PICES/GLOBEC Symposium T2-2707 Oral

Hake habitat in the California Current System: Distribution, dynamics and ecosystem implications

Vera N. **Agostini**[1], J.E. Little[2], J.C. Field[3], R.C. Francis[2] and A.B. Hollowed[4]

[1] Pew Institute for Ocean Science, Rosenstiel School of Marine and Atmospheric Sciences, Univ. of Miami, 4600 Rickenbacker Causeway, Miami, FL, 33149, U.S.A.
E-mail: vagostini@rsmas.miami.edu
[2] School of Aquatic and Fishery Science, University of Washington, Seattle, WA, 98190, U.S.A.
[3] Southwest Fisheries Science Center, National Marine Fisheries Service, 110 Shaffer Rd., Santa Cruz, CA, 95060, U.S.A.
[4] Alaska Fishery Science Center, National Marine Fishery Service, Sand Pont Way, Seattle, WA, 98193, U.S.A.

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 **Aydin**[1] and the CCCC CFAME Task Team

[1] Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA, 98115-0070, U.S.A. E-mail: Kerim.Aydin@noaa.gov

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

Jason D. **Baker**, Jeffrey J. Polovina and Even A. Howell

Pacific Islands Fisheries Science Center, NMFS, NOAA, 2570 Dole Street, Honolulu, HI, 96822-2396, U.S.A. E-mail: jason.baker@noaa.gov

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 18ºC 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 Curchitser[2], Leah R. Feinberg[3], C. Tracy Shaw[3] and William T. Peterson[4]

[1] Oregon State University, College of Oceanic & Atmospheric Sciences, 104 COAS Admin. Bldg., Corvallis, OR, 97331-5503, U.S.A. E-mail: hbatchelder@coas.oregonstate.edu
[2] Lamont-Doherty Earth Observatory of Columbia University, Oceanography 103-E, 61 Route 9W, Palisades, NY, 10964-8000, U.S.A.
[3] Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, 2030 S. Marine Science Drive, Newport, OR, 97365, U.S.A.
[4] Northwest Fisheries Science Center, Hatfield Marine Science Center, 2030 S. Marine Science Drive, Newport, OR, 97365, U.S.A.

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)

Tatyana A. **Belan**[1,2] and Ludmila S. Belan[1]

[1] Far Eastern Regional Hydrometeorological Research Institute, 24 Fontannaya Street, Vladivostok, 690990, Russia. E-mail: Tbelan@ferhri.ru
[2] Institute of Marine Biology, FEBRAS, 17 Palchevskogo Street, Vladivostok, 690041, Russia

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 euthrophication. 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

Nicholas A. **Bond**[1], D.V. Holliday[2], Calvin W. Mordy[1], Jeffrey M. Napp[3] and Phyllis J. Stabeno[4]

[1] Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, P.O. Box 354235, Seattle, WA, 98195-4235, U.S.A. E-mail: Nicholas.bond@noaa.gov
[2] BAE Systems, 4669 Murphy Canyon Road, Suite 102, San Diego, CA, 92123, U.S.A.
[3] Alaska Fisheries Science Center, NOAA, 7600 Sand Point Way NE, Seattle, WA, 98115, U.S.A.
[4] Pacific Marine Environmental Laboratory, NOAA, 7600 Sand Point Way NE, Seattle, WA, 98115, U.S.A.

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**

Dept. of Atmospheric Environmental Sciences, Kangnung National University, Kangnung, 210-702, Republic of Korea. E-mail: choihyo@knusun.kangnung.ac.kr

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 0º~90º. 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 22.8ºC 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 23.5ºC. As the typhoon moved from Okinawa toward the East Sea, the weekly mean surface temperatures increased, showing a difference of 0.7ºC. 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

Miriam J. **Doyle**[1], Susan J. Picquelle[2], Kathryn L. Mier[2] and Mick Spillane[1]

[1] Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, P.O. Box 354235, Seattle, WA, 98195, U.S.A. E-mail: miriam.doyle@noaa.gov
[2] NOAA Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, U.S.A.

