PICES XIII W3-2004 Invited
Modeling the California Current ecosystem: Can the small inform the large?

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The California Current system is a highly dynamic environment, where physical and biological processes interact at a number of spatial and temporal scales. Effort has been devoted to developing both small and large-scale ecosystem models for this area. Capturing complex processes at meaningful scales has been challenging. Climate metrics (*e.g.* PDO, ENSO) have been used to represent potential environmental forcing on fish populations and ecosystems, often aggregating impacts across large spatial scales and range of species. Simplifications have been invariably necessary, but their adequacy at times questionable. In this presentation I will argue that considering the life histories of key individuals and their link with the environment could help us define appropriate scales and guide us in our attempts to link models. Pacific hake, one of the key species in this system, will be used as an example. I will discuss how quantifying specific habitat features for this species may help us: 1) better understand the link between the physical and biological structure of the system; 2) characterize the functioning and dynamics of the ecosystem as a whole.

PICES XIII W3-2121 Poster
An application of NEMURO.FISH for multi-species modeling

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A coupled fish bioenergetics model with lower trophic ecosystem model (NEMURO.FISH) has been developed under PICES CCCC/MODEL Task Team activities. NEMURO.FISH was originally developed for herring and saury, however, the model equations are able to be easily applied to other pelagic fish species. Under a project "Global Change and its effect for agriculture, forest and fisheries" (supported by Ministry of Agriculture, Forest and Fisheries, Japan), we have started constructing a sardine and anchovy version of NEMURO.FISH. The first goal was to seek proper parameters for sardine and anchovy in a simple 3-box NEMURO.FISH. We will present the differences in parameters between species (saury, sardine and anchovy) and differences in growth between them. Further we demonstrate the importance of multi-species modeling in the northwestern Pacific, as the predatory pressure on zooplankton from Japanese sardine is so large that other species have a risk of encountering shortages of food.

PICES XIII W3-2033 Poster
Population genetic characteristics of the Japanese anchovy, *Engraulis japonicus*, in Korean waters

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We used a portion of mitochondrial 12S ribosomal RNA gene sequences (339 bp) to investigate the phylogenetic and population genetic characteristics of the Japanese anchovy, *Engraulis japonicus*, in Korea. A total of 85 mtDNA haplotypes were obtained from the samples collected from 3 localities (the Southern area of Yellow Sea, the

western part of Jejudo, and the eastern part of the South Sea) in Korean waters during March of 2002. One haplotype AN8T103, obtained from the southern area of the Yellow Sea, formed an independent phylogenetic group in the PAUP analysis, which was separated by 2.0-4.1% of sequence divergence from others. This distinct haplotype appears to be one that carried by immigrants from other study area, but further study is needed. Genetic divergence, except for AN8T103, was moderate to substantial (0.3-3.8%) and nucleotide diversity within populations was 0.015 (Yellow Sea), 0.013 (Jejudo), and 0.015 (South Sea), respectively. Female gene flow was substantial or high (*Nm* = 25.5-36.44), and the genetic distance between localities was not statistically significant. These results indicate that the Japanese anchovy populations occurring in Korean offshore waters were formed with randomly dispersed individuals over geographic areas.

PICES XIII W3-2012 Invited
Modeling of transportation of phyto- and zooplankton in the Kuroshio and Kuroshio Extension

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A three-dimensional ecosystem model was constructed, with a focus on the effects of advective processes on transportation routes of fish eggs and larvae and size dependent variations of plankton biomass in the frontal region of the Kuroshio and the Kuroshio Extension in the western North Pacific. The model consisted of a lower trophic-level model with 11 compartments, based on NEMURO, coupled with an eddy-resolving physical model assimilated to satellite altimetry. The model was driven by a surface forcing from January 1997 through April 2004. A transportation experiment of pseudo-eggs of jack mackerel released in the East China Sea was consistent with larval distributions observed from 2001 to 2004, and indicated that interannual variation in transportation between the Pacific and the Japan Sea was caused by surface-current variation mainly attributed to wind forcing and interaction with eddies. Downstream of the Kuroshio, a high concentration region of phyto- and zooplankton was distributed along the northern edge of the front, where variation of the biomass was controlled primarily by advective processes due to the stream. Moreover local maxima (minima) were formed in convergence zones located downstream (upstream) of the meander ridge (trough), as observed. On the other hand, in the fringe areas of the Kuroshio the variation was affected mainly by *in situ* biological growth. Consequently in the frontal region, a small difference in initial growth rate between small and large-sized plankton induced a large difference in their biomass, coupled with advective process due to convergence and divergence, cross-frontal current and eddy-stream interaction.

PICES XIII W3-2063 Invited
Climate-driven fluctuations in fish stocks of the California Current

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The ocean climate of the California Current and associated coastal waters has a regime-like cyclical behavior with a dominant period of 50 to 60 years. The major pattern of variability appears to be an alternation between strong and weak flow of the California Current, and these two states are accompanied by many other systematic changes such temperature, nutrient levels and lower trophic level productivity. Episodic El Niño-like events are superimposed on this system.

Pacific sardines (*Sardinops sagax*) appear to respond to a weaker California Current by colonizing offshore waters in a band extending northward to British Columbia. During periods of strong current flow, sardines abandon the offshore area, productivity and abundance declines, and the remaining population inhabits nearshore waters at the equatorward end of the range. Strong flow of the California Current is associated with higher levels of nutrients and high productivity at lower trophic levels than is seen under conditions of weak flow. Consequently nearshore species such as anchovies (*Engraulis mordax*) as well as salmonids and groundfish tend to prosper under conditions of strong flow. I hypothesize that two other major coastal pelagic species, mackerel (*Scomber japonicus*) and jack mackerel (*Trachurus symmetricus*) respond to the transitions between flow regimes, so that the four species have a

characteristic cyclic relationship. All of these properties appear to be exhibited by similar boundary current ecosystems around the world. Productivity and behavior of many coastal fish stocks can be explained by these principles, and various cases are examined.

