Is so clear climate signal in the Pacific North-West SubArctic for the marine ecosystem bottom level? (T2-2662)

Yasunori Sakurai, Sachi Miyanaga, Jun Yamamoto and Ken Mori

How environmental factors affect the stock size of ommastrephid squid, *Todarodes pacificus* - A possible scenario (T2-2718)

Shanmuganandan Samarajalingam

Climate variability and ecosystem impacts on the North Pacific: A study with reference to identification of major determinants of decadal variability in the marine ecosystem of North Pacific region (T2-2207)

Yulia N. Tananaeva and Marat A. Bogdanov

Interannual variability in development of the seasonal processes and their possible influence on fishery resources of the North Atlantic and North Pacific (T2-2643)

Galina A. Vlasova

Estimation of the hydrodynamic regime of the water movement under the influence of the atmospheric processes in the Bering and Okhotsk Seas (T2-2285)

Thomas C. Wainwright

Short-term predictability of plankton production in a coastal upwelling zone (T2-2683)

Taketo Hashioka and Yasuhiro Yamanaka

Determination mechanism of seasonal and regional variations of phytoplankton groups by top-down and bottom-up controls obtained by a 3-D ecosystem model (T2-2679)

PICES/GLOBEC Symposium T2-2707 Oral
Hake habitat in the California Current System: Distribution, dynamics and ecosystem implications

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The California Current (CC) system is a highly dynamic environment, where physical and biological processes interact at a number of spatial and temporal scales. Climate variability has been known to impact production of a number of CC species. Studies have often attempted to link climate forcing directly with production variability, aggregating impacts across large spatial scales and range of species. The focus has been on directly linking climate with fish abundance metrics, often overlooking a more detailed analysis of how climate forcing impacts the ocean habitat of fish. This study focuses on hake habitat in the California Current. We use acoustic data to examine the distribution of hake in the CC system in relation to poleward flow. We describe interannual differences in flow regime and hake distribution. An ecosystem model is used to examine potential effects of changes in hake distribution on the northern CC ecosystem structure. We find that hake habitat is a dynamic entity whose boundaries are defined by the physical characteristics of the system. These boundaries change in response to interannual climate forcing and this has implications for the northern California ecosystem structure.

PICES/GLOBEC Symposium T2-2686 Oral
Redefining carrying capacity ten years onward?
CCCC research on a moving target

Kerim Aydin¹ and the CCCC CFAME Task Team

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The PICES Climate Change and Carrying Capacity (CCCC) Program began ten years ago with a goal of investigating climate-driven changes in productivity and structure in marine ecosystems. This set up two moving targets: first, climate and fish productivity have varied considerably over the past 10 years; second, our understanding of climate links to productivity, and the tools, language and conceptual models we have used to describe them, have continually evolved. As a synthesis activity, the Climate Forcing and Marine Ecosystems (CFAME) Task Team of CCCC sought in part to describe key aspects of this new understanding. Specifically, on what scales of time, space, and species is carrying capacity a useful concept? Whether viewed as observed decreases in fish size, bottlenecks at critical survival periods, shifts in the timing of predator/prey interactions, changes in bioenergetics based on prey or temperature supply, changes in a stock-recruitment curve, or simply as K in a population equation, the concept of carrying capacity is a paradox: it is a stable (unchanging) limit, yet it is only interesting if used to describe a population that changes. In this review, we examine two, key questions of this paradox: if climate and carrying capacity change constantly, on what scale should we talk about production limits for the North Pacific? And as we move from climate understanding to using our knowledge of climate to better manage fish resources, how should we address and communicate our new understanding of the expectation of sustained production in a constantly changing environment?

PICES/GLOBEC Symposium T2-2635 Oral

Apparent link between survival of juvenile Hawaiian monk seals and ocean productivity

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The Hawaiian monk seal population is declining and low juvenile survival due to prey limitation is believed to be a primary cause. The transition zone chlorophyll front (TZCF) is a large-scale oceanographic feature separating the vertically stratified, low surface chlorophyll subtropical waters and the vertically mixed cool, high chlorophyll Transition Zone waters. The TZCF annually migrates over 1000 km latitudinally and its southern extent in winter varies. We hypothesize that when the front migrates southward, it brings colder, more productive waters into monk seal foraging habitat, thereby enhancing the prey base and consequently survival. We expect this effect will be strongest at seal populations situated furthest north and nearest the TZCF. To test this hypothesis, we explored relationships between survival of over 3000 monk seals during 1984-2004 and the southern-most latitude of the 18°C isotherm (a proxy for the TZCF). We found a statistically significant nonlinear relationship between the winter position of the TZCF and survival of monk seals through age four years at the most northerly atolls. When the front remained further north, survival was poorer. The relationship was strongest following a two-year lag, perhaps indicating the time required for enhanced productivity to influence the food web and improve the seals' prey base. No such relationship was found at subpopulations located further south nor among adult animals at any site. Variation in ocean productivity may mediate prey availability in monk seal foraging habitat and consequently influence juvenile survival in the northern portion of their range.

PICES/GLOBEC Symposium T2-2677 Poster

Influence of currents, topography and behavior in controlling euphausiid distributions in the northern California Current

Harold P. **Batchelder**¹, Enrique Curchitser², Leah R. Feinberg³, C. Tracy Shaw³ and William T. Peterson⁴

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Euphausiids are patchily distributed in the Northern California Current (NCC), with acoustically observed aggregations in summer 2000 near Heceta Bank and off Cape Blanco. Larval stages of *Euphausia pacifica* are often most abundant over Oregon continental shelf waters, whereas adults are more common along and seaward of the shelf break. This difference in distribution could be due to differential spatial mortality of eggs and larvae along an onshore-offshore gradient, or may be due to vertically sheared advection influencing life stages with different preferred depth distributions. In this study we examine the second of these two mechanisms. We use a coupled physical circulation-biological model to examine interactions of mesoscale physical features, shallow and irregular bottom topography, and animal behavior in creating and maintaining euphausiid aggregations in a dynamic upwelling environment. A 3-dimensional Regional Ocean Modeling System simulation (*ca.* 4 km horizontal resolution) of 2000 using observed wind forcing and boundary conditions provided by a larger-scale, coarser-resolution ROMS simulation provided flow fields that were used in individual based particle simulations, where vertical velocities were modified by stage-dependent individual behaviors. We focus only on retention and loss processes interacting with animal behavior that might create spatio-temporal patterns consistent with field observations of *Euphausia pacifica* distributions made during the US GLOBEC program in the NCC.

PICES/GLOBEC Symposium T2-2634 Poster

Long-term changes of marine environment in the coastal zone of Peter the Great Bay (Sea of Japan)

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Long-term changes in three coastal areas of Peter the Great Bay have been analyzed. The following basic parameters are discussed: natural environmental conditions, concentrations of selected pollutants in bottom sediments and the structure of benthic communities. Available biological data for the period from the 1930s to 2001 showed that the most significant alterations of benthos are connected with chronic pollution and progressive eutrophication. The most dramatic ecological situations occurred in 1975-1980, when industrialization and urbanization growth was the most intensive. Decreasing pollution load in some bays in 2001 due to a decline of the Russian Far East economy resulted in recovery of benthic communities in these areas.

PICES/GLOBEC Symposium T2-2684 Poster
Linkages between physical conditions in the coastal Gulf of Alaska and zooplankton biomass and size composition during 2002-04

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This study represents early results from a synthesis study supported by the Northeast Pacific (NEP) element of the Global Ocean Ecosystem Dynamics (GLOBEC) Program. Its objective is to illustrate the steps that are being taken to link the physical state of the coastal Gulf of Alaska (GOA) shelf to summertime zooplankton concentrations and community composition. The present analysis focuses on seasonal mean properties along the Seward line during the summers of 2002-04. This period of study is selected because there were substantial year-to-year differences in the climate forcing and apparent lower-trophic level response, and because of the availability of a wealth of data collected under the auspices of GLOBEC. The analysis is based primarily on the following sets of parameters: basin-scale atmospheric forcing as provided by the NCEP Reanalysis Project, local air-sea interactions (*i.e.*, surface fluxes) as specified by direct measurements from moored buoys complemented by data from the NCEP Reanalysis, temperature, salinity and current profiles as observed continuously by the moorings and intermittently during ship surveys, nutrient data (primarily nitrate concentrations) from moorings and ships, and indices for zooplankton biomass and type as estimated acoustically from a mooring. The outcome of this stage of our project is to provide context for our future work, which will compare the region of the Seward line to that of the shelf of Kodiak Island and will include consideration of sub-seasonal variability, with the ultimate goal of better understanding the mechanisms related to bottom-up control on the GOA shelf.

PICES/GLOBEC Symposium T2-2716 Poster
Impacts of Typhoon Songda (2004) on the variation of sea surface temperature in the eastern coastal Sea of Korea

Hyo **Choi**

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The purpose of this study is to investigate how sea surface temperature in the East Sea of Korea was influenced by the passage of Typhoon Songda from September 2 through September 8, 2004. Rainfall amounts were evaluated using a three-dimensional non-hydrostatic meteorological model, MM5, using NCEP as initial input data for the model. There were 22 levels in the vertical spread from 10 m to 10 km with sequentially larger intervals between levels with increasing altitude. In the numerical process, triple nesting involved grid sizes of 125 x 105 in the horizontal (27-km interval) and 23 in the vertical in the coarse domain; in the second domain, the horizontal grid was 82 x 82 (9-km interval) and in the third domain, 61 x 61 (3-km interval). For further investigation on precipitation events and intensity, meteorological radar was used and for sea surface temperature data and pictures, GOES-9 IR satellite pictures were also simultaneously analyzed. Before September 4, 2004, there was no effect of Typhoon Songda on the Korean peninsula and the East Sea of Korea. Precipitation of a few mm/hour was observed near the southeast edge of the Korean peninsula at 0600LST, September 5, when the center of Typhoon Songda was located near Okinawa Island. As the center of Songda approached about 500km away from Kyushu Island, Japan at 0000LST, September 6, the effect was remarkable, showing rainfall of 20~25 mm/hour along the eastern coast of Korea and Ulreung Island in the East Sea. As the typhoon approached the Korea Strait, the precipitation area extended to higher latitude along the eastern coast and in the East Sea of Korea (Japan Sea). In general, the precipitation area was located in the first quadrant of the typhoon circle like 0°~90°. On September 7, when the typhoon passed through the Korea Strait, the area of precipitation became much wider along the eastern coastal region of Korea and in Ulreung Island than the previous days. Under these patterns of precipitation, the variation of seven days' mean sea surface temperature (here, weekly mean sea surface temperature) along the eastern coastal sea of Korea, especially in the Ulchin coastal sea was 22.8°C on September 2 under no influence of the typhoon. On the other hand, on September 7, before the typhoon decreased to an extra-tropical cyclone, the mean sea surface was 23.5°C. As the typhoon moved from Okinawa toward the East Sea, the weekly mean surface temperatures increased, showing a difference of 0.7°C. It may be possible to infer that as the typhoon transited from Okinawa toward the Korean peninsula, it forced relatively warm water

northeastward toward the East Sea. The driving mechanism of precipitation and numerical simulation results on this meteorological event will be discussed.

