Table of Contents

Keynote Address iii
Science Board Symposium abstracts (S1) 1
BIO Topic Session abstracts (S2) 13
BIO Topic Session abstracts (S3) 31
FIS/BIO Topic Session abstracts (S4) 41
MEQ Topic Session abstracts (S5) 59
MEQ Topic Session abstracts (S6) 69
POC/MONITOR Topic Session abstracts (S7) 75
POC Topic Session abstracts (S8) 95
CCCC Topic Session abstracts (S9) 113
CCCC/MODEL Topic Session abstracts (S10) 141
TCODE Electronic Poster Session abstracts (S11) 149
BIO Paper Session abstracts (BIO) 157
FIS Paper Session abstracts (FIS) 167
General Poster Session abstracts (GP) 189
MIE-AP Workshop and Advisory Panel Meeting (W1) 215
CCCC/REX Workshop abstracts (W2) 217
CCCC Workshop abstracts (W3) 227
PICES/CLIVAR Workshop abstracts (W4) 233
MEQ Workshop (W5) and HAB Meeting abstracts 247
MBM-AP Workshop abstracts (W6) 259
Index of Authors 265
PICES Acronyms 279

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

Keynote Address

PICES XIII
Send out the turtle fleet!

Jeffrey J. **Polovina**

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In order to describe the oceanic habitats and migratory pathways of large pelagic animals, biological oceanographers are sending out fleets of animals with electronic tags. Since 1997, I have worked with a number of colleagues deploying fleets of pelagic animals including sea turtles, tunas, moonfish, and whale sharks. I will describe some of the insights we have gained from sending out fleets of loggerhead, olive ridley, and leatherback sea turtles in the North Pacific. The turtles we tracked come from a variety of sources including turtles caught in long-line fisheries, turtles captured by research scientists, and turtles released from aquaria. Electronic tags are attached to the turtles to transmit frequent estimates of the turtle's positions via an Argos satellite. These data together with environmental data from satellite remote sensing are used to describe the oceanic habitat used by these turtles. The results indicate that loggerheads travel across the North Pacific, moving seasonally north and south primarily through the region 28°-40°N, and occupy sea surface temperatures (SST) of 15°-25°C. Their dive depth distribution indicated that they spend 40% of their time at the surface and 90% of their time at depths less than 40 m. Loggerheads are found in association with fronts, eddies, and geotropic currents. Specifically, the Transition Zone Chlorophyll Front (TZCF) and the meanders and eddies in and south of Kuroshio Extension Current (KEC) appear to be important forage and migration habitats for loggerheads.

In contrast, olive ridleys were found primarily south of loggerhead habitat in the region 8°-31°N latitude, occupying warmer water of the subtropical gyre with SSTs of 23°-28°C. They have a deeper dive pattern than loggerheads, spending only 20% of their time at the surface and 60% shallower than 40 m. However, the three olive ridleys identified from genetics to be of western Pacific origin spent some time associated with major ocean currents, specifically the southern edge of the KEC, the North Equatorial Current (NEC), and the Equatorial Counter Current (ECC). These habitats were not used by any olive ridleys of eastern Pacific origin suggesting that olive ridleys from different populations may occupy different oceanic habitats. Finally leatherback turtles use a range of habitats including the California Current and the equatorial currents. Like the olive ridleys they forage subsurface with a high proportion of their time-at-depth in the 25-50 m depth range in both the eastern and equatorial Pacific.

PICES XIII
Abstracts

S1 Science Board Symposium
Beyond the continental slope - complexity and variability in the open North Pacific Ocean

Session Convenors: R. Ian Perry (SB), Vladimir I. Radchenko (BIO), Yukimasa Ishida (FIS), John E. Stein (MEQ), Kuh Kim (POC), Igor I. Shevchenko (TCODE), and Harold P. Batchelder and Suam Kim (CCCC)

Most of the area of the North Pacific Ocean is in the pelagic realm, beyond the major currents and marginal seas that border the continents. This oceanic region has often been perceived as physically homogeneous and stable with low biological productivity. In reality, it is a spatially and temporally dynamic environment of high complexity. *The diversity and structure of open ocean ecosystems are influenced by both horizontal and vertical structure of the ocean's physical and biological properties and by their seasonal cycles*. *Sharp contrasts in oceanic bottom topography caused by seamounts and islands add additional structure and complexity*. In spite of its relatively low primary productivity, the region supports complex ecosystems with high biodiversity, and is home to many endangered species. Marine resources are important to the peoples of the North Pacific and are fished by fleets from many Pacific Rim nations. This session seeks to improve our understanding of the *physical, chemical, and biological* structure and dynamics of North Pacific *oceanic waters far beyond the continental shelf, with particular emphasis on the subtropical gyre*. The symposium will consider how these complex subtropical oceanic ecosystems are structured and maintained, in light of their generally low productivity. It will provide opportunities to compare and contrast these areas with neighbouring regions of higher productivity. How important are small and meso-scale features such as fronts and eddies to the growth, survival, and distribution of upper trophic level species? How do ecosystems in the open ocean respond to changes in vertical and horizontal structure? How have sub-tropical waters been affected by recent global changes? What are the major factors causing changes to open ocean ecosystems, particularly in the sub-tropics? What are the physical and biological links between the subtropical gyre and other regions of the North Pacific? What are the human interactions with these systems?

Monday, October 18, 2004 11:30-17:20

11:30-11:50 **Niklas Schneider** (Invited)
The forcing of the Pacific Decadal Oscillation (S1-2150)

11:50-12:10 **Franklin B. Schwing, Roy Mendelssohn and Steven J. Bograd**
When did the 1976 regime shift occur? (S1-2096)

12:10-12:30 **Howard J. Freeland**
Argo as an aid to environmental monitoring and assessment - An example from the Gulf of Alaska (S1-1818)

12:30-13:30 **Lunch**

13:30-13:50 **Jinping Zhao, Shujiang Li, Weizheng Qu and Jie Su**
Long-term climate change in the Yellow Sea and East China Sea (S1-2122)

13:50-14:10 **Robert Bidigare, Y. Chao, R. Lukas, R.M. Letelier, S. Christensen and D.M. Karl**
Temporal variations in phytoplankton community structure and physical forcing at Station ALOHA (22.75ºN, 158ºW) (S1-2185)

14:10-14:30 **Michael R. Landry and Cecelia C. Sheridan** (Invited)
Zooplankton community complexity and temporal variability in the subtropical North Pacific (S1-2049)

14:30-14:50 **Michael P. Seki** (Invited)
Processes and patterns at oceanic "hot spots" in the subtropical North Pacific (S1-2165)

14:50-15:10 **Coffee break**

15:10-15:30 **Akihiko Yatsu, Masatoshi Moku, Hiroshi Nishida, Kaori Takagi, Norio Yamashita and Hiroshi Itoh**
Possible ecological interactions between small pelagic and mesopelagic fishes in the Kuroshio-Oyashio Transition Zone and Kuroshio Extension in spring (S1-1833)

15:30-15:50 **Denzo Inagake, Kazuyuki Uehara, Harumi Yamada, Koji Uosaki and Miki Ogura** (Invited)
Relation between tuna resources and atmosphere-ocean variability in the North Pacific (S1-2018)

15:50-16:10 **Oleg N. Katugin and Gennadiy A. Shevtsov**
Patterns of distribution and biology of the North Pacific oceanic squid *Berryteuthis anonychus* with implications for the species life cycle (S1-2113)

16:10-16:30 **Julie A. Hall**
Links between biogeochemistry and ecosystems in marine environments (S1-2133)

16:30-16:50 **Edward J. Gregr, Karin M. Bodtker and Andrew W. Trites**
Exploring the structure of the oceanic environment: A classification approach (S1-1994)

16:50-17:10 **Vadim F. Savinykh**
Dynamics of plankton and nekton communities in the Western Subtropical Gyre (S1-2079)

17:10-17:20 **Discussion**

Posters

John R. Bower and Taro Ichii
The red flying squid (*Ommastrephes bartramii*): A review of recent research and the fishery in Japan (S1-1827)

Alexander I. Glubokov and Serguei B. Popov
Results of Russian echointegration and trawl surveys in the Donut Hole during autumn 2003 (S1-1773)