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

Albert J. **Hermann**[1], Thomas M. Powell[2], Elizabeth L. Dobbins[1], Enrique N. Curchitser[3] and Dale B. Haidvogel[4]

[1] Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, P.O. Box 357941, Seattle, WA, 98195, U.S.A. E-mail: Albert.J.Hermann@noaa.gov
[2] Department of Integrative Biology, U. C. Berkeley, 3060 Valley Life Sciences, Bldg 3140, Berkeley, CA, 94720-3140, U.S.A.
[3] Lamont-Doherty Earth Observatory of Columbia University, P.O. Box 1000, 61 Route 9W, Palisades, NY, 10964-8000, U.S.A.
[4] Institute of Marine and Coastal Sciences, Rutgers University, 71 Dudley Rd, New Brunswick, NJ, 08901-8521, U.S.A.

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

K. David **Hyrenbach**[1], D.J. Anderson[2], Y. Tremblay[3], S.A. Shaffer[3], M. Antolos[3], D.P. Costa[3], S.J. Bograd[4], D. Foley[5], D.M. Palacios[5], E.N. Flint[6] and M.B. Naughton[7]

[1] Duke University Marine Laboratory, 135 Marine Lab Road, Beaufort, NC, 28516-8648, U.S.A. E-mail: khyrenba@duke.edu
[2] Department of Biology, Wake Forest University, 246 Winston Hall, Winston-Salem, NC, 27109-7325, U.S.A.
[3] Department of Ecology & Evolutionary Biology, University of California, 100 Shaffer Road, Santa Cruz, CA, 95060-5730, U.S.A.
[4] NOAA Southwest Fisheries Science Center, 1352 Lighthouse Avenue, Pacific Grove, CA, 93950-2097, U.S.A.
[5] Joint Institute for Marine and Atmospheric Research, University of Hawaii, 1000 Pope Road, Honolulu, HI, 96822-2336, U.S.A.
[6] USFWS - Pacific Remote Islands NWRC, P.O. Box 50167, Honolulu, HI, 96850-5000, U.S.A.
[7] USFWS - Finley National Wildlife Refuge, 26208 Finley Refuge Road, Corvallis, OR, 97333-9533, U.S.A.

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

Gail V. **Irvine**[1], Scott J. Carpenter[2] and Jeff Barnhart[3]

[1] Alaska Science Center, US Geological Survey, 1011 E. Tudor Rd, Anchorage, AK, 99503, U.S.A. E-mail: gail_irvine@usgs.gov
[2] Paul H. Nelson Stable Isotope Laboratory, Dept. of Geoscience, 121 Trowbridge Hall, University of Iowa, Iowa City, IA, 52242-1379, U.S.A.
[3] Alaska Department of Fish and Game, Division of Commercial Fisheries, 211 Mission Rd, Kodiak, AK, 99615-6399, U.S.A.

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 $\delta^{18}O$ and $\delta\ ^{13}C$ 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 $\delta^{18}O$ values that represent a combined warming of bottom waters and a decrease in ambient $\delta^{18}O$ values due to an increase in freshwater influx into the ACC. $\delta\ ^{13}C$ 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

Jaime **Jahncke**[1], Benjamin L. Saenz[1,2], Chris Rintoul[1], Russell Bradley[1] and William J. Sydeman[1]

[1] PRBO Conservation Science, Marine Ecology Division, 4990 Shoreline Highway, Stinson Beach, CA, 94970, U.S.A. E-mail: jjahncke@prbo.org

[2] Stanford University, Mitchell Earth Sciences Building, Room 403, 397 Panama Mall, Stanford, CA, 94305, U.S.A.

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 fluorometery 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*)

Sukyung **Kang**, Ki Baik Seong, Chae Sung Lee, Young Hee Hur and Cheul Ho Lee

Salmon Research Team, East Sea Fisheries Research Institute, NFRDI, 424-1, Songhyun-ri, Sonyang-myeon, Yangyang-gun, Gangwon-do215-821, Republic of Korea
E-mail: kangsk@momaf.go.kr

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?

Gennady A. **Kantakov**

Sakhalin Research Institute of Fisheries and Oceanography, 196 Komsomolskaya Street, Yuzhno-Sakhalinsk, 693023, Russia. E-mail: okhotsk@sakhniro.ru

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 dichotermal 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

Eun Jung **Kim**[1], Suam Kim[1] and Dae-Yeon Moon[2]

[1] Department of Marine Biology, Pukyong National University, Busan, 608-737, Republic of Korea. E-mail: eunjung.kim@gmail.com
[2] Tuna Lab. National Fisheries Research & Development Inst., Busan, 619-902, Republic of Korea

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

T.C. **Kline**, Jr.