PICES/GLOBEC Symposium T2-2652 Oral
**Climate-ecosystem connections in the Northeast Pacific Ocean:
Linkages between Gulf of Alaska ichthyoplankton and physics at
the local and basin scales**

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Environmental conditions during the early life of marine fish contribute to the overall impact of climate on year-to-year recruitment of fish populations. The present study focuses on a 21-year time-series of larval fish abundance from late-spring surveys, 1981 through 2003, in the northwest Gulf of Alaska. It was hypothesized that larval abundance in this area was linked to species-specific combinations of environmental variables and that local conditions imparted a stronger influence on fish early life dynamics than the broader scale ocean basin environment. Links between species abundance and the physical environment were explored using Generalized Additive Modeling (GAM). The environmental data set included climate indices, and atmospheric and oceanographic variables representative of both the local study area and the broader basin of the Gulf of Alaska and Northeast Pacific Ocean during late winter through spring months. The emergent, species-specific associations between larval abundance and environmental variables reflected patterns in life history strategies among species. For instance, abundance of Pacific sandlance larvae was linked most strongly with water temperature and wind conditions, locally, during March, the peak period of emergence of larvae from coastal sediments. Further, the weak connections between starry flounder abundance and all environmental variables reflect the limited exposure of the early life history stages of this species to the pelagic environment due to a short egg incubation period and larval duration. Results of the GAM analysis also indicated that the relative importance of local versus basin scale environmental conditions to the prevalence of larvae in late spring was species specific and again reflective of life history characteristics. This type of ichthyoplankton time-series study shows good potential for identifying levels of resilience or vulnerability of individual species early life history patterns to fluctuating oceanographic conditions.

PICES/GLOBEC Symposium T2-2692 Oral
**A model-based investigation of lower trophic level covariance
across the Northeast Pacific on interannual time scales**

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As part of GLOBEC synthesis, we have begun simulating lower trophic level (NPZ) dynamics of the Northeast Pacific between Baja California and the Bering Strait, out to ~1500 km offshore. A “generic” NPZ model, relevant to both the California Current and the Gulf of Alaska under a single set of internal parameters, is implemented on a 10-km resolution grid (the Northeast Pacific grid; NEP) and simulated over a span of years which includes multiple El Niños (and the 1997-1998 event in particular). The NEP model is embedded in a larger-scale circulation model of the North Pacific. EOF analysis of NEP circulation model output yields dominant spatial modes which correlate strongly with standard measures of El Niño (*e.g.* the Multivariate El Niño Index, MEI), and correspond to observed modes of SSH variability from altimeter data. Here we examine the output of the NEP-NPZ model using a similar EOF approach to ascertain: 1) the degree and structure of spatial covariance across the Northeast Pacific from the generic NPZ model; 2) the dominant physical-biological mechanisms yielding that covariance; 3) the correlation of such spatial modes with the MEI.

PICES/GLOBEC Symposium T2-2703 Poster

**North Pacific albatross response to a dynamic oceanic habitat:
Interannual variability in the Transition Zone chlorophyll front**

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North Pacific albatrosses engage in vast foraging trips, routinely covering 1000s of kilometers in search of prey to feed their chicks. Traditionally, albatrosses and other seabirds have been regarded as ideally suited for foraging in patchy oceanic systems, where prey resources are widely spaced and unpredictable. In recent years, the advent of satellite tracking has shed new light on the habits of these far-ranging marine predators. Starting in 1998, foraging trips of Black-footed (*Phoebastria nigripes*) and Laysan (*P. immutabilis*) albatrosses breeding on Tern island, French Frigate Shoals, were monitored during the chick-brooding period (January-February). Adult albatrosses are most constrained during this breeding phase because chicks must be fed frequently. Therefore, adults must rely on the availability of prey within several hundred kilometers of the breeding colony. Subsequent analyses of tracking data during this period reveal the importance of chlorophyll and temperature fronts as determinants of albatross distributions at-sea. Additionally, multi-year analysis of tracking data with remote sensing imagery highlights possible mechanisms relating observed interannual variability in reproductive success with changing water mass distributions in the North Pacific. In particular, a massive breeding failure observed in 1999 occurred during an anomalous year when the Transition Zone Chlorophyll Front (TZCF) was displaced farther north than in previous years. We hypothesize that interannual variability in frontal position of the TZCF influences albatross reproductive success at this colony. These observations suggest that oceanic birds, in spite of their far-ranging habits, can be affected by the spatio-temporal heterogeneity of oceanographic features in the North Pacific.

PICES/GLOBEC Symposium T2-2696 Poster
**Stable isotope ratios of modern Alaskan bivalve shells:
Monitoring Gulf of Alaska coastal ocean dynamics during recent
El Niño-La Niña events**

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El Niño-Southern Oscillation (ENSO) events produce global effects that are not fully understood. Most frequently, ENSO events are described in terms of changes in sea surface temperatures, through changes in thermoclines, productivity and cascading food web effects are known from some areas. In the Gulf of Alaska, El Niño events are associated with pooling of warm surface waters and changes in productivity. We are examining high-resolution data from individual bivalves to retrospectively examine and elucidate patterns of coastal ocean temperature and productivity during the recent 1997-1998 El Niño and 1999 La Niña events in the Gulf of Alaska. Bivalves of both shallow-water (butter clam, *Saxidomus giganteus*) and deep-water (scallop, *Patinopecten caurinus*) species are being compared, to provide a more comprehensive view of how conditions during an El Niño event are expressed in the Alaska Coastal Current (ACC). Analysis of $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values are conducted on micro-samples extracted at sub-monthly resolution from shell carbonate. They allow us to assess intra- and inter-annual variation in coastal marine surface waters and shelf bottom waters. Data from the 1997-98 time period for *P. caurinus*, collected from ~100m, indicate atypical winter $\delta^{18}\text{O}$ values that represent a combined warming of bottom waters and a decrease in ambient $\delta^{18}\text{O}$ values due to an increase in freshwater influx into the ACC. $\delta^{13}\text{C}$ values from both bivalve species suggest variable and potentially heightened winter productivity. Results from these modern shells will aid with the interpretation of similar data from archeological midden materials in this region.

PICES/GLOBEC Symposium T2-2687 Poster
Krill and krill-predator responses to short-time scale variability
in wind-driven upwelling in the Gulf of the Farallones,
California

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We examined krill and krill-predator responses to interannual, seasonal and event scale variability in wind-driven upwelling in the Gulf of the Farallones. We conducted research cruises in 2004 (May-October) and 2005 (February-October). We characterized the physical oceanography using CTD casts and continuous CT and fluorometry measurements. We concurrently determined the abundance and distribution of krill using hydroacoustics and nets, and of krill-predators (*i.e.*, birds and mammals) using standardized transects. Physical oceanographic conditions as well as the abundance and distribution of krill and krill-predators varied greatly at multiple time scales. At interannual scales, we found that krill and krill-predator abundance was higher in 2004 than 2005. Strong northwest winds resulted in upwelling and elevated fluorescence early in 2004, but these events were delayed in 2005. Anomalous oceanographic conditions resulted in low prey availability for upper trophic level predators in 2005; this was evidenced by massive nest abandonment by Cassin's auklets *Ptychoramphus aleuticus*, a krill-eating seabird, on the Southeast Farallones Islands and late arrival of blue whales *Balaenoptera musculus*, a krill-specialist, to the central California region. At seasonal scales we found that krill abundance was greater in winter and spring whereas krill-predator abundance was greater during spring and summer. High abundance of krill in winter and spring was largely due to the presence of *Euphausia pacifica*. Spring and summer corresponds to the auklet breeding season and the blue whale migration cycle along California. At the event scale, we found that krill and krill-predator distribution differed between upwelling and non-upwelling conditions. Cassin's auklets foraged in large numbers at the upwelling front during strong upwelling, but were widely dispersed along the shelf break when upwelling was absent.

PICES/GLOBEC Symposium T2-2702 Oral
The impacts of environmental variations on long-term changes of biological characteristics and run timing of Korean chum salmon (*Oncorhynchus keta*)

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Chum salmon, caught from 1985 to 2004 spawning season were examined to reveal the impacts of environmental variations on long-term changes of biological characteristics and those of run timing of chum salmon to Korea. Chum salmon, especially males have become larger in the 2000s compared to the 1980s. The length compositions of female chums were 3 to 7cm larger than those of males in the late 1980s, however, the sexes are similarly sized in the 2000s. The main age groups of returning spawners in the 1980s were 3 and 4 year olds; however, age 4 became dominant in the 1990s and 2000s. The sex ratio of returning spawners has changed with female proportions increasing from 34~43 % for the late 1980s to 45~55% in the 1990s and 2000s. The timing of chum salmon returns for spawning have become earlier in more recent years; mid November in the 1980s, in early November in the 1990s and in late October in the 2000s. Run timing is not significantly related to water temperature in the coastal area and river. However, an extremely cold year, 2002, delayed the return timing, while a warm year, 1990, had an early return. Precipitation of the river and daily relative returning chum salmon have positive relation at the 5% significant level.

PICES/GLOBEC Symposium T2-2662 Poster

Is so clear climate signal in the Pacific North-West Subarctic for the marine ecosystem bottom level?

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The goal of this research is to identify climate change signals in lower-trophic level marine ecosystems within the north-western marginal Pacific seas. Based on surface and *in situ* ocean conditions the climate change signal is traced during the last 30 years for the upper ocean layer. The region of research included seasonally ice-covered seas - the northern part of the Sea of Japan, the Okhotsk Sea and nearby Pacific Ocean regions. Layer temperature, salinity, vertical thickness of the dichothermal layer, MLD, ice coverage, particularly currents transport and zooplankton are main parameters that track (or respond to) seasonal, interannual and intradecadal variability. Environmental change impacts the low-trophic levels, for example, zooplankton biomass and species structure. It is obvious that upper layer warming has led to declines in total zooplankton biomass among investigated sites based on the original data.

PICES/GLOBEC Symposium T2-2669 Oral
The responses in distribution and biology of tropical tuna species in relation to ENSO

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El Niño/Southern Oscillation (ENSO), is a major interannual physical forcing in the tropical Pacific that affects the entire ecosystem, including the distribution of tuna. In this paper we delineate the distributional and biological responses of tropical tuna species relative to ENSO. Three tuna species, were chosen for this study: skipjack tuna (*Katsuwonus pelamis*), bigeye tuna (*Thunnus obesus*), and yellowfin tuna (*Thunnus albacares*). These species have different depth distribution and thermal limitations. We analyzed biological and spatial information from Korean fishing data. Distributional centroids of the three species were calculated and compared with ENSO factors. During El Niño years the longitude of the main fishing grounds of skipjack tuna changed: the centroid shifted to the east. In contrast, during El Niño events, the fishing centroids of bigeye and yellowfin tuna shifted to the west. Furthermore, ENSO also affected some biological characteristics of skipjack tuna. During ENSO events there was a decrease in the mean length and diminution in gonad index with time-lags of 5 months and 8-9 months, respectively.