Oleg N. Katugin and Evgenyi V. Slobodskoy
Population structure of the North Pacific oceanic squid *Ommastrephes bartramii* as inferred from variability in biological traits and genetic markers (S1-2114)

Andrei V. Suntsov
Ichthyoplankton of the equatorial frontal zone east of Galapagos Islands (S1-1878)

Andrei V. Suntsov
Species composition and abundance of mesopelagic fish assemblage on the periphery of the North Atlantic subtropical gyre (S1-1877)

PICES XIII S1-2185 Oral

Temporal variations in phytoplankton community structure and physical forcing at Station ALOHA (22.75ºN, 158ºW)

Robert **Bidigare**[1], Y. Chao[2], R. Lukas[1], R.M. Letelier[3], S. Christensen[1] and D.M. Karl[1]

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Potential biological responses to basin-scale climate forcing in the Pacific are assessed based on temporal variations in phytoplankton community structure observed at Station ALOHA (1990-2003) and the output of a Regional Ocean Modeling System (ROMS) model. Phytoplankton populations were monitored monthly during this period using taxon-specific pigment analyses. These analyses revealed distinct temporal patterns, with highest pelagophyte abundance during the periods 1990-1993 and 1996-2003. For other key groups, such as the haptophytes and cyanobacteria, there appears to be a recent post-1996 enhancement in their biomass relative to the previous period of observation. An Ocean General Circulation Model, based on the terrain-following vertical coordinate primitive equation ROMS model, was used to simulate hydrographic dynamics at Station ALOHA. Preliminary analysis comparing the model simulation with TAO observations has shown that the model can realistically reproduce the low-frequency (seasonal-to-interannual) variability. The ROMS simulation during 1990-2003 will be first compared against the HOT physical measurements and then used to help interpret the observed changes in phytoplankton community structure at Station ALOHA.

PICES XIII S1-1994 Oral

Exploring the structure of the oceanic environment: A classification approach

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Despite a recognized need for ecosystem-based management, there is still no consensus on how to define the analytical unit – the ecosystem. We identified distinct oceanic regions in the North Pacific by applying image classification algorithms to environmental parameters output from a ROMS model. We pooled the ROMS output by Levitus seasons and into 2 periods on either side of the 1976-1977 regime shift to investigate seasonal and long-term changes in these regions. We found changes in the regions' sizes and positions before and after the regime shift that are presumably related to well-known water masses (*e.g.*, the Alaskan gyre). Seasonal effects of known atmospheric features (*e.g.*, the Aleutian Low) on the regions are also apparent. Statistical comparisons showed that the seasonal regions were more similar between regimes than from one season to the next within a regime. Prior to the regime shift there were greater differences between seasonal patterns than after, implying that the timing of seasonal transitions have been altered. These transitions warrant more attention since the reproductive success for many northern latitude species depends in part upon environmental conditions in the spring. Significant differences in chlorophyll-*a* distributions among the post-1976 regions supported our hypothesis that these regions are biologically distinct. Our approach allows temporal and spatial fluxes to be characterized at a range of scales. This flexibility in identifying ecosystem boundaries makes it a powerful tool for oceanographers to explore and test hypotheses about marine ecosystem dynamics in the move towards ecosystem-based management.

PICES XIII S1-1827 Poster

The red flying squid (*Ommastrephes bartramii*): A review of recent research and the fishery in Japan

John R. **Bower**[1] and Taro Ichii[2]

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This poster presents a review of the biology, ecology, fisheries, and resource status of the red flying squid (*Ommastrephes bartramii*) focusing on recent literature published in Japan. *O. bartramii* is a large oceanic squid distributed in temperate and subtropical waters of the Pacific, Indian and Atlantic Oceans. The North Pacific population comprises two cohorts (autumn and winter-spring) and four stocks: 1) central stock of the autumn cohort, 2) east stock of the autumn cohort, 3) west stock of the winter-spring cohort, and 4) central-east stock of the winter-spring cohort. The population undergoes a large-scale seasonal north-south migration. Spawning grounds occur in subtropical areas where the sea surface temperature ranges 21-25^{o}C, and feeding grounds occur in northern waters near the Subarctic Boundary. *O. bartramii* matures at 7-10 months and has an estimated one-year lifespan. In the North Pacific, adult squid generally occur at 0-40 m depth at night and at 150-350 m during the day. They prey primarily on fishes, squids and crustaceans. Predators include marine mammals and fishes. The North Pacific population of *O. bartramii* was the target of an international driftnet fishery during 1978-1992, with annual catches reaching more than 200,000 tons during the 1980s. It is now targeted by jigging boats from Japan, China, South Korea and Taiwan. Annual catches in the Japanese jigging fishery ranged from 50,000 to 80,000 tons during the mid-1990s, but have since dropped. The cause of this drop is not known. In 2000, the biomass of the autumn cohort was estimated to be about 370,000 tons. There are no recent biomass estimates of the winter-spring cohort. The review concludes with nine suggested areas for future research.

PICES XIII S1-1818 Oral

Argo as an aid to environmental monitoring and assessment – An example from the Gulf of Alaska

Howard J. **Freeland**

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The spring of 2002 saw an unusual climate anomaly develop within the waters of the Gulf of Alaska. This anomaly was characterized by rapid warming at the sea surface and an injection of a large T/S anomaly between 80 m to 150 m depth. Much has already been written about the development and origin of this anomaly, and some descriptions of its impacts have been prepared. In the northern Gulf of Alaska the anomalies resulted in a massive stabilization of the water column through the spring and fall of 2002. By February 2003 it was apparent that very little vertical mixing had taken place in the upper ocean and that this would be restricting the supply of nutrients which potentially could be damaging to the productivity of the marine ecosystem. This paper will show how the unusual climate anomalies developed and how the Argo array allows us to monitor the development and evolution of a climate anomaly in near real-time. Evidence will also be shown implying that the anomaly appears to have been associated with large scale changes in the flow of water in the northern Pacific Ocean.

PICES XIII S1-1773 Poster
Results of Russian echointegration and trawl surveys in the Donut Hole during autumn 2003

Alexander I. **Glubokov** and Serguei B. Popov

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Studies were conducted from 15 to 26 November, 2003. A total of 13 hauls within 0-310 m were made in their course; the overall length of echointegration tacklines being 1586 miles at the 0-500 m layer. The trawl survey was made using a midwater trawl (111/786) with an 86 m horizontal and 60 m vertical opening, and 110 mm mesh size in the codend. A small mesh insert (liner) 6 m long was used (20 mm mesh). The echointegration survey employed an FCV-1200L (28 khz) and a trawl sounder SI-1010. No pollock was recorded in any of the tracklines made. Near-surface concentrations of jellyfish and, possibly, of mesopelagic fishes were observed throughout the entire area. The catches included ten species of fish, as well as Commander Island squid, and medusas. Pollock was found only in one haul made at the central-eastern sector of the Donut Hole boundary within a 120-180 m layer. Smooth lumpsucker was most frequent among the fish species in catches. In total, 46 fish of this species were taken; two individuals of atka mackerel were caught in the south of the Donut Hole. At night three mesopelagic fish species were numerous in the trawl wing meshes. The catch size and composition data obtained were similar to the results of the 1998-2002 surveys made in the Central Bering Sea by vessels from Poland, China and the Republic of Korea pursuant to the terms of the Convention on Conservation and Management of Pollock Resources in the Central Bering Sea.

PICES XIII S1-2133 Oral
Links between biogeochemistry and ecosystems in marine environments

Julie A. **Hall**

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Complex interactions between chemical factors such as concentration, distribution, and bioavailability of macronutrients and micronutrients that are required for life, and biological processes such as primary production, grazing and predation that alter the form and distribution of chemical elements in the ocean system are critical to the structure of marine ecosystems. The inputs, losses, dynamics, and chemical forms of micro- and macronutrients influence the autotrophic and heterotrophic organisms found in the ocean with subsequent non-linear impacts on metabolic rates and processes, population dynamics, and food web and community structure. The bioavailability of macro- and micronutrients required for the functioning of specific enzymes and metabolic pathways may exert considerable control on the species composition of communities of marine organisms and functional metabolic pathways. Changes in microbial and phytoplankton activity due to changes in the concentrations, types and ratios of macro- and micronutrients can alter the composition, production, and subsequent degradation of organic matter.