PICES XIII W3-2205 Oral
Recent distribution and ecology of sardines in the north-eastern Pacific Ocean

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Pacific sardine (*Sardinops sagax*) in the north-eastern Pacific Ocean supported one of the largest fisheries in the world during the early portion of the last century with catches approaching one million tons for several years. The stock collapsed in the late 1940s and virtually disappeared from the northern portion of the range in Canada. In the early 1980s abundance of the stock in the main spawning area off southern California began to increase and in 1992 sardines were once again captured off the south west coast of Vancouver Island. Overall abundance of the population continued to increase almost exponentially through the 1990s plateauing at about one millions tons at the turn of the century. By the mid-1990s sardines were becoming prevalent in Canadian waters again in significant numbers especially during warm periods such as the 1997-98 El Niño when evidence of spawning was also observed. In recent years fish are being found infrequently in offshore areas but are abundant in the several large inlets along the west coast of Vancouver Island. Links are drawn between sardine biology and ecology in relation to ocean conditions and the implication for longer term sardine population dynamics.

PICES XIII W3-2183 Oral
Preliminary study of growth of larval and early juvenile Japanese sardine in the Kuroshio-Oyashio transition region

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The abundance of 1-year old recruits of Japanese sardine *Sardinops melanostictus* is a function of egg abundance and survival processes in the larval and juvenile stages in the Kuroshio-Oyashio transition region (KOTZ). This study aimed to estimate the growth rates of late larval and early juvenile stages of *S. melanostictus* collected in a surface/midwater trawl survey in KOTZ during spring of 1997-2002, and examine the relation of growth rates to the standardized CPUE of the surface/midwater trawl survey and number of eggs spawned in the waters off Pacific coast of Japan. Mean growth rates during the late larval and early juvenile stages (20-50 mm SL) were back calculated using the data of otolith daily increments. The annual mean growth rates (G) were fastest in 1997 (0.79 ± 0.15 mm d^{-1}) and slowest in 2001 (0.55 ± 0.10 mm d^{-1}) among the 7 survey years, and were positively correlated with the standardized CPUE (C) ($C = 9.12\ G - 5.25$, $r^2 = 0.502$, $P = 0.115$). The annual mean growth rates in *S. melanostictus* were slower in 1999, 2001 and 2002 relative to the mean value in the 7 survey years, while those in Japanese anchovy *Engraulis japonicus* were relatively fast in the same years in KOTZ. We concluded that the annual mean growth rates in *S. melanostictus* was a positive function of the survival rates during the larval and early juvenile stages, and inversely fluctuate with those in *E. japonicus*, resulting in the contrasting survival rates during early life stage in the transition region.

PICES XIII W3-2182 Oral
A review of the population dynamics of Japanese sardine in the Northwestern Pacific

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We review the basic biology and inter-annual and inter-decadal variability of distribution, abundance, growth and reproductive success rates of the Pacific stock of Japanese sardine *Sardinops melanostictus*. Historical catch records since the 17th century indicate a cycle of approximately 50 years (Klyashtorin, 2002). The distribution of adults expands to the central Pacific and southern areas of the Okhotsk Sea during periods of high abundance, shrinking to coastal and southern areas when abundance is low. Juveniles are transported from winter spawning grounds in the southern Japan to the Kuroshio/Oyashio Transition Zone via Kuroshio and Kuroshio Extension during spring as far east as 180 degrees longitude. Mean body weights at ages 0-5 are negatively correlated with biomass of sardine, suggesting density-dependent growth. Reproductive success rates (recruitment per spawning biomass: RPS) are significantly affected by spawning biomass and winter sea surface water temperature in Kuroshio Extension. Using an IBM-type model, Suda and Kishida (2003) indicated that temperature, prey density, interaction with other pelagics in Kuroshio are all significant factors for growth and survival from spawning grounds to nursery area. The implications of temperature on RPS will be discussed in relation to bottom-up processes, competition with anchovy, the abundance of predators, and other factors.

PICES XIII W3-1845 Poster
NPZ monitoring in the coastal area of the Japan Sea

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Frequent measurements of water temperature and salinity, dissolved oxygen and nutrients (phosphates and silicates), phyto- and zooplankton concentration, and species composition were conducted at two points in Peter the Great Bay from May to October of 1998 and 1999. One point was located in pre-estuarine zone of Suyfun River at the depth 18 m, and other one (48 m) – at the shelf outside of the pre-estuarine zone. The interval between observations was 1-2 weeks. The monitored period includes the final phase of spring blooming, the whole summer blooming cycle, and almost the whole autumn blooming cycle. Concentrations of nutrients had a tendency to increase from spring to autumn, due to the decomposition of detritus formed in spring. However, they were exhausted in times of diatoms blooming (in June of both years and in late August - September of 1998). Fluctuations of phytoplankton and zooplankton abundance also did not coincide. Copepods had maximal biomass in May, July, and September, but phytoplankton blooms began just after termination of these periods. So, a top-down control dominated in the ecosystems. To understand primary and secondary production rates, a mass balance was calculated for two groups of phytoplankton (diatoms and flagellates) and two groups of zooplankton (copepods and sagittas), taking into account advective components. Diatoms had maximal production in June and September, flagellates – lower maximum in July-August, copepods had maximal production in June and September, and sagittas – in June, with certain interannual differences. Thus, the zooplankton seasonal cycle is well adapted to the seasonal cycle of primary production, but the observed fluctuations of phytoplankton and zooplankton biomasses are strongly distorted because of mortality and advection.