PICES/GLOBEC Symposium T2-2656 Oral
Salmon meta-population response to oceanic carbon subsidies during early marine feeding: Climate change implications

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Oceanic carbon subsidies inferred from mean early marine (continental shelf feeding) pink salmon whole-body stable carbon isotope composition, $\delta^{13}\text{C}$, was correlated to the marine survival rate calculated from the returns to release (R/R) ratio for a pink salmon (*Oncorhynchus gorbuscha*) meta-population comprising the production of four Prince William Sound, Alaska salmon hatcheries during NEP U.S. GLOBEC (1998 to 2003). The R/R of each sub-population, *i.e.*, that of each hatchery (R/R_H), ranged from 50% to 200% of the meta-population R/R (R/R_M). Sub-population deviations from the meta-population were parameterized by subtraction, $R/R_H - R/R_M$ (D_S), and by ratio, $R/R_H/R/R_M$ (D_R), for linear and multiple regression modeling. Oceanic subsidies measured as $\delta^{13}\text{C}$ was a significant factor ($P < 0.05$) explaining about 30% of R/R_M . Neither D_S nor D_R was correlated to R/R_M . However, D_S and D_R were correlated to R/R_H ($R^2 \sim 0.6$) whereas $\delta^{13}\text{C}$ was not. Multiple regression increased correlations compared to simple regression, but by < 0.03 and were not always significant. The meta-population thus responded to oceanic subsidies whereas sub-populations did not. Sub-population survival parameters were not related to meta-population performance. Oceanic subsidies are hypothesized to link climate-driven inter-decadal sub-arctic northeast Pacific oceanic zooplankton population cycles with salmon population cycles. Accordingly, subsidy potential would be greater during oceanic zooplankton population peaks. Manifestation of oceanic subsidies may require a meta-population approach, thus analyses based on single populations may be inappropriate, at least for short time series (*e.g.*, a half-dozen years), for detecting effects of climate change. Single populations appear to be otherwise driven by local effects of unknown source(s).

PICES/GLOBEC Symposium T2-2694 Oral
**Quantifying tradeoffs between ecology, economy and climate in
the northern California Current ecosystem**

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United States West Coast fisheries operate in a highly variable marine environment and have experienced various degrees of success and failure in the last half century. The interactions and concomitant tradeoffs between fleets, marine resources and climate conditions have shaped this history yet prove challenging to quantify. To explore ecosystem effects of fishing and climate in the Northern California Current Ecosystem and its fisheries, we perturbed a food-web model over the 1960-2000 time period as well as evaluated equilibrium properties of the system at present when subjected to different fishing policies. We then examined relationships and tradeoffs in both ecological (species biomass) and economic (fleet revenue) terms in response to these perturbations. Recognizing that the nature of relationships and tradeoffs likely reflect both the nature of the perturbation and the time scale considered, we examined three perturbations (individual fleets separately, all fleets simultaneously, climate inclusion/exclusion) at three different time scales (historical by decade, entire 40 year historical period, equilibrium 100 year period). We found strong, temporally distinct tradeoffs between climate and fishing both through the lens of ecology and economy. We discuss these results as they apply to ecosystem-based fishery management as an innovative method for interdisciplinary modeling.

PICES/GLOBEC Symposium T2-2689 Oral

Do pollock have an impact on planktivores in the eastern Bering Sea?

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Walleye pollock (*Theragra chalcogramma*) constitute the vast majority of fish biomass over the eastern Bering Sea shelf. Although known for their propensity for cannibalism, all ages of pollock consume zooplankton, including species of large copepods and euphausiids. We collected various ecological time series representing multiple trophic levels and analyzed these with statistical data exploration methods to ask one question. Is there evidence of the potential for pollock to influence the dynamics of other species of planktivores in the eastern Bering Sea? Data series examined included total pollock biomass, adult pollock abundance, juvenile pollock abundance, Togiak herring biomass and age 4 recruitment, zooplankton biomass from the middle shelf region, and jellyfish abundance. Combining the individual time series elements into a synthesized perspective allowed a holistic description of trends between adult pollock biomass and numerical abundance with the abundance of age-1 pollock, herring recruits, jellyfish and zooplankton. An integrated examination of these ecosystem data showed a strong negative relationship between adult pollock and zooplankton, suggesting top-down control of the zooplankton by pollock. Negative correlations also existed between adult pollock and age-1 pollock, and between jellyfish and zooplankton. However, a weak positive correlation between adult pollock biomass and jellyfish biomass suggests that conditions favorable for pollock may also favor jellyfish, thus leaving in doubt whether jellyfish exert top-down control on zooplankton. Our preliminary findings suggest a pervasive role of pollock in shaping Bering Sea ecosystem structure.

PICES/GLOBEC Symposium T2-2638 Oral
**Multi-annual changes of bottom temperatures in the Pacific off
the North Kurils and South Kamchatka and demography of
selected groundfish species**

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The results of eight oceanological and bottom trawl surveys (totally 650 stations) conducted within the Pacific waters off the northern Kuril Islands and southeastern Kamchatka in 1993-2000 during similar calendar period (late summer – autumn) are analyzed. The data enable identification of several periods with different thermal conditions. The years 1993-1995 were characterized by the existence of two areas with low bottom temperatures (less than 1°C): off central Paramushir Island and southeastern Kamchatka. 1995 temperatures were the coldest with a wide area of negative bottom temperatures off southeastern Kamchatka. The years 1996-1998 were considerably warmer, with the entire survey area having bottom temperatures > 1°C. In 1999 the situation changed and 1999-2000 were essentially colder than previous period. A wide area with low temperatures occurred off southeastern Kamchatka. It should be noted that considerable temperature changes occurred in the northern part of the survey region only, while bottom temperatures remained > 1°C during the whole study period elsewhere.

The multi-annual changes of survey indices of 32 common groundfish species (4 skates, Pacific cod, walleye pollock, sablefish, prowfish, 2 eelpouts, Atka mackerel, 5 sculpins, 6 snailfishes, sawback poacher, shortraker rockfish, Pacific ocean perch, broadbanded and shortspine thornyheads, Kamchatka flounder, northern rock and flathead soles, Pacific and Greenland halibuts) were analyzed. The majority of species do not demonstrate considerable changes of relative abundance interannually, that may relate to the rather stable temperature conditions within most of the region. However, the analysis of survey indices calculated for the northern region only showed that the relative abundance of the majority of species studied is strongly affected by interannual or longer changes in bottom temperature.

PICES/GLOBEC Symposium T2-2661 Oral
Climate-related changes in abundance and reproduction of dominant euphausiids in the northern Gulf of Alaska in 1998-2004

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Interannual changes in abundance of the dominant euphausiids *Thysanoessa inermis*, *Thysanoessa spinifera*, *Thysanoessa longipes* and *Euphausia pacifica* were studied in the northern Gulf of Alaska during the production season from 1998 to 2004. *Thysanoessa inermis* and *T. longipes*, which inhabit the Alaska Coastal Current, showed a significant increase in abundance from 1998 to 2002, but declined in 2003. In contrast, the abundance of *E. pacifica* occurring on the outer shelf tended to decrease through 2002, but increased in 2003. The abundance of *T. spinifera* did not change. The peak of *T. inermis* reproduction occurred in April in 1998-1999, increased in magnitude and extended through May in 2000-2002, but declined in 2003. Similar trends were observed for *T. longipes*, which start to spawn in March. The spawning of *T. spinifera* and *E. pacifica* extended from April through July, and from July through August, respectively. The spawning of *T. inermis*, *T. longipes* and *T. spinifera* appeared to be closely related to the duration and magnitude of spring diatom bloom on the inner shelf, while the spawning of *E. pacifica* occurred later, when the temperature of the mixed layer increased. A strong association of the increase in abundance of *T. inermis* and *T. longipes* with the extended cold phase of the North Pacific indicates that progressive cooling on the inner shelf in 1998-2002 may have resulted in greater reproductive and survival success of *T. inermis* and *T. longipes*, while reproductive success of *E. pacifica* increased during the warm phase of 2003-2004.

PICES/GLOBEC Symposium T2-2636 Oral
**North Pacific ecosystem dynamics investigated with satellite
remotely sensed oceanographic data and a coupled physical-
ecosystem model, 1990-2004**

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The output from an ocean circulation model coupled with an NPZD biological model with 2 size classes of phytoplankton and zooplankton are used to investigate interannual changes in the lower trophic level ecosystem over the North Pacific. Ecosystem variables considered include primary production, small phytoplankton, diatoms, microzooplankton, and mesozooplankton. Spatial ecosystem dynamics and impacts from the 1997-98 El Niño and the 1999-2002 La Niña are described. Ecosystem impacts from Rossby waves are investigated with longitude-time plots. Empirical orthogonal function analyses are used to describe interannual ecosystem changes. Comparisons between satellite remotely sensed variables and model variables are presented. Linkages between physical, chemical and ecosystem variables for El Niño and La Niña events in various ocean regions are discussed and synthesized.

PICES/GLOBEC Symposium T2-2718 Poster
How environmental factors affect the stock size of
ommatrephid squid, *Todarodes pacificus* - A possible scenario

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Recruitment success in squids depends largely on environmental conditions at the spawning and nursery grounds. The ommastrephid squids are commercially important, however their annual catches fluctuate widely. They produce gelatinous, nearly neutrally buoyant egg masses that contain many small eggs. The egg masses are thought to occur within or above the pycnocline at temperatures suitable for egg development (*e.g.*, 15-23°C in *T. pacificus*) and under conditions of reduced predation. After hatching, the paralarvae presumably ascend to the surface layer and are advected into convergent frontal zones. We observed something resembling a *T. pacificus* egg mass within the pycnocline at 70-120 m depth (temperature range: 18-21°C) in the Tsushima Current using an ROV. We also estimated from laboratory studies that hatchlings ascend to the surface at temperatures of 18-23°C. Results of a previous study (by YS) suggested that annual catches of *T. pacificus* increased during periods of weak winds and warm air temperature, suggesting that the strength of winter winds may affect recruitment. We will present a scenario for how stock size in ommastrephid squids might fluctuate due to environmental factors such as the winter wind stress, air temperature at the sea surface, and mixed layer depth at the spawning grounds. We will also suggest how to forecast the stock fluctuation related to climatic regime shifts and global warming.