Through uptake, metabolic transformations, active and passive transport, extracellular complexation and recycling, biological communities exert considerable control on the oceanic abundance and distribution of macro- and micronutrients and other particle-reactive elements. Such transformations may themselves be influenced by factors internal to marine food webs, such as species composition, as well as external factors that may vary in time and space. Understanding marine biogeochemical cycles and ecosystems requires a significant increase in our understanding of the interactions between biological and geochemical processes. A series of key issues and examples will be presented.

PICES XIII S1-2018 Invited
Relation between tuna resources and atmosphere-ocean variability in the North Pacific

Denzo **Inagake**, Kazuyuki Uehara, Harumi Yamada, Koji Uosaki and Miki Ogura

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It was noted in the early 1980s that some pelagic fish stocks, *e.g.* three species of sardine off Japan, California and Chile, show concurrent fluctuations with a period of several decades. Recent discussions on climate impacts on fish stock fluctuations tend to expand from small pelagic fishes to top predators. This study examines the impacts of atmosphere-ocean variability on recruitment fluctuations of tunas in the North Pacific, *i.e*. Pacific bluefin tuna (PBT), albacore (ALB), and skipjack (SKJ). PBT recruitment fluctuates with a period of around 20 years with three peaks in the middle 1950s, 1970s and 1990s. ALB recruitment shows a similar fluctuation to those of PBT, except with low recruitment in the late 1950s. SKJ recruitment has increased from the 1970s with about 20-year period fluctuations, with two peaks in the mid 1980s and in recent years. Significant correlations were noted between PBT recruitment and the Pacific Decadal Oscillation (PDO), Aleutian Low Pressure Index (ALPI) or Southern Oscillation Index (SOI); ALB recruitment and PDO; and SKJ recruitment and PDO or WP (West Pacific Index), respectively. Especially, sea surface temperature in a spawning area shows significant correlation with recruitments of the three species examined and the period of high temperature in a spawning area corresponded with high recruitments. In addition, ALB high recruitment also corresponded with low temperature in a spawning area during winter, outside the spawning seasons. Climate changes are considered to change larval survival rates in their breeding grounds through changes in food availability, growth rate and the period vulnerable to predation.

PICES XIII S1-2113 Oral
Patterns of distribution and biology of the North Pacific oceanic squid *Berryteuthis anonychus* with implications for the species life cycle

Oleg N. **Katugin** and Gennadiyi A. Shevtsov

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Berryteuthis anonychus (Pearcy et Voss, 1963) is a wide-ranging squid species occurring mostly in offshore areas across the entire boreal zone of the North Pacific Ocean (NPO). Being an oceanic pelagic species, its distribution and life cycle are closely associated with oceanographic current structure. Distribution of this species is uneven, with the densest squid concentrations observed in the northeast Pacific. In the western NPO the species is less commonly encountered. High abundance of this squid in epipelagic layers of the subarctic region, and its associated importance in oceanic food webs, as well as its potential value as a commercial target for the far seas fishery, encouraged research activity into the species biology, including distribution patterns of various life stages. A large amount of data on *B. anonychus* has been obtained during the last four decades of the 20th century, mostly from Russian trawling surveys in the NPO. Having combined all data on squid distributions (spatial, vertical and temporal), and biology (mostly information on the squid size and maturity), we produced a general overview of intraspecific variability and life history characteristics. These were related to general circulation patterns and bottom topography of the NPO.

The general pattern of *B. anonychus* spatial distribution by size and maturity suggests that there exists a major putative geographic separation of the distributional range into “eastern” and “western” sections, with most ontogenetic stages, from paralarvae and early juveniles to immature and maturing adults, occurring within each area. If this in fact is the case, the “western” part of the range is geographically more restricted while the “eastern” one is expanded both latitudinally and longitudinally. In the central and eastern NPO, young squids with dorsal mantle length (DML) less than 21 mm were occasionally observed in the south of the Subarctic Current System area. Larger squids were generally distributed over a broader range of longitude and tended to be found further north. This pattern was most evident for the “eastern” group where larger squids generally occurred north- and eastward of the “paralarval area”. Squids in advanced maturity stages (III and IV) were found in the upper part of the Ridge Domain, mostly in the Gulf of Alaska, and also were occasionally present along the northern boundary of the research area that partially coincided with the southern limit of Alaskan Stream. They were also rarely present to

the west and east of the Emperor Seamounts, and far oceanward of the Kuril Chain to the north of the Subarctic Front. Prespawning or spawning *B. anonychus* have never been observed or reported, nor have egg-masses or newly-hatched individuals. Generally speaking, there was rather good correlation between distribution patterns of squid in various ontogenetic stages, and a major subdivision of the Subarctic Current System into the Western Subarctic and Alaskan gyres.

From squid occurrence and distributional patterns and from a trend that suggests a northward increase in size and maturity of the squid throughout its geographic range, we suggest the following hypothetical life history. *B. anonychus* spawns most likely at great depths (of about 500 m, or even deeper) with spawning areas associated with underwater rises. After hatching, paralarvae are distributed in the highly productive upwelling zones. Growing juvenile squids appear to be dispersed by major oceanic circulatory features. Following the Western Subarctic ("western" group), and Alaskan ("eastern" group) gyres, rapidly growing young squid are transported cyclonically, and finally appear in the vicinity of their natal areas. At the onset of maturation, and during the process of maturity, squids are widely distributed in upper pelagic waters in highly productive zones, where they actively feed. By the time they are sexually mature, and ready to spawn, they are already distributed over their home areas, and finally move down to deep-water layers, where they spawn, completing their life cycle.

PICES XIII S1-2114 Poster

Population structure of the North Pacific oceanic squid *Ommastrephes bartramii* as inferred from variability in biological traits and genetic markers

Oleg N. **Katugin**[1] and Evgenyi V. Slobodskoy[2]

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Ommastrephes bartramii (LeSueur, 1821) is an oceanic species, widely distributed in the subtropical and low temperate zones of the World Ocean, including the North Pacific Ocean (NPO). This is an offshore species that pursues strictly oceanic life cycle strategy. Combining data from different sources, including variability in biological features (size structure, maturity, distribution of individuals on different stages of ontogenetic development, genetic variability and differentiation) provides valuable information on the species life cycle and population structure.

Our research suggests that in the NPO, *O.bartramii* could be characterized by a complicated intraspecific structure that includes both spatial and temporal components. In general, there exists geographical differentiation of populations from the eastern and western parts of species distributional ranges in the NPO. This is supported by slight but significant variability in at least one polymorphic gene marker. On the other hand, successively spawned squid groups belong to different seasonal cohorts with varying biological traits, *e.g.*, time of spawning and hatch, growth rate, size at maturity. Basically from two to four cohorts are encountered by different authors. Using a restricted number of genetic markers, we did not manage to reveal any genetic differences between at least two seasonal cohorts in the northwestern Pacific Ocean (NWPO). The observed pattern of differentiation in *O.bartramii* implies that "western" and "eastern" areas of the species reproductive range in the NPO were supposedly isolated for a sufficient time to accumulate minor stable genetic differences. In the NWPO, the isolation between seasonal cohorts is either absent, or is regularly violated leading to leveling off of any possible differences. It may also imply that observed differences in size structure between seasonal cohorts in the NWPO are related to seasonal variability in growth rates of the squid, and hence in differences of size at maturity. Breaking up of any possible barrier to gene flow between inraspecific groups of *O.bartramii* could be related to specific biological features of the squid. These include functional structure of the species geographical range, reproductive cycle, ontogenetic migrations, *etc.* The following factors may also be of high importance: seasonal and annual fluctuations in stock abundance, physical and biological environmental impacts, which either separately, or in any possible combination result in temporal and (or) spatial shifts of spawning events, survival of paralarvae, migration routes, *etc.*

PICES XIII S1-2049 Invited
Zooplankton community complexity and temporal variability in the subtropical North Pacific

Michael R. **Landry**[1] and Cecelia C. Sheridan[2]

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Classic zooplankton sampling studies in the subtropical North Pacific revealed both the remarkable diversity of species there and the relative constancy of their rank-order abundance. They thus advanced the notion of a quintessential climax community that was internally regulated by inherent biological complexity. A decade of systematic zooplankton collections in Hawaii Ocean Time-series (HOT) Program has challenged that perspective, with clear evidence of seasonal as well as long-term temporal variability. In this presentation, we consider this new view in the context of a variable and changing physical environment.

