PICES/GLOBEC Symposium T3-2631 Poster

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

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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

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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 0ºC 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

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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 pallasi*) 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

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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 *Colonectris lencomelas* 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 $\delta^{13}C'$ and $\delta^{15}N$, compared well with values predicted from shelf zooplankton using literature values and concurrent samples. Mean halibut $\delta^{13}C'$ 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 $\delta^{15}N$, near +16.5, whereas AI the lowest, between 14.5 and 15.0. The mean $\delta^{15}N$ for BC and GOA ~ +15.5. Mean $\delta^{15}N$ were consistent with a two trophic increase relative to zooplankton. Isotopic ontogenetic trends and patterns varied by sex and area. BC female $\delta^{13}C'$ 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 $\delta^{15}N$ 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 $\delta^{15}N$ 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 subartic 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.