Prince William Sound Science Center, P.O. Box 705, Cordova, AK, 99574, U.S.A.
E-mail: tkline@pwssc.gen.ak.us

Oceanic carbon subsidies inferred from mean early marine (continental shelf feeding) pink salmon whole-body stable carbon isotope composition, $\delta^{13}C$', 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 $\delta^{13}C$' 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 $\delta^{13}C$' 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

Jodie E. **Little**[1], R.C. Francis[1], M.G. Dalton[2] and J.C. Field[3]

[1] School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA, 98195-5020, U.S.A. E-mail: jelittle@u.washington.edu
[2] California State University, Monterey Bay, Institute for Earth Systems Science and Policy, Seaside, CA, 93955-8001, U.S.A.
[3] Santa Cruz Laboratory, Southwest Fisheries Science Center, NMFS, NOAA, 110 Shaffer Rd, Santa Cruz, CA, 95062, U.S.A.

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?

Bernard A. **Megrey**[1], George L. Hunt, Jr.[2] and Jeffrey M. Napp[1]

[1] NOAA – Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115-6349, U.S.A. E-mail: bern.megrey@noaa.gov

[2] School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA, 98195, U.S.A.

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

Alexei M. **Orlov** and Vasily A. Ul'chenko

Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17 Verkhnyaya Krasnoselskaya, Moscow, 107140, Russia. E-mail: orlov@vniro.ru

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

Alexei I. **Pinchuk**, K.O. Coyle and R.R. Hopcroft

Institute of Marine Science, University of Alaska Fairbanks, P.O. Box 730, Seward, AK, 99664, U.S.A. E-mail: ftaip1@uaf.edu

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

Jeffrey J. **Polovina**[1], Fei Chai[2], Donald Kobayashi[3], Lei Shi and Yi Chao[4]

[1] Pacific Islands Fisheries Science Center, Honolulu Lab., National Marine Fisheries Service, NOAA, 2570 Dole Street, Honolulu, HI, 96734, U.S.A. E-mail: Jeffrey.Polovina@noaa.gov
[2] School of Marine Sciences, 5741 Libby Hall, University of Maine, Orono, ME, 04469, U.S.A.
[3] Pacific Islands Fisheries Science Center, NOAA, Honolulu, HI, 96822, U.S.A.
[4] California Institute of Technology, Jet Propulsion Laboratory, M/S 300-323, Pasadena, CA, 91109, U.S.A.

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 ommastrephid squid, *Todarodes pacificus* - A possible scenario

Yasunori **Sakurai**[1], Sachi Miyanaga[1], Jun Yamamoto[2] and Ken Mori[3]

[1] Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, 041-8611, Japan. E-mail: sakurai@fish.hokudai.ac.jp
[2] Hakodate Branch, Field Science Center for Northern Biosphere, Hokkaido University, Hakodate, Hokkaido, 041-8611, Japan
[3] Hokkaido National Fisheries Research Institute, Kushiro, 085-0802, Japan

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^{o}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^{o}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^{o}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

S. **Shanmuganandan**

School of Earth and Atmospheric Sciences, Madurai Kamaraj University, Palkalainagar, Madurai-625021, Tamilnadu, India. E-mail: shanmug@eth.net

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

Yu.N. **Tananaeva** and M.A. Bogdanov

Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17 Verkhnyaya Krasnoselskaya, Moscow, 107140, Russia. E-mail: julian9@mail.ru

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

Galina A. **Vlasova**

Pacific Oceanological Institute, FEBRAS, 43 Baltiyskaya Street, Vladivostok, 690041, Russia
E-mail: gavlasova@mail.ru

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

Thomas C. **Wainwright**

Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, 2032 Southeast OSU Drive, Newport, OR, 97365, U.S.A. E-mail: thomas.wainwright@noaa.gov

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 Hashioka[1] and Yasuhiro **Yamanaka**[2,3]

[1] Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan. E-mail: hashioka@ees.hokudai.ac.jp
[2] Graduate School of Environmental Science, Hokkaido University, Sapporo 060-0810, Japan
[3] Frontier Research Center for Global Change, Yokohama, 236-0001, Japan

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

Sinjae **Yoo**[1] and Harold Batchelder[2]

[1] Korea Ocean Research and Development Institute, Sa-dong 1270, Ansan, 425-170, Republic of Korea. E-mail: sjyoo@kordi.re.kr

[2] Oregon State University, College of Oceanic & Atmospheric Sciences, 104 COAS Admin. Bldg., Corvallis, OR, 97331-5503, U.S.A.

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.