PICES XIII S1-2079 Oral
Dynamics of plankton and nekton communities in the Western Subtropical Gyre

Vadim F. **Savinykh**

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The Western Subtropical Gyre is characterized as a low productivity region with low plankton biomass, but also has schools of large predators. The mechanism of this phenomenon is not clear. According to our investigations, the biomass of phytoplankton increases from subarctic to subtropical waters by about 100 times. In contrast, the biomass of small- and mid-sized zooplankton double from sub-tropical to subarctic waters. Large-sized zooplankton are 10 times more plentiful in subarctic than subtropical waters

What are the main causes of the increase in the productivity of subtropical waters? First is the drift of inshore species into open waters with the Kuroshio current. Juveniles of sardine, anchovy, mackerel, Japanese flying squid are main foods of skipjack and albacore tuna. Second is ontogenetic accumulation of forage species into the upper layers. For example, *Euphausia pacifica* form surface spawning schools, and larva of some myctophids and bathylagids concentrate into the surface 1-meter layer. These species are among the main foods of skipjack, dolphin, frigate mackerel *etc.* Third is transport of organic substances from subarctic into subtropical waters by predators. Most large fishes and squids migrate only once into subtropical waters and die just after spawning. Their organic substances may be used by bacterioplankton and gelatinous zooplankton. Forth is accumulation of plankton and micronekton around seamounts and into other dynamic zones. These regions are feeding areas for albacore tuna. It is interesting that most high abundance predators that inhabit subtropical waters have life spans of no more than 1 year. These species concentrate into the northwestern periphery of the Subtropical gyre. Longer-lived fishes are spread more widely into the central part of the gyre and do not form large accumulations; that is why longlines are the best fishery gear for them. Thus, inshore-offshore and north-south transport of organic substances are the basic methods of enrichment of the low productivity Subtropical Gyre.

PICES XIII S1-2150 Invited
The forcing of the Pacific Decadal Oscillation

Niklas **Schneider**

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The Pacific Decadal Oscillation (PDO) is the leading mode of variability of sea surface temperature in the North Pacific. It is a widely used index for Pacific Decadal variability, North American and East Asian climate, the North Pacific ecosystem, and modulations of tropical Pacific to North American teleconnections. We show that North Pacific SST and the PDO can be accurately reconstructed from a first-order, auto-regressive model forced by El

Nino, intrinsic variability of the Aleutian Low, and ocean thermocline depth and zonal advection anomalies in the Kuroshio Extension. The latter result from the slow adjustment of the ocean gyres to changes of the wind stress, and are estimated from the history of the Pacific wind stress and Rossby wave dynamics. The leading mode of the reconstructed SST anomalies capture the time evolution and spatial pattern of the PDO. The resulting evolution equation of the PDO shows that it too is dependent only its own history, and the forcing indices - the coupling of the PDO to other modes of North Pacific SST variability is small. The contribution of the different forcing mechanisms is frequency dependent. At annual and shorter time-scales the Aleutian Low dominates, at interannual time-scales teleconnections from the tropics and intrinsic variations of the Aleutian Low are of equal importance. The influence of gyre anomalies in the Kuroshio Extension is on par with the other two forcing at decadal time scales.

PICES XIII S1-2096 Oral
When did the 1976 regime shift occur?

Franklin B. **Schwing**, Roy Mendelssohn and Steven J. Bograd

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Many physical and biological time series from the North Pacific display a relatively sharp change in about 1976, which has been deemed a climate 'regime shift'. This has led to an oversimplification that the entire North Pacific environment and ecosystem shifted suddenly and simultaneously following the 1976-77 winter. However, many studies have reported changes 'in about 1976' that more accurately should be portrayed as being initiated years earlier. Thus the doctrine of a global 1976 regime shift was established. We characterize the evolution of a number of North Pacific physical and biological variables leading up to 1976, and provide evidence that there has been significantly more variable temporal behavior than has been supposed. For example, ocean temperatures below the upper mixed layer and in the northern extremes of the North Pacific began warming around 1970 and do not show a clear shift in 1976. Likewise, many fishery time series suggest population shifts near 1970. One interpretation of a regime shift is an evolving phenomenon whose signals 'propagate' into different regions, depths, and fields having different response times, depending in part on the process that is directly supplying the climate signal. We define changes in North Pacific climate and ecosystem structure during the 1960s-70s, classified spatially and by variable type, provide examples, and suggest mechanisms that may be responsible for a more gradual climate change in the interior ocean followed by a near-surface acceleration. We apply these ideas to more recent climate 'shifts' attributed to 1989 and 1998.

PICES XIII S1-2165 Invited
Processes and patterns at oceanic "hot spots" in the subtropical North Pacific

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The pelagic oceanic environment in the subtropical North Pacific is often perceived as being homogeneous, offering few visual cues to maintain spatial orientation. However, while spatial heterogeneity is effectively restricted to vertical gradients of light, temperature, and abundance of organisms, regions of strong and complex horizontal oceanographic variability abound throughout the open ocean ecosystem in the form of large-scale frontal systems and mesoscale dynamic features where productivity is enhanced and/or trophic transfer facilitated. These include such phenomena as basin-scale physical (*e.g.*, Subtropical Front) and biological (*e.g.*, Transition Zone Chlorophyll Front) fronts, and meso-scale frontal meanders and eddies. In addition, abrupt topography in the form of seamounts are common features in the pelagic subtropics that can have a profound influence on adjacent open ocean food webs in a variety of ways, particularly so for those that rise within the upper few hundred meters of the surface. Accompanying these oceanographic and topographic areas of enhancement are often concentrations of migratory nekton species and collectively has commonly become referred to as oceanic "hot spots". A combination of *in situ* and remotely sensed observations at these special areas provide insight to understanding the processes and patterns that functionally underlay these "hot spots" and are presented here. These oceanographic and topographic features are fouind to often give rise to localized regions of higher productivity leading to aggregation and development of a

forage base while physical gradients and structure provide cues for predators to locate prey or more directly, aggregate or concentrate food items.

PICES XIII S1-1878 Poster
Ichthyoplankton of the equatorial frontal zone east of Galapagos Islands

Andrei V. **Suntsov**

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During her 34th cruise, Russian *R/V* "Akademik Kurchatov" performed a short transect crossing the equatorial frontal zone, east of Galapagos islands (87-88° W). This study analyzes stratified samples collected with two types of plankton nets (Juday type) and covering the upper 200 m of the water column. The sample period coincided with austral winter, when the equatorial front is weakly developed. The ichthyoplankton collection included 53-55 species from 25-26 families. Family Myctophidae was the most species rich, with larvae of 14-15 species recorded. Less diverse families were Gonostomatidae and Nomeidae (4 species). Other families were represented by 1-2 species. Larvae of *Vinciguerria lucetia* and *Auxis rochei* numerically dominated the ichthyoplankton. The larvae of these two species, as well as early stages of *Diogenichthys laternatus, Nannobrachium* sp. (Myctophidae) and *Psenes sio* (Nomeidae) comprised more than 60 % of the total ichthyoplankton collected and occurred in more than 20% of samples. Eggs of 17-19 fish species were also recorded in ichthyoplankton, including *B. nigrigenys*, *Maurolicus* sp., *Vinciguerria lucetia*, *Stomias* sp., Myctophidae gen. sp., *Oxyporhamphus micropterus*, *Exocoetus sp.*, *Cheilopogon* sp., *Trachipterus cf. fukuzaki*, *Psenes sio*, *Auxis rochei*, *Cubiceps pauciradiatus.* In general, ichthyoplankton composition was rather typical for the eastern tropical Pacific and was principally composed of larvae of epipelagic and mesopelagic species. Small numbers of larvae of coastal species (Serranidae, Gobiidae) were probably dispersed from the nearby Galapagos Islands.