PICES/GLOBEC Symposium T2-2207 Poster

**Climate variability and ecosystem impacts on the North Pacific:
A study with reference to identification of major determinants of
decadal variability in the marine ecosystem of North Pacific
region**

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Long-term variation in greenhouse gases and also ozone depletion effected changes in atmospheric forcing, ocean dynamics and also disruption in the ecosystem. These changes are varied over space and in time. The last few decades experienced decadal variation in marine ecosystems as result of climate change due to many causes. Understanding decadal variability in different marine ecosystems particularly in relation to basin wise information can help to enhance the capability of building the conceptual framework for the large and small-scale ecosystems. The North Pacific Ocean played a very vital role in explaining the climate change and its impact on the ecosystem. Hence the present study is an attempt to explain the effects of seasonal and decadal variability on the marine ecosystems of the North Pacific. Sea surface temperatures and sea level pressure in the North Pacific have undergone unusual changes over the last five years. These changes to the North Pacific Ocean climate system are different from those that dominated for the past 50-80 years, which has led scientists to conclude that there is more than one key to the climate of the region. The analysis of review of literature indicates that during the last four winters from 1999-2002 (ranging from November to March) sea surface temperatures were cooler than normal along the U.S. west coast and warmer than normal in the coastal Gulf of Alaska. These conditions differ from those of the Pacific Decadal Oscillation (PDO), thought to be the primary key that causes the climate of the North Pacific to change. As a result, the scientists presumed that the conditions that have occurred since 1999 are independent of the PDO. The study was based on the secondary data and also a detailed review of literature. The Pacific Decadal Oscillation is a basin-wide oceanic pattern similar to El Niño/Southern Oscillations (ENSO) but much larger. It lasts a couple of decades rather than a year or less like El Niño and La Niña. According to Bond and his colleagues, the unusual levels of pressure and temperature seen in the last five years are a departure from the pattern seen in the PDO, which represented the principal mode of long-term climate variability in the North Pacific for the 20th century. These results show that a single index such as the PDO is incomplete for characterizing the state of the North Pacific climate system. While the two climate oscillations (PDO and ENSO) have similar spatial climate fingerprints,

they have very different behavior in time. Two main characteristics distinguish PDO from El Niño/Southern Oscillation (ENSO): first, 20th century PDO “events” persisted for 20-to-30 years, while typical ENSO events persisted for 6 to 18 months; second, the climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics - the opposite is true for ENSO. Major changes in northeast Pacific marine ecosystems have been correlated with phase changes in the PDO; warm eras have seen enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the contiguous United States, while cold PDO eras have seen the opposite north-south pattern of marine ecosystem productivity.

PICES/GLOBEC Symposium T2-2643 Poster
**Interannual variability in development of the seasonal processes
and their possible influence on fishery resources of the North
Atlantic and North Pacific**

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The important factors determining the development of production processes in the ocean, are the timing of the beginning and ending, and therefore the duration of the phenological seasons. Analysis of weekly sea surface temperature (SST) maps, constructed by the satellite data at VNIRO, indicated a number of important features and regularities of interannual variability in the beginning and duration of cold and warm seasons in the different regions of the North Atlantic and North Pacific. The time of steady transition of a conditionally chosen isotherm through any meridian or a parallel was accepted as the beginning of a season. The moment of crossing of the chosen site by the isotherm on its movement in the opposite direction was considered as the end of a season. Also the analysis of variability of Norwegian, Bering and Okhotsk Seas' ice cover was carried out.

As a result of our studies we have the following features of thermic conditions: Interannual changes of time of the beginning of a season (warm and cold) are opposite on a sign to interannual changes of its duration. Trends to an earlier beginning and longer duration of the warm season in the North Atlantic and the cold season in the North Pacific for the last 10-15 years are revealed. Speed of warming up depends on terms of its beginning - the earlier warming up has begun, the longer it will continue. Speeds of cooling and warming up usually are in inverse dependence - quicker warming up leads to a slower cooling. Duration of freezing-over complies with the same regularities and can be predicted using time of freezing-over beginning in the current year.

Such significant changes in duration of the cold period in the North Atlantic and North Pacific may impact strongly on the biological and fish productivity. We provide some examples (pacific salmons, saury, pollock, herring, mackerel, poutassou).

PICES/GLOBEC Symposium T2-2285 Poster

Estimation of the hydrodynamic regime of the water movement under the influence of the atmospheric processes in the Bering and Okhotsk Seas

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This investigation describes water circulation in the Bering and Okhotsk Seas, considering the influence of various types of atmospheric processes (Polyakova, 1999). To examine this we used a hydrodynamic model (Vasiliev, 2002) calculating the integral functions of the flow from the surface to the bottom.

Maps of the vertically integrated water circulation were built for the following types of atmospheric circulation: “north-western” and “okhotsk-aleutian” types. Hydrodynamic structures are distinguished that are independent of the atmospheric circulation, while other structures are strongly dependent on specific atmospheric forcing. The non-depending (independent) structures are characterized by the cyclonic activity in Bering and Okhotsk Seas in whole. Hydrodynamic structures depending on the atmospheric circulation types have their peculiarities in the spatial-temporal distribution.

Under the influence of the atmospheric circulation of the “north-western” type:

- a mosaic of the anticyclonic vortices forms along the 500 m isobath on the western side of the Aleutian Basin in the Bering Sea;
- a series of the anticyclonic vortices (eddies) is located in south part of the Kuril Islands of the Okhotsk Sea.

In conditions of the “Okhotsk-Aleutian” type:

- in the Bering Sea, single anticyclonic vortices penetrate from Pacific Ocean to Aleutian Basin;
- in the Okhotsk Sea, a large anticyclonic vortex and a large cyclonic vortex are observed in the South Kuril region.

PICES/GLOBEC Symposium T2-2683 Poster
Short-term predictability of plankton production in a coastal upwelling zone

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Recruitment of fishes often depends on availability of food at appropriate times and locations for early feeding. Thus, predictability of recruitment may depend on predictability at the event scale (time scale: days to weeks, space scale: 0.1-10 km) of lower trophic production. Spring-summer primary and secondary production in the Northern California Current is largely driven by upwelling-supplied nutrients. Nearshore surface nitrate concentration correlates well with local wind-derived upwelling indices, but this correlation does not carry through to copepod abundance. Previous work has focused on the ability of coupled biophysical plankton models to reproduce patterns in nutrient, phytoplankton, and zooplankton concentrations for a time series of observations on the Newport Hydrographic (NH) Line. Here, I examine the intrinsic predictability of these observations from physical data (wind, light) on event scales using linear and non-linear statistical time-series transfer-function models, and compare the quality of these predictions with predictions from a NEMURO-like plankton dynamics model. By using a nested hierarchy of models of increasing complexity, starting with a null model hypothesizing no relationship between plankton and physical variables, the statistical models allow testing the level of model complexity needed to predict biological response to physics. The work aims to answer the question: Which type of model (simple statistical or plankton dynamics) is preferable for predicting lower trophic production? The answer will be revealed at the symposium.

PICES/GLOBEC Symposium T2-2679 Poster
Determination mechanism of seasonal and regional variations of phytoplankton groups by top-down and bottom-up controls obtained by a 3-D ecosystem model

Taketo Hashioka¹ and Yasuhiro Yamanaka^{2,3}

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We developed a 3-D ecosystem-biogeochemical model and applied it to the western North Pacific in order to understand how seasonal and horizontal variations of phytoplankton groups are determined by top-down and bottom-up controls. Our model shows that the annually averaged biomass of diatoms represented as a percentage of total phytoplankton is 50 to 60% in the subarctic and less than 30% in the subtropical regions, which is consistent with the observed values. From the viewpoint of bottom-up control, we investigated which limitation factor of photosynthesis rate determines the annually averaged P/B ratio and the dominant phytoplankton group. In oligotrophic regions, nutrient concentrations determine the dominant group through the difference in the P/B ratio of each group. However, in the subarctic region, the difference in the P/B ratio does not contribute in determining the dominant group. We also investigated how the diatom percentage is determined seasonally by both bottom-up and top-down controls at Kuroshio extension, subarctic and subtropical sites. At the Kuroshio extension and subarctic sites, from winter to the beginning of spring bloom, diatoms have a high growth rate without grazing pressure by zooplankton, and the diatom percentage rapidly increases to greater than 70%. From the end of spring bloom to summer the diatom percentage decreases to 30%, due to grazing by copepods that have returned to the surface from deep waters, and as silicate limits photosynthesis by diatoms. Therefore, at these sites, the seasonal variation of diatom percentage is not only regulated by nutrient concentration, but also by grazing preferences by zooplankton.

PICES/GLOBEC Symposium T2-2701 Invited
Seasonal, inter-annual and ENSO scale changes in the North Pacific ecosystems

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In recent years, many specific scientific research efforts have enhanced our understanding of the changes in biological communities in North Pacific ecosystems. These studies have revealed details of the ecosystem dynamics mostly on regional and local scales. In this study, we attempt to assemble a coherent, synoptic view of North Pacific ecosystem change as a whole within shorter than inter-decadal time-scales. Recent basin-scale information on physical forcing and satellite-derived estimates of chlorophyll-*a* provide high spatial and temporal resolution data that have revealed seasonal to ENSO scale changes. Comparable data and information of lower-trophic level biological communities (other than chlorophyll) are restricted to research hot-spots - *e.g.*, sites of limited geographic scope, where specific research programs have conducted short-term studies. Our approach is to combine the synoptic basin-scale picture of physical forcing and chlorophyll-*a* with details of trophic structure derived from more trophically detailed regional studies. Analysis of ocean color data shows interesting basin-scale patterns in seasonality and inter-annual changes in surface chlorophyll-*a*. Based on this, we concentrate on a couple of regions to compare and contrast the responses in other parts of food web to gain a broader understanding of changes in the North Pacific ecosystem as a whole.

Theme 3 Pan-Pacific comparisons, with an emphasis on comparisons of similar species or processes from multiple coastal ecosystems and of open ocean-coastal linkages and climate connections

Friday, April 21, 2006 8:30-18:00

- 08:30-09:05 **David L. Mackas and Kazuaki Tadokoro** (Invited)
Zooplankton of the eastern and western subarctic Pacific: Similarities in the face of strong decadal variability and contrasting mean environments (T3-2680)
- 09:05-09:30 **R.C. Francis, J.E. Little, J.F. Kitchell, I. Kaplan, J.C. Field, K. Aydin, M. Dalton, S. Gaichas, J. Hinke, S. Martell, R. Olson, C. Walters and G. Watters**
Comparison of climate impacts on five fishery ecosystems of the North Pacific (T3-2645)
- 09:30-09:55 **Andrew Thomas, P. Ted Strub and Peter Brickley**
Does phytoplankton biomass vary out-of-phase in the California Current and Gulf of Alaska on interannual time scales? (T3-2660)
- 09:55-10:20 **Rubén Rodríguez-Sánchez and Daniel Lluch-Belda**
Spatial dynamics of small pelagic fish in the California Current system on the regime time-scale. Parallel processes in other species-ecosystems (T3-2700)
- 10:20-10:45 **Coffee Break**
- 10:45-11:10 **Akinori Takasuka, Yoshioki Oozeki, Hiroshi Kubota and Ichiro Aoki**
Why were anchovy and sardine regime shifts synchronous across the Pacific? (T3-2672)
- 11:10-11:35 **Akihiko Yatsu and CFAME Task Team**
Mechanistic linkages of fish population dynamics to climatic forcing: Comparative study on selected stocks representing five life-history strategies in the North Pacific (T3-2665)