PICES XIII S1-1877 Poster
Species composition and abundance of mesopelagic fish assemblage on the periphery of the North Atlantic subtropical gyre

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Subtropical gyres, found in all major oceans, represent unique marine ecosystems, hosting highly diverse pelagic communities with rather stable species composition and biomass. In October 1999, Russian *R/V* sampled deep sea pelagic biota southwest of Azores archipelago, near the northern periphery of the North Atlantic subtropical gyre (36°14' N, 33°57' W). The deployment of six non-closing Isaaks- Kidd midwater trawls, covering various depth strata, resulted in the collection of 2354 fish specimens representing 66 species from 20 families. With the exclusion of extremely abundant bristlemouths (Cyclothone spp.), mainly caught below 200 m, the most abundant species in the collection was *Notolychnus valdivae*, followed by *Vinciguerria attenuata*, *Argyropelecus hemigymnus*, *Chauliodus danae*, *Lampanyctus* sp., *Diogenichthys atlanicus*. The majority of species collected were represented by just few specimens. The entire fish collection was composed almost exclusively of mesopelagic species, with only few typical representatives of bathypelagic fauna – *e.g. Eurypharynx pelecanoides*, *Lynophryne* sp. The only non deep-sea representative in the collection were juvenile specimens of *Anguilla anguilla*, almost invariable caught with each tow. Myctophids were by far the most diverse, comprising nearly half (30 species from 15 genera) of the entire species diversity. Of these, *Notolychnus valdivae* formed one third of all lanternfish specimens collected. Other dominant myctophids were *Lampanyctus* sp. (9.6% of all myctophids), *Diogenichthys atlanticus* (9.0), *Lampanyctus photonotus* (6.3), Benthosema *suborbitale* (5.2). Less diverse families in the area sampled were Melanostomiidae (5 species), Gonostomaidae (4), Phosichthyidae (4), Sternoptychidae (4).

PICES XIII S1-1833 Oral

Possible ecological interactions between small pelagic and mesopelagic fishes in the Kuroshio-Oyashio Transition Zone and Kuroshio Extension in spring

Akihiko **Yatsu**[1], Masatoshi Moku[2], Hiroshi Nishida[1], Kaori Takagi[1], Norio Yamashita[1] and Hiroshi Itoh[3]

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We examined horizontal and vertical distributions and feeding habits of juveniles of Japanese sardine (*Sardinops melanostictus*), Japanese anchovy (*Engraulis japonicus*), mackerels (*Scomber* spp.), adults of a gempylid (*Nealotus tripes*), juveniles and adults of dominant myctophid fishes (*Ceratoscopelus warmingii*, *Symbolophorus californiensis*, *Notoscopelus* spp. (mostly *N. resplendens*), and *Myctophum asperum*) in the Kuroshio-Oyashio Transition Zone and Kuroshio Extension in spring obtained by a nighttime midwater trawl survey during 1995-2004. Geographic distributions of these commercial small-pelagics and mesopelagics generally overlapped throughout the study area and period. Consecutive sampling in close proximity in 1995 revealed vertical segregation of major distributions between small pelagics and mesopelagics. In the upper 20 m layer, Japanese anchovy comprised 88% of the total wet weight followed by *C. warmingii* (3%) and *S. californiensis* (3%). Myctophids in the upper 20 m layer were dominated by juveniles relative to adults when compared to deeper layers. Euphausiids and myctophids were the most important prey for adult black snake mackerel, suggesting a prey shift from anchovy larvae at the juvenile stage. Major diets of juveniles of small pelagics and juveniles and adults of myctophids were copepods with a slight to moderate overlap of species composition in the stomach contents. Given the prevalence of mesopelagic fishes in the study area, which is the key area for reproductive success of Japanese sardine and anchovy, early growth and survival of commercial species may be largely affected by mesopelagic fishes through competition in addition to bottom-up and top-down effects.

PICES XIII S9-2122 Oral

Long-term climate change in the Yellow Sea and East China Sea

Jinping **Zhao**[1], Shujiang Li[1], Weizheng Qu[2] and Jie Su[2]

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The Yellow Sea and East China Sea (YE) are marginal seas of North Pacific (NP) Ocean. The first and second EOF modes of sea surface air temperature (SSAT) in the NP show a north-south oscillation in the western side of the ocean, which is correlated with the Kuroshio and Oyashio systems. However, the climate system in the YE is affected mainly by the southern part of the oscillation though half of the seas are located farther north. The EOF of SSAT in the YE seas shows a spatially synchronous variation. The temporal pattern of the first mode of the EOF correlates with air temperature and sea surface temperature (SST) in Qingdao. In decadal scale, an obvious low frequency variation shows a negative temperature anomaly period from 1956 to 1987. After then, a positive anomaly is dominant and reaches its maximum around 1998. Then it looks like to restart a negative process. A long-term warming trend of SST in the past 40 years is clear with the rate of 0.09°C/decade, comparable with the global averaged SST increase of 0.1°C/decade. The temperature increase in coastal areas is much higher than that in offshore areas. The correlation of long-term variation of SSAT and SST in the YE with either ENSO or PDO is unexpectedly poor, with correlation coefficients of about 0.15. Therefore, long-term climate change in the YE must be a locally dominant and complicated system, as it is strongly affected by the processes in Northwest Pacific Subtropical High system, Equatorial Current system, Asian Monsoon system and the land climate system.

S2 BIO Topic Session
Mechanisms that regulate North Pacific ecosystems: Bottom-up, top-down, or something else?

Session Convenors: Douglas DeMaster (U.S.A.), George L. Hunt, Jr. (U.S.A.), Michio J. Kishi (Japan), Jeffrey M. Napp (U.S.A.) and Andrew Trites (Canada)

Within the PICES region, dramatic changes have been observed in the past 50 years in the structure and function of marine ecosystems. In an effort to understand what caused these, often dramatic, changes, various hypotheses have been proposed as controlling mechanisms for entire ecosystems or for particular components of the ecosystems (*e.g.* fish stocks and apex predators). Each of the hypotheses (*e.g.*, Trophic Cascade, Oscillating Control, Nutritional Stress, and Regime Shift) has at its core a fundamental assumption that control is the result of bottom-up, top-down, or a wasp-waist trophic pyramid restriction. Is it really that simple? Are these hypotheses testable? Will they lead us to a predictive capability? This session will critically examine these hypotheses, as applied to ecosystems and important marine populations from the western and eastern North Pacific Ocean. The goal is to review, based on observations and model results, the basic assumption (source of control), and to evaluate the strength and weaknesses of the individual hypotheses. The session will also explore how the different control mechanisms might affect the ability of managers to maintain sustainable fisheries in the region. The possibility of publishing the results in a special issue of a leading international journal will be explored.

Day 1 Tuesday, October 19, 2004 8:30-17:30

08:30-09:00 **Mary E. Power** (Invited)
Food webs, fluxes, and flow paths: A fluvial perspective (S2-2173)

09:00-09:20 **John C. Field, Robert C. Francis and Kerim Y. Aydin**
Top-down modeling and bottom-up dynamics: Linking fisheries-based multispecies models with climate hypotheses in the Northern California Current (S2-2003)

09:20-09:40 **Jeffrey M. Napp, George L. Hunt Jr., Sue E. Moore and Christine T. Baier**
Who is regulating zooplankton production (or How to resolve issues of control)? (S2-2106)

09:40-10:00 **Xuelei Zhang, R.X. Li, M.Y. Zhu, Z.L. Wang, L.H. Zhang, Y. Li and Y.J. Hao**
Changes of net phytoplankton in Sanggou Bay, Northern China: Evidence for consumer regulation of primary producer (S2-1802)

10:00-10:20 **Coffee break**

10:20-10:50 **Philippe Cury** (Invited)
Who is controlling whom in marine ecosystems: Observed changes, possible mechanisms and trends in top-down, bottom-up and wasp-waist controls (S2-1846)

10:50-11:10 **Andrew Bakun**
Mechanisms of "wasp-waist" control in marine ecosystems (S2-1852)

11:10-11:30 **William Sydeman, John Calambokidis, Derek Lee, Steve Ralston, Dave Johnston, Chet Grosch and Francisco Chavez**
Phase relationships and controls of the upwelling-dominated central California Current ecosystem (S2-2148)

11:30-11:50 **Vladlena V. Gertseva, Thomas C. Wainwright and Vladimir V. Gertsev**
Juvenile salmon survival in coastal waters of the Northeast Pacific Ocean: Top-down or bottom-up control? (S2-1858)

11:50-12:10 **Jennifer L. Nielsen and Gregory T. Ruggerone**
Top-down and bottom-up linkages among climate, growth, competition, and production of sockeye salmon populations in Bristol Bay, Alaska, 1955-2000 (S2-2068)