- 11:35-12:00 **Douglas Hay, Kenneth A. Rose, Jake Schweigert and Bernard A. Megrey**
Geographic variation in herring populations in the North Pacific: Understanding latitudinal responses to climate change (T3-2706)
- 12:00-13:15 **Lunch**
- 13:15-13:40 **Kenneth A. Rose, Bernard A. Megrey, Shin-ichi Ito, Francisco Werner, Douglas Hay, Maki Noguchi Aita, Yasuhiro Yamanaka, Michio J. Kishi, Jake Schweigert, Matthew Birch Foster, Dan Ware, David Eslinger, Robert Klumb and S. Lan Smith**
Geographic variation in fish growth and population responses to regime shifts in the North Pacific: A comparison of herring and saury using NEMURO.FISH, a coupled fish bioenergetics and NPZ model (T3-2674)
- 13:40-14:05 **R. Ian Perry, Jake Schweigert and Kenneth A. Rose**
Carrying capacity and climate change: Drivers and responses of North Pacific fish populations (T3-2690)
- 14:05-14:30 **Randall M. Peterman, Brigitte Dorner, Steven L. Haeseker, Brian J. Pyper and Franz J. Mueter**
Kalman-filter reconstructions emphasize the importance of regional-scale (< 800 km) environmental processes in driving temporal variation in recruits per spawner in Northeastern Pacific salmon (*Oncorhynchus*) populations (T3-2681)
- 14:30-14:55 **N.V. Varnavskaya**
Distribution and migration routes of American and Asian salmon stocks in connection with water temperatures and major current flows in the northern part of the Pacific Ocean (T3-2715)
- 14:55-15:25 **Coffee Break** (Posters down by 12:00)
- 15:25-15:50 **William J. Sydeman, Yutaka Watanuki, Alexander S. Kitaysky, Christine L. Abraham, Julie A. Thayer, K. David Hyrenbach, Ken H. Morgan, Mark A. Hipfner, Leslie Slater and Chester E. Grosch**
Marine birds and ocean climate in the North Pacific: A Meta-Analysis (T3-2704)

- 15:50-16:15 **S.M. McKinnell**
Pacific salmon and climate at the onset of the 21st century;
What concepts survived the CCCC decade and what new
questions have emerged? (T3-2711)
- 16:15-16:40 **Closing Perspective Talk 1 (Makoto Kashiwai)**
- 16:40-17:05 **Closing Perspective Talk 2 (John C. Davis)**
- 17:05-17:40 **Closing Panel Discussion**
- 17:40-18:00 **Closing Session**

Posters

R. Beamish, X. Jin, A. Yatsu, S. Kim, E. Dulepova, L. Low, J. King, G. McFarlane and L. Klyashtorin
Impacts of climate and climate change on the key species in the subarctic Pacific (T3-2631)

Hyo Choi
Coastal climate influenced by air-sea interaction and moisture advection adjacent the East Sea of Korea - Winter snowfall (T3-2717)

David Hyrenbach, Chris Rintoul, Mike Henry, Ken Morgan and William Sydeman
Characterizing marine bird distributions across the subarctic North Pacific using platform of opportunity vessels (2002-2005): Seasonal and inter-annual variability (T3-2699)

Thomas C. Kline, Jr. and Steven R. Hare
Spatial and ontogenetic variability in the trophic status of Pacific halibut (*Hippoglossus stenolepis*) across its range in the Sub-Arctic Northeast Pacific Ocean and Bering Sea (T3-2657)

Andrew W. Leising, Cindy Bessey, Catherine Johnson and Jeffrey Runge
Latitudinal variation in environmental forcing of copepod overwintering and its effects on population dynamics for the copepod *Calanus pacificus* along the U.S. West Coast (T3-2685)

Michael A. Litzow, Kevin M. Bailey, Fredrick G. Prahl and Ron Heintz

Alternate lipid states in boreal fish communities: The essential fatty acid limitation hypothesis (T3-2633) (*Withdrawn*)

G.A. McFarlane, S. Kim, J.R. King, R.J. Beamish, C. Zhang and J.H. Oh

Contrast in life histories of commercially exploited marine fishes off the coasts of Canada and Korea, and changes in ecosystem structure (T3-2658)

Shadananan K. Nair

A study of the influence of Pacific anomalies on the aridity conditions and temporary climate shifts in India (T3-2654)

C. Tracy Shaw, Leah R. Feinberg, William T. Peterson, Alexei Pinchuk, William Sydeman, Hiroya Sugisaki, Irina Bragina, Se-Jong Ju and Jaime Gómez-Gutiérrez

A pan-Pacific comparison of the biology of *Euphausia pacifica* (T3-2691)

Vladimir I. Korochentsev, Vera A. Kochetova and Sergey A. Shevkun

Calculation of the ulf (ultra low frequency) electro-magnetic field over typhoon zone (T3-2664)

Kaori Takagi, Akihiko Yatsu, Masatoshi Moku, Chiyuki Sassa, Masayuki Noto and Hiroshi Nishida

Abundance and horizontal distributions of small epipelagic fishes and myctophids in the Kuroshio-Oyashio Transition Zone (T3-2640)

Kaori Takagi, Akihiko Yatsu, Hiroshi Itoh and Hiroshi Nishida

Possible food resource partitioning by small epipelagic fishes and myctophids in the Kuroshio-Oyashio Transition Zone - A preliminary study on copepods (T3-2639)

PICES/GLOBEC Symposium T3-2631 Poster

Impacts of climate and climate change on the key species in the subarctic Pacific

R. **Beamish**¹, X. Jin², A. Yatsu³, S. Kim⁴, E. Dulepova⁵, L. Low⁶, J. King¹, G. McFarlane¹ and L. Klyashtorin⁷

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There was consistent evidence that climate and climate change profoundly affected the productivity of many key species in the commercial fisheries of Canada, China, Japan, Korea, Russia and the United States. The scale of climate influence varied among areas and species. There were a number of changes in trends of productivity at the time of the 1977 and 1989 regime shifts. There were also ENSO related impacts as well as 50 to 60 year cycles. In some countries, fishing mortality remains as the principal factor affecting the dynamics of commercial species. A key to interpreting the effects of greenhouse gas induced climate change is the understanding of the impacts on natural climate events. In particular, it is necessary to understand how the winter atmospheric circulation patterns will be affected. At present, there is little more than speculation about the future of key commercial fisheries. As global warming impacts are recognized, the general management approach appears to be adaptive. There was no indication of management plans that would mitigate global warming impacts other than increasing production of seafood through marine aquaculture. Walleye pollock are perhaps the key indicators of the large-scale climate impacts on productivity and distribution as they occur in the commercial fisheries of all countries and represent the single largest landings of all species. Pacific sardine, anchovy, Pacific saury, common squid, jack mackerel, pink salmon and chum salmon are other key species that could be monitored as indicators of changes in trends of climate and ocean ecosystems.

PICES/GLOBEC Symposium T3-2717 Poster
Coastal climate influenced by air-sea interaction and moisture advection adjacent the East Sea of Korea - Winter snowfall

Hyo Choi

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In general, the coastal climate should be affected by air-sea interaction, moisture content due to its advection, and various wind fields in the coastal sea. The purpose of this study is to investigate how much the coastal climate, especially snowfall events in the eastern coastal region of Korea and on the sea surface of the East Sea of Korea could be influenced by air-sea interactions such as sensible and latent heat. The connection of wind fields and moisture advection are explored for several specific snowfall events: Case 1 from 0000UTC December 6, 2002 through 1200UTC December 9, 2002; Case 2 from 0000UTC January 13 through 15, 2003 and Case 3 from January 21 through 24, 2003. A 3D-numerical model, MM5 V3.5 with NCEP data used as initial input. There were 22 levels in the vertical spread from 10 m to 10 km with sequentially larger intervals between levels with increasing altitude. In the numerical process, a triple nesting was made with a grid size of 125 x 105 in the horizontal (27-km interval) and a vertical grid of 23 in the coarse domain. In the second domain, the grid was 82 x 82 (9-km interval) and in the third domain, the horizontal grid was 61 x 61 (3-km interval). Nine kilometer 2.50 degree interval terrain data was used for the largest domain and then the 0.9km interval data was used for fine mesh domain.

Before snowfall events, synoptic westerly or north-westerly winds prevailed, accompanying cold air masses with low relative humidity from mainland China, while during periods of snowfall, north-easterly wind and easterly wind prevailed in the eastern mountainous coastal region and coastal sea. In the East Sea, sensible and latent heat fluxes due to the great difference of sea surface temperature and air temperature continuously induced a great amount of evaporation from the sea surface. The easterly wind transported heat and moisture from the East Sea toward the coastal sea and further toward the top of mountains in the west. The transported moisture should be uplifted and cooled, being saturated and making the formation of a great amount of clouds, under westerly cool air masses. Finally, the cooled cloud particles resulted in the formation of ice and rain particles inside stratocumulus clouds in the low levels. Snowfall band or precipitation band coincided with minimum sensible heat flux band along the coastal line or negative value area and it is similar to latent heat flux band, where snowfall occurred. Snowfall band directly coincided with the area of relative humidity of 100%. Below 0°C air temperature, cloud water

droplets can form ice phase like snow, as low cloud moved down toward the ground surface of coastal area in the east. Vertical distribution of total cloud mixing ratio gives good information on the height of cloud formation and on the determination of snowfall or rainfall. As time progressed during each event, the snowfall band or relative humidity band moved from the coast toward the East Sea, sequentially. Under this circumstance, the sea surface temperature in the coastal sea was also changed.

PICES/GLOBEC Symposium T3-2645 Oral
Comparison of climate impacts on five fishery ecosystems of the North Pacific

R.C. **Francis**¹, J.E. Little¹, J.F. Kitchell², I. Kaplan³, J.C. Field⁴, K. Aydin⁵, M. Dalton⁶, S. Gaichas⁵, J. Hinke⁷, S. Martell⁸, R. Olson⁹, C. Walters⁸ and G. Watters⁷

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This paper offers a synthesis of examples and insights from working groups sponsored by National Center for Ecological Analysis and Synthesis (NCEAS) in which we used food web modeling to investigate the importance of links between climate and food web dynamics in five North Pacific fishery ecosystems (Central North Pacific, Eastern Tropical Pacific, Northern California Current, Gulf of Alaska, Eastern Bering Sea). We show that a) climate can affect ecosystem productivity and dynamics from both the bottom up and top down; b) biomass trajectories of single populations at mid and upper trophic levels cannot always be used to detect bottom-up physical effects; c) in some systems climate, fishing and food web dynamics interact in ways that cannot be fully captured in either ecosystem or single species models. We discuss how these kinds of models might help move fishery science and management into an “ecosystem-based” arena.