12:10-13:30 **Lunch**

13:30-14:00 **Bernard A. Megrey and Francisco E. Werner** (Invited)
Evaluating the role of top-down versus bottom-up ecosystem regulation from a modeling perspective (S2-2043)

14:00-14:20 **Anne B. Hollowed and Vera N. Agostini**
A review of the role of environmental disturbance and resource partitioning as a source of population regulation in marine ecosystems (S2-2001)

14:20-14:40 **Jie Zheng and Gordon H. Kruse**
Recruitment variation of eastern Bering Sea crabs: Density-dependent, "climate-control", or "top-down" effects? (S2-1929)

14:40-15:00 **Steven R. Hare**
The Thompson-Burkenroad debate revisited - What drives fluctuations in Pacific halibut abundance? (S2-1904)

15:00-15:20 **Coffee break**

15:20-15:40 **Kerim Y. Aydin, Sarah K. Gaichas and Patricia A. Livingston**
Wasp-waist control and beer-belly oscillations: An evaluation of population hypotheses in the Bering Sea and Gulf of Alaska (S2-2109)

15:40-16:00 **Franz J. Mueter, Michael C. Palmer and Brenda L. Norcross**
Bottom-up and top-down controls of walleye pollock on the Eastern Bering Sea shelf (S2-2038)

16:00-16:20 **Yongjun Tian, Hideaki Kidokoro and Tatsuro Watanabe**
Long-term changes in fisheries production of the Japan Sea with emphasis on the impacts of fishing and climate regime shifts during the last three decades (S2-2000)

16:20-16:40 **Kenneth F. Drinkwater**
Marine ecosystem responses to the warming of 1920s and 1930s in the northern North Atlantic (S2-2085)

16:40-17:00 **Richard J. Beamish and Gordon A. McFarlane**
The natural regulation of long lived fishes and the impact of "longevity over fishing" (S2-2066)

17:00-17:30 **Open Discussion**

Day 2 Wednesday, October 20, 2004 8:30-12:10

08:30-09:00 **Hiroyuki Matsuda** (Invited)
How to test, use and manage sardine-anchovy-chub mackerel cycles (S2-2117)

09:00-09:20 **Akinori Takasuka, Yoshioki Oozeki, Ichiro Aoki, Ryo Kimura, Hiroshi Kubota and Takashi Yamakawa**
Differential optimal temperatures for growth of larval anchovy and sardine: A potential mechanism for regime shifts? (S2-1956)

09:20-09:40 **Rubén Rodríguez-Sánchez, Daniel Lluch-Belda and Sofía Ortega-García**
Possible mechanisms underlying latitudinal abundance changes of Pacific sardine in the California Current system during the last warming regime (1980-1997) (S2-1991)

09:40-10:00 **Vera N. Agostini, Andrew Bakun and Robert C. Francis**
Larval stage controls on sardine recruitment variability: Predation or food availability? (S2-1934)

10:00-10:20 **Coffee break**

10:20-10:50 **Yasunori Sakurai, Sachi Miyanaga and Jun Yamamoto** (Invited)
Why do ommastrephid squids increase in abundance during warm regimes? (S2-1939)

10:50-11:10 **Andrew W. Trites, Arthur J. Miller and Herbert D. G. Maschner**
Bottom-up forcing and the decline of Steller sea lions in Alaska: Assessing the ocean climate hypothesis (S2-1821)

11:10-11:30 **Alexander Kitaysky and Alan Springer**
When, where and why Steller sea lions experience physiological stress - Evidence from stress hormones and diet quality (S2-2116)

11:30-11:50 **Douglas P. DeMaster, Paul Wade and Phillip Clapham**
The cascading whale predation hypothesis: Testing with existing data (S2-2145)

11:50-12:10 **George L. Hunt Jr.**
Are the control mechanisms of marine birds and mammals scale-dependent? (S2-1826)

Posters

Igor V. Melnikov
Pelagic predatory fishes as consumers of Pacific salmon: Distribution in the Russian exclusive economic zone and adjacent waters, their abundance and some biological features (S2-1948)

Hyunju Seo, Kibeik Seong, Suam Kim and Sukyung Kang
Interannual variability in chum salmon (*Oncorhynchus keta*) growth in relation to environmental change during the 1980s-1990s (S2-2023)

PICES XIII S2-1934 Oral
Larval stage controls on sardine recruitment variability: Predation or food availability?

Vera N. **Agostini**[1], Andrew Bakun[2] and Robert C. Francis[1]

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Linear processes have dominated our view of food web energy transfer in marine ecosystems. Fish species are generally modeled by representing trophic energy transfers among adult biomasses, but population dynamics are in many cases determined at non-adult life history stages. Taking into account earlier life stages and the potential non-linearities introduced in the food web by mortalities inflicted at these earlier levels, may present a more complete view of trophic system dynamics, in which control might be exerted by number of mechanisms (top-down, bottom-up *etc.*) each operating at different life history stages. This study focuses on Pacific sardine (*Sardinops Sagax*). Sardines inhabit some of the most highly productive areas of the ocean (upwelling areas). Despite this, they reportedly thrive during warm periods characterized by comparatively lower productivity. Amongst the explanations advanced for the apparent sardine success during warm periods: a) lowered predation pressure on early life history stages; b) access to waters with higher food availability. We examine zooplankton abundance in the sardine larval habitat off the coast of southern California. Our results show that increased food availability (represented here by zooplankton abundance) in the larval habitat cannot alone explain successful sardine year classes. We suggest that zooplankton abundance may also be an index of predation pressure on early life history stages, with decreased predation pressure during warm years being one of the factors allowing for bursts in sardine recruitment.

PICES XIII S2-2109 Oral
Wasp-waist control and beer-belly oscillations: An evaluation of population hypotheses in the Bering Sea and Gulf of Alaska

Kerim Y. **Aydin**, Sarah K. Gaichas and Patricia A. Livingston

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Hypothesized controlling factors for highly variable groundfish populations off Alaska include changing climate regimes, benthic and pelagic energy pathways, prey switching by top predators, and exploitation-triggered cascades. As each hypothesis is based on a subset of available species data, each holds a degree of "truth." Yet can a composite controlling hypothesis be synthesized from these individual theories, and will it be useful for predictive ecosystem-based fisheries management? Here, we approach the question with two sets of models. The first are "minimum realistic" multispecies models, each containing the minimum complexity required to duplicate a particular control hypothesis. The second are "ecosystem-level" energy flow models, driven by the output of the minimal models, which will be used to ask two questions: (1) do the embedded minimal models produce ecosystem-level predictions which may be evaluated against supplementary data (for example, does the Oscillating Control Hypothesis for Bering Sea Pollock make verifiable predictions for other forage fish); and (2) do control hypotheses "collide" to produce emergent behavior with negative consequences for predictability? We suggest that, if the controlling factors collide, prediction should be approached in terms of "resonance." Regimes emerge as species life-histories interact with frequencies of variation, and dominant species groups at times control the expansion of resources (the wasp-waist) and at times buffer their collapse (the beer-belly). Under such a world view, "ecosystem-based" fisheries management does not fine-tune ecosystems to maximize productivity, but rather bounds expectations by predicting the long-term frequency and magnitude of booms and busts under alternative management policies.

PICES XIII S2-1852 Oral
Mechanisms of "wasp-waist" control in marine ecosystems

Andrew **Bakun**

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Contrary to the situation in terrestrial ecosystems where adult and pre-adult stages usually occupy nearly the same trophic level, adults and early life stages in marine systems may operate at quite different trophic levels. This introduces the potential for unstable feedback loops to form between different trophic levels, leading to abrupt populations collapses and explosions, and to massive system reorganizations (*i.e.*, *regime shifts*). Surveys of available *regime shift*-like experiences tend to implicate the populations of small planktivorous pelagic fishes that form the *wasp-waists* of most marine ecosystems as being key actors in the feedback mechanisms that apparently are involved. Several classes of mechanisms potentially involved in initiating and maintaining radical ecosystem shifts are discussed, including: (1) the "simplest loop" wherein *wasp-waist* species prey on the early stages of their larger predators, (2) the effect of geographical shifts in the areas of operation of the mobile wasp-waist populations on less mobile (or slower responding) predators and prey, and (3) changes of dominance among wasp-waist populations that may exchange phytoplanktivores (which may in some cases provide important services in controlling eutrophication, hypoxia. *etc.*), for zooplanktivores (which may be particularly efficient predators on early life stages of desirable fishes). Operation and consequences of such mechanisms will be illustrated, as time allows, by several case histories.