PICES/GLOBEC Symposium T3-2706 Oral
Geographic variation in herring populations in the North Pacific: Understanding latitudinal responses to climate change

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Pacific herring (*Clupea pallasii*) occupy shelf waters (< 200 m depth) in all coastal areas in the northern Pacific, from the northern Bering Sea to California in the eastern Pacific, and to the Yellow Sea in the western Pacific. Within this range herring display both geographical (latitudinal) variation and location-specific climate variation (inter-annual climate variation). On both sides of the Pacific, the biological responses of herring to latitudinal variation are similar to those in many fish species. Compared to northern areas, in southern areas spawning time is earlier, duration of spawning time is longer, age and size of sexual maturity is younger, and asymptotic size (L_{∞} and W_{∞}) is smaller. In contrast, latitudinal differences in length-weight relationships, egg size, size-specific fecundity and relative fecundity are relatively small when compared among widely separated locations. Other aspects of geographic and temporal variation are not well understood. In recent years some more trends in geographic differences are emerging. Population diversity varies less in the north where there are fewer, but larger populations. The territory occupied by individual herring populations in the north may exceed that in the south. There may be a latitudinal difference in mean density of the adult stock (g/m^2) estimated as the ratio of spawning stock biomass to the estimated habitat used by the stock. Among North American populations there also appears to be a latitudinal difference in recruitment, and the factors affecting it. Specifically, trophic conditions during the juvenile stages, especially during the first winter, appear to have greater impact in northern areas, although this remains speculative. Understanding the impacts of climate change on herring requires that we also understand the extent of latitudinal variation in biological and ecological processes. This paper presents a summary and synthesis of such latitudinal variation in Pacific herring, examined in the context of climate change.

PICES/GLOBEC Symposium T3-2699 Poster

Characterizing marine bird distributions across the subarctic North Pacific using platform of opportunity vessels (2002-2005): Seasonal and interannual variability

David Hyrenbach^{1,2}, Chris Rintoul², Mike Henry³, Ken Morgan⁴ and William Sydeman²

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In 2002, we initiated a multi-year program of marine bird and mammal surveys from British Columbia (Canada) to Hokkaido (Japan) using the bulk-cargo carrier ‘*Skaubryn*’ as a platform of opportunity. This project seeks to characterize persistent spatial patterns in upper-trophic predator assemblages across the sub-arctic North Pacific Ocean, and temporal fluctuations in community structure. We used the observations collected during the first two pilot cruises (June and October 2002) to refine our strip transect survey methods. While different taxa showed distinct distributions of perpendicular sighting distances, we selected a 400-m strip width as the most appropriate strip width to survey the entire avifauna. Using standardized survey protocols, we have conducted nine more surveys to date. Herein, we provide a synthetic atlas of the seasonal (spring, summer, fall) and interannual (2002 - 2005) distribution of the numerically dominant seabird species since the summer of 2002. Our replicate surveys have documented spatial gradients in faunal distributions, with a particularly striking east-west segregation of three shearwater species: Sooty Shearwaters *Puffinus griseus* dominate off BC and in the Gulf of Alaska, Short-tailed Shearwaters *P. tenuirostris* are numerically dominant in the Southern Bering Sea, and Streaked Shearwaters *Colonyctris leucomelas* are most numerous in the Kuroshyo – Oyashio current. We have also documented seasonal latitudinal shifts of species ranges, and year-to-year fluctuations in overall abundance concurrent with changing water mass distributions. These results suggest that repeated and standardized surveys from bulk-cargo carriers provide synoptic snapshots ideal to characterize the spatial and temporal structure of upper-trophic predators at basin-wide scales.

PICES/GLOBEC Symposium T3-2657 Poster
Spatial and ontogenetic variability in the trophic status of Pacific halibut (*Hippoglossus stenolepis*) across its range in the Sub-Arctic Northeast Pacific Ocean and Bering Sea

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We established the trophic status of Pacific halibut using natural stable isotope abundance during 1999 to 2001 from continental shelf areas of British Columbia (BC), northern Gulf of Alaska (GOA), Aleutian Islands (AI, split into E and W at 172° West), and eastern Bering Sea (EBS). Muscle tissue samples stratified by sex and age were collected in conjunction with an existing monitoring program. Lipid-normalized-carbon and nitrogen isotope values, respectively $\delta^{13}\text{C}'$ and $\delta^{15}\text{N}$, compared well with values predicted from shelf zooplankton using literature values and concurrent samples. Mean halibut $\delta^{13}\text{C}'$ ranged from a high of -17.5 in BC to lows of ~ -19.0 for eastern and ~ -18.5 western AI. GOA and EBS mean values were similar, ~ -18.0 . EBS halibut had the highest mean $\delta^{15}\text{N}$, near $+16.5$, whereas AI the lowest, between 14.5 and 15.0 . The mean $\delta^{15}\text{N}$ for BC and GOA $\sim +15.5$. Mean $\delta^{15}\text{N}$ were consistent with a two trophic increase relative to zooplankton. Isotopic ontogenetic trends and patterns varied by sex and area. BC female $\delta^{13}\text{C}'$ decreased from ~ -16.0 to -18.0 whereas males decreased from ~ -16.5 to -17.5 . Older aged EBS males decreased from ~ -18.0 to -19.5 . Female $\delta^{15}\text{N}$ increased with age as much as ~ 1.5 ‰ in all areas except for older EBS halibut. BC and GOA males increased, but ≤ 1.0 ‰. Like EBS females, younger males increased ~ 1.5 ‰. The $\delta^{15}\text{N}$ of older EBS halibut was similar to those from the other areas. The observed patterns are ascribed to a half trophic level ontogenetic increase, which was more marked for females and immigration of older age classes into the EBS. Changes in these patterns over inter-decadal time spans could be used to explain dramatic shifts in growth of halibut across much of its range.

PICES/GLOBEC Symposium T3-2685 Poster
Latitudinal variation in environmental forcing of copepod overwintering and its effects on population dynamics for the copepod *Calanus pacificus* along the U.S. West Coast

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Dormancy or “overwintering” in the late summer to fall is a major feature in the life cycle of large calanoid copepods in temperate and subarctic waters. During dormancy, copepods descend to depth, cease feeding, and have highly reduced metabolic rates. These dormant periods may last different periods of time, from a few months to longer than 6 months, depending on the physiological state of the copepod and environmental conditions, such as temperature and food supply. The cues that both induce and terminate copepod dormancy are not fully known, however, day length, temperature, and food supply are possible factors. Using an Individual-Based Model (IBM) of *Calanus pacificus*, we investigated how latitudinal differences (from San Diego, CA to British Columbia, Canada) in the seasonal timing of events – e.g. the timing of the spring transition, the seasonal cessation of the upwelling season, and the local light and temperature cycles – may affect the dormancy timing and subsequent population dynamics of this key copepod species. Results of the model, and a limited comparison with field-sampled data, will be presented.

PICES/GLOBEC Symposium T3-2633 (Withdrawn)
Alternate lipid states in boreal fish communities: The essential fatty acid limitation hypothesis

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Little is known about the role that biochemical ecology plays in community transitions following climate regime shifts. We document a biochemical effect of climate-induced community transitions in the boreal Pacific and Atlantic oceans: opposite population trajectories of lipid-rich and lipid-poor fish species. We compared published estimates of fish lipid content and population trajectories following climate shifts in four boreal continental shelf ecosystems (Bering Sea, Gulf of Alaska, Scotian Shelf and North Sea). In all cases, increasing and decreasing species differed in total lipid content, and the resulting relatively lipid-rich or lipid-poor communities persisted at a decadal time scale. Original data from five species of northeast Pacific fish (total lipid 1.0% - 28.9% wet mass) and published data for 29 species of myctophids (total lipid 0.5% - 46.3% wet mass) show that lipid content is positively correlated with the content of two essential fatty acids (EFA), suggesting that lipid-rich and lipid-poor fish communities can be viewed as EFA-rich and EFA-poor, respectively. We propose the hypothesis that climate-forced changes in production of EFA contribute to alternate ecosystem states that favor either lipid-rich or lipid-poor fish species.

PICES/GLOBEC Symposium T3-2680 Invited
**Zooplankton of the eastern and western subarctic Pacific:
Similarities in the face of strong decadal variability and
contrasting mean environments**

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The zooplankton communities of the eastern and western sides of the subarctic Pacific are very similar, despite strong contrasts in important environmental controls such as rate and direction of transport by currents, seasonal temperature range, the steepness of north-south water property gradients, vertical stratification, source and amount of nutrient supply, and presence/absence of blooms by large-celled phytoplankton. In the past decade, large scale bio-oceanographic programs such as GLOBEC and SOLAS/SERIES/SEEDS have generated a wealth of new information on short term processes and rates, and on cross-basin differences in life history strategy and in body size, condition, and diet. New and ongoing monitoring programs, plus more intensive analyses of existing sample archives, have clearly demonstrated that both sides undergo large interannual and decadal fluctuations of productivity, seasonal phenology, and species dominance hierarchy. Although not yet conclusive, we are also finding evidence of cross-basin synchrony of at least some of the “regime shifts” in productivity and community structure.

PICES/GLOBEC Symposium T3-2658 Poster
Contrast in life histories of commercially exploited marine fishes off the coasts of Canada and Korea, and changes in ecosystem structure

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The history of commercial fisheries off the coasts of Canada and off of Korea are very different. These histories, in conjunction with different ecosystems, have resulted in disparate current species compositions. In Canadian waters, the dominant oceanographic domain is the coastal upwelling domain off of the west coast of Vancouver Island, the northernmost extent of the California Current System. This ecosystem is dominated by demersal species complexes, with an abundance of long-lived species such as flatfish, rockfish, sablefish, and halibut. During summer, migratory pelagics such as Pacific hake, Pacific salmon, and recently Pacific sardine, move into this area to feed. In the late 1970s, Canada declared jurisdiction for 200 miles from their coastline, and targeted major fisheries in Canada have been managed with a quota system. As such, fisheries off the west coast of Vancouver Island have been moderate. Off the Korean coast, a major oceanographic domain is the Tsushima Warm Current Ecosystem in the East/Japan Sea. This ecosystem is currently dominated by short-lived pelagic and demersal fish. Historically, Korea has shared marine resources in this area with neighbouring countries, but stock assessment and quotas have only recently (since the late-1990s) been implemented for some major species. As such, fisheries can be described as intensive, and many stocks have been described as overfished. A joint Canada-Korea study has been initiated to compare these ecosystems as they relate to community composition and dominate fish species. Each ecosystem responded differently to climate impacts such as regime shifts under different exploitation histories. In the future, both countries will face the challenge of global climate warming, its impacts on ecosystems and both countries will need to develop adaptable fisheries and management of those fisheries. The challenges will be different for the two countries: Canada will need to conserve fish populations, while Korea will need to focus on rebuilding fish populations.

PICES/GLOBEC Symposium T3-2711 Oral
**Pacific salmon and climate at the onset of the 21st century;
What concepts survived the CCCC decade and what new
questions have emerged?**

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Beamish and Bouillon (1993) was one of the most influential papers on marine ecosystem variability in the late 20th century. This work was a significant motivator for many of the concepts and key questions explored by the CCCC program. It considered North Pacific ecosystem variation on a larger scale than had been routinely considered by biologists and it proposed a mechanism for low frequency variation in salmon abundance that had not received much attention climate forcing. In subsequent years, various groups of investigators have taken this proposal and others and subjected them to greater scrutiny. Some have reported that Pacific salmon recruitment does not covary on the largest of scales in the North Pacific and some have reported inverse north-south production regimes. My talk dissects these ideas, critically examines their foundations, considers the accumulation of new data, and reassembles the parts to see which ideas have survived and what remains as the key questions for the 21st century.

PICES/GLOBEC Symposium T3-2654 Poster
A study of the influence of Pacific anomalies on the aridity conditions and temporary climate shifts in India

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Indian monsoons undergo wide interannual variability. Changes in rainfall amount as well as its seasonality are reflected in the aridity pattern and local climate, posing a serious challenge to the food and water security and the immerging and still largely agriculture dependent national economy. Marked variations in rainfall seasonality have reflected in agricultural output in areas where irrigation is not well developed and also in the extinction of some seasonal plant species in certain parts. Changes in the frequency and intensity of severe weather systems bring catastrophies in almost every year. Though such events are connected to global anomalies, especially in the Pacific, many of their interrelationships are yet to be identified. This paper analyses the possible links between the interannual variabilities in rainfall and aridity indices in different zones of India with south pacific anomalies. The aridity index that depends on rainfall and local temperature conditions can be used as a measure in assessing tendencies in local climate. Relationship of the anomalies in aridity indices and monsoons during the years 1900-2000 with different phases of SOI, north Pacific indices and pacific decadal oscillation has been examined. Aridity indices and regional climate pattern showed large variations in all zones during the last century, and the seasonality of rainfall influenced the aridity more than the deviations in total rainfall. Extremes in rainfall, aridity and climate coincide with pacific anomalies in certain occasions, but a direct one to one relationship could not be established in all occasions in any of the zones.

PICES/GLOBEC Symposium T3-2690 Oral
Carrying capacity and climate change: Drivers and responses of North Pacific fish populations

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The carrying capacity of North Pacific ecosystems for living marine resources is one of the two central foci of the PICES Climate Change and Carrying Capacity Program, but it appears to have received less attention than the climate change focus. We compare the productive capacities of the regional marine ecosystems of the North Pacific for commercial fish and invertebrates, normalized by area and primary production, as one measure of the (time-invariant) carrying capacities of these systems. We then focus on Pacific herring populations across the North Pacific as an example species in several of these regional ecosystems. By using estimates of population biomass, rather than commercial catch data, we identify temporal variations in the carrying capacities of these regional ecosystems for herring, and explore their spatial coherence. We also identify potential drivers causing large (regime) scale variations in carrying capacity, including both physical and biological processes as represented by model studies.

PICES/GLOBEC Symposium T3-2681 Oral

Kalman-filter reconstructions emphasize the importance of regional-scale (< 800 km) environmental processes in driving temporal variation in recruits per spawner in Northeastern Pacific salmon (*Oncorhynchus*) populations

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Important clues about mechanisms driving productivity of salmon (*Oncorhynchus* spp.) populations can be inferred from estimates of the spatial scale across which salmon stocks from multiple systems show positive correlation in their time series of productivities. Over 110 pink (*O. gorbuscha*), chum (*O. keta*), and sockeye (*O. nerka*) salmon populations in the Northeastern Pacific show positive correlation at regional scales (*i.e.*, less than about 800 km). Substantial evidence now exists that coastal summer sea-surface temperature has a similar spatial scale of correlation and provides a better index of temporal variation in recruits per spawner than large, ocean-basin-scale processes. Although large-scale climatic forcing is undoubtedly also relevant, region-specific responses to that large-scale forcing appear to be more important. Evidence also suggests that the dominant “signal” of large-scale forcing is decadal-scale in nature, and such temporal trends may be masked by the high interannual variability common in stock-specific salmon data sets. Here we extend previous analyses by applying a Kalman filter to the salmon data to better estimate longer-term trends in productivity that may be obscured by interannual variation and measurement errors in spawner abundance. The resulting reconstructed time series of salmon productivities show regional scales of positive correlation among populations (within and across species) similar to those identified in our previous work. These results suggest that better understanding of mechanisms causing temporal variation in salmon productivity may come from research on regional-scale processes, not just large-scale processes. Better management may also result from this shift in perspective.

PICES/GLOBEC Symposium T3-2700 Oral
Spatial dynamics of small pelagic fish in the California Current system on the regime time-scale. Parallel processes in other species-ecosystems

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A previous large-scale, long-term analysis of the California Current system (CCS) suggests that climatic regime shifts in the northeast Pacific appear to have forced a changing population size associated with major geographical variations in the position of the center of distribution and bulk of the biomass of Pacific sardine (*Sardinops caeruleus*). This finding allows an explanation of i) the disappearance of the sardine population about 60 years ago from the northern part of the CCS, and also its return after the 1980s, and ii) the inverse relation of sardine and northern anchovy (*Engraulis mordax*) abundance. This differs from theories suggesting that environmental regime shifts lead to progressive changes in population growth rates within assumed geostationary stocks. The questions arising are: is this natural pattern of variation only recorded in the Pacific sardine? and what is the importance and implications of this process for fishery management? In this work 1) the large-scale, long-term (1931-1997) variability of tropical species in the CCS is included in the sardine-anchovy analysis, and 2) examples are shown for other pelagic and benthic species and communities from other ecosystems (Eastern Bering Sea, Northwestern Pacific, Northeastern Atlantic, North Sea), where changes of abundance are also associated with changes in the center of distribution. We discuss the importance of transcending the unidimensional approach (analysis of variability over time scales).

PICES/GLOBEC Symposium T3-2674 Oral

Geographic variation in fish growth and population responses to regime shifts in the North Pacific: A comparison of herring and saury using NEMURO.FISH, a coupled fish bioenergetics and NPZ model

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NEMURO.FISH consists of a fish bioenergetics model coupled to the NEMURO lower trophic model, and evolved as a central synthesis tool from the MODEL Task Team activities of the CCCC Program for performing cross-species and geographical comparisons of fish responses to climate variability. The NEMURO component simulates the daily dynamics of the lower trophic levels by simulating the uptake and recycling dynamics of nitrogen and silicon, and the photosynthesis and grazing interactions of multiple functional groups of phytoplankton and zooplankton. The fish bioenergetics component simulates the daily numbers of individuals, and their mean weight, in each age class over multiple generations. Three zooplankton groups simulated in NEMURO provide the prey for the fish models. Analyses will be presented that illustrate the advantages of synthesis centered on a common set of quantitative models. The examples involve simulation of historical regime shift effects on a north-south progression of three herring populations in the eastern North Pacific, and

comparison of herring responses in the east basin with saury responses in the west basin. All populations showed a late 1970's shift in growth, but the direction and magnitude of the responses differed within herring populations and between herring and saury populations. Responses were also predicted during other time periods for various combinations of the populations. We discuss the advantages and limitations of the coupled modeling approach, likely future directions of our collaborative effort, and progress and challenges in using simulation modeling tools for forecasting climate effects on fish populations.

PICES/GLOBEC Symposium T3-2691 Poster

A pan-Pacific comparison of the biology of *Euphausia pacifica*

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The euphausiid *Euphausia pacifica* is widely distributed throughout the Pacific Ocean. This presentation will synthesize data sets from around the Pacific to compare aspects of the biology of *E. pacifica* in different regions. Data collected off the west coast of North America show that *Euphausia pacifica* tend to be most abundant at or near the shelf break. We will compare their distribution and abundance among regions to see if this pattern is found in other areas of the Pacific. Seasonal cycles of abundance and habitat preferences (inshore, shelf break, offshore) will be compared in each study area. Length frequencies for adult males and females will be compared among regions to determine whether cohorts or stable age distributions are observed, and whether there are seasonal changes in age structure. Growth data from molting rate experiments or size-frequency analysis will be compared where available. There are a number of studies that address reproduction by *Euphausia pacifica*. These studies suggest that reproduction is strongly influenced by environment, with animals in inland basins having a shorter reproductive season than those in open ocean environments. We will expand this comparison to more regions around the North Pacific using data on presence and absence of eggs (spawning period), seasonal variations in density of eggs and females, and measurements of brood sizes and egg diameters where available.

PICES/GLOBEC Symposium T3-2664 Poster
Calculation of the ulf (ultra low frequency) electro-magnetic field over typhoon zone

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Many disastrous atmospheric phenomena are accompanied by great gradients of pressure, velocity of transfer of air and water layers, their temperature as well as magnetic discharges in the atmosphere. These influence each other according to physical laws that are not yet explored properly. Due to many reasons (obstacles on the way to approach the researched area, safety), it is desirable to do research on electrical atmospheric discharges using remote sensing. With remote sensing it is possible to examine the number of discharges in a unit of volume, their coordinates, power of electric discharge, frequency range of electromagnetic waves that are irradiated by lightning, discharges, *etc.*

The present report suggests corrective mathematical algorithms that provided estimates of power and location of electric discharges. Initial data for the suggested mathematical algorithm are voltage of electric and magnetic field measured in some area of space. These parameters may be measured at a great distance, for example, using satellites or aircrafts.

The field dimensions for one or more frequencies could be processed using a mathematical algorithm, which in real time (1:3 seconds) would assess electrical conditions of the field inside the atmospheric phenomenon.

In practice, the methods were applied during explorations made in the 1990s by the Institute of Measurements of the Earth Magnetic Fields in Troitsk. There are plans to enlarge the range of frequencies under research by considering other space phenomena that may have an influence.

PICES/GLOBEC Symposium T3-2704 Oral
Marine birds and ocean climate in the North Pacific: A meta-analysis

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In the North Pacific, many time series, some greater than 30 years in duration, have been obtained for marine bird communities at sea (*e.g.*, CalCOFI, Line P.) and on colonies (*e.g.*, Farallon Is., CA; Triangle Is., B.C., Talan Is., RU, Teuri Is., Japan). In this paper, we use time series analysis to investigate marine bird responses to climate variability and change on multiple temporal scales. For the longest series (*e.g.*, Farallones), we used wavelets to describe apparent periodicities in climate variability as revealed by species-specific responses. Wavelets revealed rich spectra, dependent in part on life history strategies and parameters of the species under consideration. Periodicities of 2, 3-5, 8-12 and 15-18 years were observed. Long-term trends in species-specific and community responses, some unidirectional and some parabolic, were found. Variance fields for some species' parameters increased while others decreased or showed no trends. The role of climate variability in the ecology of North Pacific marine birds is clearly demonstrated, but the influence of climate change is less convincing due to contradictory patterns of response. Moreover, as near apex predators, marine bird responses to climate fluctuations reflect changes in prey resource availability. Marine birds are secondary and tertiary consumers feeding primarily on macrozooplankton, forage fish, young-of-the-year predatory fish, and squids. As an example, the long-term prey harvest of a single species distributed across the North Pacific (Rhinoceros Puffin, *Cerorhinca monocerata*) demonstrates quasi-synchronous changes in forage fish communities in varying regions in response to climate fluctuations. Therefore, marine bird parameters such as diet and breeding success may be useful indicators to both physical and biological changes in North Pacific marine ecosystems.