PICES XIII S2-2066 Oral
The natural regulation of long lived fishes and the impact of "longevity over fishing"

Richard J. **Beamish** and Gordon A. McFarlane

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The abundance of long lived fishes such as sablefish is controlled naturally through bottom-up processes that regulate recruitment. However long lived species have not evolved to adapt to top–down controls. Fishing becomes a top-down control that reduces the resiliency of long lived species to extended periods of low food production. The extreme reduction of age classes in a population through fishing is "longevity over fishing". "Longevity over fishing" can cause the collapse of a population during extended periods of poor food production.

PICES XIII S2-1846 Invited
Who is controlling whom in marine ecosystems: Observed changes, possible mechanisms and trends in top-down, bottom-up and wasp-waist controls

Philippe **Cury**

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The structure and functioning of marine ecosystems can drastically change and affect fisheries in a more or less reversible way. The analysis of controls appears to be a key issue for understanding ecosystem dynamics, particularly in a context of global changes (climate change and overexploitation). Controls can help to predict drastic changes of major living components that occur in marine ecosystems, known as regime shift (a sudden shift in structure and functioning of a marine ecosystem, affecting several living components and resulting in an alternate steady state). This presentation provides an overview of patterns (regime shifts, species replacements and alternations) that have been observed in marine ecosystems. Mechanisms by which regime shifts and ecosystem changes may be initiated and sustained in marine ecosystems are then reviewed. Those changes can be environmentally driven (through bottom-up control of the food web, or via direct effects on recruitment, *etc.*), ecologically driven (*e.g.*, through top-down forces such as predation), mediated behaviourally (*e.g.* behavioural

adaptations to habitat change, mixed species schooling) or driven by human exploitation that selects species or preferential fish sizes (top-down control). Bottom-up control, initiating and sustaining regime shifts or species replacements via environmental forcing, is documented in most ecosystems. However fishing (a case of top-down control) appears to have played an important role in regime shift processes in several ecosystems. Even though we are far from possible generalization regarding the dynamics of the controls, it is suggested that fishing down the food-web may cause worldwide ecosystems to be more sensitive to bottom-up forces, *i.e.* to climate change. We will gain scientific insight by developing models, experiments and observations that will combine bottom-up and top-down controls into the same framework (until now most approaches have been considering them independently). We also need to relate processes to pattern to disentangle the effects of controls on population dynamics, particularly their combined effects. This should help us to move towards 'ecosystem ecology' as a discipline in its own right, and towards an effective Ecosystem Approach to Fisheries.

PICES XIII S2-2145 Oral
The cascading whale predation hypothesis: Testing with existing data

Douglas P. **DeMaster**, Paul Wade and Phillip Clapham

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Springer *et al.* (2003) have hypothesized that the removal of large whales by commercial whaling in the region of the Bering Sea/Aleutian Islands has led to cascading trophic interactions that have caused the sequential decline of populations of harbor seals, northern fur seals, Steller sea lions and northern sea otters. This hypothesis has stirred considerable interest because of its implication regarding ecosystem based management. Based on a review of available data, it appears that the Springer *et al.* hypothesis is not consistent with data on: 1) trends in large whale biomass and pinniped biomass in this area during the last 30 years, 2) trends in marine mammal populations in other areas occupied by killer whales; and 3) the importance of baleen whales as prey for killer whales in high latitudes. Based on this review, it appears that the hypothesis proposed by Springer *et al.* should be modified or rejected. One possible modification of the hypothesis would be to separate the link between commercial whaling in the 1960s and 1970s and the dynamics of the populations of harbor seals, northern fur seals, Steller sea lions, and northern sea otters. Available data are consistent with the hypothesis that predation by killer whales may be an important factor in explaining trends in these four populations of marine mammals in the Bering Sea/Aleutian Islands area.

PICES XIII S2-2085 Oral
Marine ecosystem responses to the warming of 1920s and 1930s in the northern North Atlantic

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During the 1920s and 1930s there was a dramatic warming of the northern North Atlantic Ocean. Warmer-than-normal sea temperatures and reduced ice conditions continued through to the 1950s and 1960s, with the timing of the decline to colder temperatures varying with location. Documented changes to the marine ecosystem off northern Europe, Iceland, Greenland and northern Canada during this warm period will be presented. Ecosystem changes included a general northward movement of fish and benthic fauna and flora. Boreal species of fish such as cod, haddock and herring expanded further north while colder water species such as capelin and polar cod retreated northward. Migration patterns of the "warmer water" species changed with earlier arrivals and later departures. The spawning locations of several fish species also spread northward. Benthos associated with Atlantic waters spread northward along Svalbard and eastward into the eastern Barents Sea. Some tropical species of fish that were unheard of in northern areas prior to the warming event became frequent visitors and many others occasional visitors. These responses will be compared to the ecosystem changes that have accompanied the warming in the 1990s.

PICES XIII S2-2003 Oral

Top-down modeling and bottom-up dynamics: Linking fisheries-based multispecies models with climate hypotheses in the Northern California Current

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We ran a dynamic model of the Northern California Current with historical estimates of fishing mortality, fisheries effort, and climate; fitting to the results of stock assessments, surveys and catch statistics. A key challenge in doing so has been determining whether, and how, to best to incorporate climate impacts and forcing processes into model dynamics, an effort that requires numerous simplifying assumptions in order to accommodate the modeling framework. Climate can affect ecosystem productivity and dynamics both from the bottom-up (through short- and long-term variability in primary and secondary production) as well as from the top-down (through variability in the abundance and spatial distribution of key predators). Although multispecies predator/prey models are generally not intended to account for biophysical processes, we have explored how the incorporation of various means of climate forcing improve the fit of the model dynamics to observed trends and landings for exploited components of the ecosystem. For example, although the model is unable to fully account for the dynamics of migratory species in this system, we can use climate to account for their dynamic role in the NCC in a manner consistent with their known response to environmental variability. We find that the incorporation of climate forcing from both the bottom-up and the top-down has the potential to result in significant improvements in model fits and performance.

PICES XIII S2-1858 Oral

Juvenile salmon survival in coastal waters of the Northeast Pacific Ocean: Top-down or bottom-up control?

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Based on the studying the abiotic and biotic relationships of juvenile salmon in the coastal waters of Northeast Pacific Ocean, we developed a mathematical model of the juvenile salmon survival in the nearshore oceanic ecosystem. Our model consists of two components: the dynamics of the number of juvenile salmon, N(t), and the growth of individual fish, W(t). Such an approach allows us to separate the bottom-up and top-down effects in the ecosystem and study the questions: Do these effects have equal influence on salmon survival? If not, what are the conditions under which salmon survival is primarily controlled by a bottom-up (or a top-down) mechanism? Calibrated on a reliable data set, our model provides a theoretical ground for a better understanding of the natural mechanisms controlling juvenile salmon survival, enabling predictions of different scenarios of juvenile salmon dynamics depending on various factors affecting fish.

PICES XIII S2-1904 Oral

The Thompson-Burkenroad debate revisited – What drives fluctuations in Pacific halibut abundance?

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The debate over the relative importance of harvest and environment on the dynamics of natural populations is epitomized by the "Thompson-Burkenroad" debate over Pacific halibut (*Hippoglossus stenolepis*) population fluctuations. The debate emerged in the 1940's and 1950's with the scientific community at that time generally siding with W. F. Thompson's view that fishing mortality was, by far, more important than environmental effects.

In the 50 years since, the debate has remained germane and broadened to many other fisheries in the North Pacific. By the late 1900s, after more years of data collection coupled with new analyses and a new paradigm on climatic regimes, the consensus view had shifted to Martin Burkenroad's original contention that environment was the more important factor, at least in regards to recruitment variability. This year, for the first time, a sex-specific assessment of halibut has allowed for separate population accounting to be made of males and females. This is important in determination of spawning biomass effect on recruitment because males and females have highly differential growth rates, hence differential exploitation rates. Additionally, both sexes both have shown inter-decadal trends in their growth rates. In this paper I revisit the Thompson-Burkenroad debate in light of new data and assessment results. I also illustrate how both fishing and environmental effects are accounted for in devising a robust harvest strategy for Pacific halibut.