PICES/GLOBEC Symposium T3-2640 Poster

Abundance and horizontal distributions of small epipelagic fishes and myctophids in the Kuroshio-Oyashio Transition Zone

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The Kuroshio-Oyashio Transition Zone (KOTZ) is the key area for recruitment of the Pacific stocks of Japanese sardine, *Sardinops melanostictus*, anchovy, *Engraulis japonicus*, and chub mackerel, *Scomber japonicus*. In addition to these commercially important small epipelagic fishes, myctophids are also dominant components of oceanic ecosystems including the KOTZ. The possibility of prey resource partitioning occurring between epipelagic fishes and vertically migratory myctophids was indicated in a recent study, but interrelation between them in the horizontal distribution of the nighttime surface layer is still not clear. We examined horizontal distributions of juvenile Japanese sardine, anchovy, chub mackerel and spotted mackerels, *S. australasicus*, juveniles and adults of four major myctophid fishes (*Ceratoscopelus warmingii*, *Diaphus perspicillatus*, *Myctophum asperum*, and *Symbolophorus californiensis*) which were collected by nighttime trawl tows at depths of 0-30 m in the KOTZ in May, during 2002-2004. While total catch in wet weight per tow increased from 2002 to 2004 (53.0, 63.2, and 70.0 kg in order of year), total catch weight of myctophids per tow decreased in 2004 (3.60, 3.85, and 1.15 kg in order of year). Adult *S. californiensis* were distributed in the northern part of the KOTZ, while juveniles were rarely caught. Distribution of juvenile *C. warmingii* was more extensive than the adults. To the contrary, the distribution of adults was more extensive than that of juveniles in *M. asperum*. Each of these three myctophids had a certain distribution pattern throughout our sampling period, but *D. perspicillatus* was distributed differently among years. The distribution of small epipelagic fishes and myctophids largely overlapped. Biological interactions between juvenile small epipelagic fishes and myctophids may be possible. Therefore we tried a quantitative analysis of distributions of small epipelagic fishes and myctophids. Furthermore, we discuss the links between the horizontal distributions of these seven species and environmental conditions.

PICES/GLOBEC Symposium T3-2639 Poster

Possible food resource partitioning by small epipelagic fishes and myctophids in the Kuroshio-Oyashio Transition Zone - A preliminary study on copepods

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The Kuroshio-Oyashio Transition Zone (KOTZ) is the key area for recruitment of the Pacific stocks of Japanese sardine, *Sardinops melanostictus*, anchovy, *Engraulis japonicus*, and chub mackerel, *Scomber japonicus*. In addition to these commercially important small epipelagic fishes, myctophids are also dominant components of oceanic ecosystems including the KOTZ. We examined stomach contents of juvenile epipelagic fishes and myctophids, which were simultaneously collected by nighttime trawl tows on the surface (< 80 m) of the KOTZ in May 2002. Meso-zooplanktons were also collected by a NORPAC net from 150m depth to the surface. Copepods in stomachs and NORPAC net samples were identified to species or genera, counted and their prosomal lengths were measured. Dry weights for each prey in the stomachs were estimated from length-weight relationships. Index of relative importance (*IRI*) of prey item *i* was calculated using frequency of occurrence (F_i), percentage in number (N_i) and weight (W_i): $IRI_i = (N_i + W_i)F_i$. In terms of *IRI*, the most important copepod prey when large copepods (including vertically migration species) were not abundant are: *Oncaea venusta* (anchovy), *Paracalanus parvus* (chub mackerel, juvenile *Notoscopelus resplendens*), *Eucalanus* (spotted mackerel), *Pleuromamma piseki* (juvenile *Diaphus perspicillatus*, juvenile and adult *Myctophum nitidulum*), and other *Pleuromamma* (juvenile *Ceratoscopelus warmingii*, adult *D. perspicillatus*). Meanwhile, the most important prey at high density of large copepods were: *P. parvus* (sardine), *Neocalanus cristatus* (mackerels), *Corycaeus affinis* (anchovy), *P. piseki* (juvenile *D. perspicillatus* and *M. nitidulum*), *P. xiphias* (adult *N. resplendens*), other *Pleuromamma* (adult *D. perspicillatus*), *E. californicus* (juvenile and adult *C. warmingii*), *M. pacifica* (juvenile *N. resplendens*). It is known that juvenile *C. warmingii* and *M. nitidulum* preyed upon doliolids and hyperiid amphipods, respectively, more than copepods in a recent study. Competition in juveniles between epipelagic fishes and myctophids for small copepods may be possible within low density of large copepods on surface waters of the KOTZ.

PICES/GLOBEC Symposium T3-2672 Oral
Why were anchovy and sardine regime shifts synchronous across the Pacific?

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We explored simple and direct biological mechanisms linking climate changes with anchovy and sardine species alternations. Why do subtle environmental changes trigger drastic alternations? Why do anchovy flourish and sardine collapse or *vice versa* under the same ocean regime? Why were fish regimes synchronous despite the reversed temperature regimes on opposite sides of the Pacific? First, the “optimal growth temperature” hypothesis was proposed as a potential biological mechanism of anchovy and sardine regime shifts, focusing on the differential optimal temperatures for growth rates during early stages of Japanese anchovy (*Engraulis japonicus*) and sardine (*Sardinops melanostictus*) (22.0 and 16.2°C, respectively) and the synchronous fluctuations of the ambient temperatures between these optimums, which potentially cause the alternations in the western North Pacific. Then, as a step toward a basin-scale synthesis of fish regime shifts, this temperature-based idea has been extended. Spawning temperature optimums were compared between Japanese anchovy and sardine, based on the long-term dataset (102,905 tows) from egg and larval surveys off the Pacific coast of Japan from 1978 to 2004. Temperatures preferred for spawning ranged from 15 to 28°C with a mid-point at 22°C for anchovy and from 13 to 20°C with a marked peak at 16°C for sardine. This relationship between *E. japonicus* and *S. melanostictus* in the western North Pacific was a marked contrast to the case between *E. mordax* and *S. sagax* in the California Current system in literature. Reversed species-specific temperature optimums under the reversed temperature regimes might provide a possible explanation of the synchronous fish regime shifts across the Pacific. The generality of the hypotheses was supported by the additional multi-species comparisons, in which the among-species differences and similarities of spawning temperature patterns were consistent with those of the long-term population dynamics patterns for various pelagic fish around Japan.

PICES/GLOBEC Symposium T3-2660 Oral

Does phytoplankton biomass vary out-of-phase in the California Current and Gulf of Alaska on interannual time scales?

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We quantify and compare chlorophyll variability in the Gulf of Alaska (GOA) and the California Current System (CCS) on seasonal and interannual timescales. 8+ years (1997-2005) of SeaWiFS ocean color data provide concurrent and synoptic views, allowing us to contrast seasonal and interannual spatial patterns and to test the hypothesis that these two regimes vary out of phase over ENSO cycles. These oceanic domains differ dramatically in environmental forcing, nutrient and light availability, wind-induced vertical fluxes and water column stability. Seasonally, an EOF analysis of monthly means shows a dominant mode (14%) where chlorophyll is shelf-intensified over the entire latitude range of the systems, peaking in May-June with weak recurrence in the northern latitudes in August and September. The next two higher modes (accounting for 15%) are dominated by shelf and shelf-break variability, one dominated by summer California shelf maxima, the other dominated by seasonally out-of-phase spring and summer maxima in the Gulf of Alaska and Pacific Northwest, respectively. These reflect northern latitude increases in April-May triggered by increasing light, changes in water column stability and nutrients made available from mixing, and southern latitude maxima reached as upwelling winds become well established in June-July in the northern CCS. On interannual scales, satellite-measured chlorophyll patterns suggest coastal phytoplankton biomass in both regions co-varies. Strongest anomalies from the climatological mean in both regions occur in the same years with the same signs, minima in 1997-98 and 2005 and maxima in 2002. We compare these results to time series of wind forcing, PMEL upwelling at 3 deg intervals, volume transport indices derived from Topex/Jason altimetry, SST patterns and larger-scale interannual signals emanating from the northeast and tropical Pacific.

PICES/GLOBEC Symposium T3-2715 Oral
Distribution and migration routes of American and Asian salmon stocks in connection with water temperatures and major current flows in the northern part of the Pacific Ocean

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The purpose of this study is to review and synthesize our own and literature data on distribution of salmon stocks collected by 1) international tagging experiments, 2) the stock identification estimations based on different systems of morphological and genetic markers such as scale characteristics, mitochondrial DNA haplotype, allozyme and nuclear microsatellite DNA alleles frequencies variations, 3) abundance of salmon registered during international surveys in ocean waters, and 4) general characteristics of water surface temperatures and major current flows in the Pacific ocean.

As revealed by international tagging experiments (1956–2004) and trawl and driftnet surveys under NPAFC research programs there are three major wintering areas in the North Pacific ocean – in the Gulf of Alaska, in the zone to the south of the western sub arctic vortex and in the central part of the northwestern Pacific Ocean in the vicinity of 41°N. The main spring and summer feeding areas are located in the western Bering Sea, in the areas to the south of the central and western Aleutian Islands, and in the northern part of the Gulf of Alaska. Recently developed Pacific Rim international genetic baselines on chum and pink (allozymes, mtDNA), sockeye and chinook (allozymes, microsatellite DNA) salmon are the important instruments to estimate stock composition during high seas salmon surveys. The data on catches of tagged salmon and genetic estimates provide information about the presence of immature, maturing and juvenile life stages of salmon from major American and Asian populations in different regions of Pacific Ocean. This data allowed their migration routes to be described, which were moderated by water temperatures, and generally coincided with major North Pacific currents. Summarizing these data made it possible to understand what local stocks shared the same migrating, wintering and feeding areas. Models of salmon ocean distribution, relative abundance and migrations based on newest data are suggested and discussed.

PICES/GLOBEC Symposium T3-2665 Oral
Mechanistic linkages of fish population dynamics to climatic forcing: Comparative study on selected stocks representing five life-history strategies in the North Pacific

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Decadal scale fluctuations of many commercial fish stocks are now well known, usually through statistical analysis and comparison of long time-series of commercial catch and large-scale climatic forcing such as the Aleutian Low. The mechanistic linkages between them are, however, poorly known. Climatic changes will affect physical processes, primary production and prey-predator relations in local ecosystems, where each fish stock (population) spends specific life stages. It is of paramount importance to reveal key biological processes, such as growth, survival, recruitment and maturation in relation to local environment, which is affected by the large-scale climate forcing. Key processes may differ from stock to stock, depending on ambient ecosystems and different life history strategies. For the synthesis of the CCCC program, the CFAME (Climate Forcing and Marine Ecosystem) Task Team decided to conduct comparative studies of conceptual mechanistic models of the linkages, as well as time series comparisons of productivity rather than catch. Target species were selected for each of five strategists from eastern and western sides of the Pacific: sardines and herring (opportunistic strategist), walleye pollock (intermediate strategist), pink and chum salmons (salmonid strategist), sablefish and halibut (periodic strategist) and dogfish (equilibrium strategist). The outline of results and their implications will be discussed.

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