PICES XIII S2-2001 Oral
A review of the role of environmental disturbance and resource partitioning as a source of population regulation in marine ecosystems

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We consider the role of spatial partitioning of resources in the context of bottom–up, top-down or wasp-waist trophic pyramid restrictions type systems. We revisit the theories of population regulation based on competition for limited resources and predation and the role of environmental disturbance on these factors. In ocean systems, environmental disturbance influences the spatial distribution of habitat creating spatially and temporally dynamic patterns of resource availability and species interaction. We present evidence for ecological disturbance and its role in mediating competition and predation using field information collected for three different systems: Three winter spawning flatfish in the Bering Sea (probably bottom-up), walleye pollock and capelin interactions on the eastside of Kodiak Island (potentially-top down or bottom-up), and pelagic fish (probably bottom-up or wasp-waist) on the west coast of North America. Our review of oceanographic influences on winter spawning flatfish shows that resource limitation has the highest probability of occurring when cross shelf advection transports reproductive products into favorable nursery grounds. Our review of walleye pollock and capelin spatial partitioning shows that competition for limited resources and spatial overlap of predator and prey is mitigated during summer months by partitioning habitat use. Review of pelagic species demonstrates a similar pattern of resource partitioning by pelagic species. We note that principles of fisheries resource management are based on density dependent regulation of populations. Our review suggests that consideration of environmental influences on resource partitioning should be considered in the formulation of management advice.

PICES XIII S2-1826 Oral
Are the control mechanisms of marine birds and mammals scale-dependent?

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I briefly review evidence for bottom-up control of marine birds and pinnipeds. In marine birds, bottom-up control is the primary mechanism of population control, though the siting of colonies may, in some cases, be determined by where they can be free of terrestrial predators or inaccessible to birds of prey. Similarly, for pinnipeds, while there is evidence for the occurrence of bottom-up control, evidence for top-down control is rare. The relative importance of top-down and bottom-up control is scale dependent, with global patterns in the biomass of marine birds and mammals being bottom-up, the location of breeding sites for seabirds and pinnipeds being at least in part controlled by predation, and the interannual variation in reproductive success or numbers of birds or pinnipeds in a colony or rookery usually being controlled by prey availability. The relative mobility of predator and prey may also affect the likelihood of top-down or bottom-up control.

PICES XIII S2-2116 Oral

When, where and why Steller sea lions experience physiological stress - Evidence from stress hormones and diet quality

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Following a rapid decline, population counts of the western stock of Steller sea lions leveled off in the mid-1990s. Whether numbers finally stabilized to match the carrying capacity of the ecosystems, or the population has been stripped to the last cohorts prior to disappearance, is not known. One of the basic problems is that we have not been able to determine which breeding populations are currently stressed. We know even less about the severity of physiological stress required to interfere with reproductive function in affected sea lions. Our objectives were to: (A) To determine which rookeries currently experience physiological stress; (B) To examine whether this level of physiological stress might affect reproductive function; (C) To determine whether poor diet quality could be a major factor causing physiological stress (the "nutritional stress" hypothesis). We used fecal samples to assess hormone levels and diet composition. Inter-seasonal and inter-rookery comparisons suggest that physiological stress is contributing to the continuing decline of Steller sea lions, probably via its effects on reproductive function. In support of the nutritional stress hypothesis, we found that the diet quality was lowest in the areas of highest physiological stress and population declines. However, on the scale of specific rookeries this pattern didn't hold. Thus, although physiological stress and its negative effects on reproductive function of individuals in the western stock of the Steller sea lion are evident, the causal factors remain to be shown. The nutritional stress hypothesis can be neither accepted nor rejected based on the results of our study.

PICES XIII S2-2117 Invited

How to test, use and manage sardine-anchovy-chub mackerel cycles

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Although we often generate hypotheses from dichotomies, a trichotomy may give an eye-opening idea. In my analysis of this trichotomy I make the following points: (1) A cyclic advantage hypothesis may explain a permanent stock fluctuation (a May-Leonard orbit) among sardine, anchovy and chub mackerel. The hypothesis is falsifiable because sardine must increase only after chub mackerel are abundant. (2) This hypothesis does not predict when the next species replacement occurs. Species replacement probably depends on temporal and spatial heterogeneity in oceanographic conditions. This is because variance of recruitment strength at a low stock level is much larger than that at a high stock level. (3) Collapse of the sardine population was caused by recruitment failure in the early 1990s. Overexploitation of chub mackerel since 1990s may prevent the stock from recovering forever. (4) Ecosystems are characterized by uncertainty, fluctuations are a permanent feature and ecosystems are complex due to community interactions. Maximum sustainable theory does not work for fisheries management because it ignores these three factors. (5) We propose a new type of multi-species management strategy called "target switching". If fishers focus their fishing effort on a temporally abundant stock, this policy increases the long term total catch and the minimum stock level. (6) If the cyclic advantage hypothesis is true, overexploitation of chub mackerel also prevents the sardine from recovering. Overexploitation of chub mackerel is an experiment for my hypothesis. I also discuss what happens "indeterminacy" by Peter Yodzis if multi-species models include process errors and environmental fluctuation.

PICES XIII S2-2043 Invited

Evaluating the role of top-down versus bottom-up ecosystem regulation from a modeling perspective

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There has been much discussion on the relative roles of top down (*e.g.*, top predators) vs. bottom up (*e.g.*, climate change and resource limitation) regulation of marine ecosystems. However, resolution of the question remains elusive and thus the importance of the impact of variability of physical forcing versus harvesting pressure on the structure and function of marine ecosystems remains unresolved in many instances. Field-based studies to establish the importance of these two processes are a difficult undertaking given the complexity of even the smallest marine ecosystem. Such studies are even more difficult in continental shelf and open ocean domains where the ecosystems under consideration are not generally isolated. Another approach in determining the extent of these controls is through theoretical or comprehensive simulation models. In this paper, we discuss present-day modeling capabilities which could help identify whether a marine ecosystem is controlled top-down or bottom-up. Modeling approaches are discussed in the context of how they relate to the response of marine ecosystems to global climate change, low frequency changes in patterns of climate variability, or fishing pressure.

PICES XIII S2-1948 Poster

Pelagic predatory fishes as consumers of Pacific salmon: Distribution in the Russian exclusive economic zone and adjacent waters, their abundance and some biological features

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Based on data collected in 35 combined surveys, carried out in the economic zone of Russia and north-western Pacific Ocean between 1984 and 2003, several features of distribution, migrations, and biology of blue shark, prickly shark, salmon shark, lancetfish and daggertooth were analyzed. The data from 1984-1996 indicate that all of these pelagic predators together consumed no more than 25-30% of the total pink salmon abundance in fall. Further, during the anadromous migrations of this salmon species, no more than 20% of the abundance was consumed. Salmon shark and daggertooth were the primary predators on pink salmon. In winter, when the distribution of young pink salmon and lancetfish partially coincide, the abundance of the latter species is usually low. In 1997-2003, abundance of pelagic fishes that prey upon Pacific salmon in the north-western Pacific Ocean and Far Eastern seas of Russia decreased significantly. This could probably serve as one of a multiple of factors causing recovery of most Pacific salmon species from Asian stocks in recent years.

PICES XIII S2-2038 Oral

Bottom-up and top-down controls of walleye pollock on the Eastern Bering Sea shelf

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Control of walleye pollock (*Theragra chalcogramma*) recruitment in the Eastern Bering Sea involves complex interactions between bottom-up and top-down processes, although the mechanisms are poorly understood. We used statistical models and stock assessment data to test some of the leading hypotheses linking recruitment variability to biotic and abiotic factors. Recruitment of pollock was on average stronger if larval and juvenile stages coincided with a mild winter and strong northward surface transport during spring. Although these relationships are consistent with the cold-pool hypothesis (Wyllie-Echeverria 1996) and the larval transport hypothesis (Wespestad *et al.* 2000),

respectively, several lines of evidence led us to reject the proposed top-down mechanisms (related to cannibalism) underlying these hypotheses. We found some statistical support for the oscillating control hypothesis (Hunt *et al.* 2002) in the form of significant interactions between ice conditions (reflecting bottom-up processes), and the abundance of adult pollock (reflecting cannibalism) during the larval and early juvenile stages. We also found that recruitment was significantly enhanced when larval or early juvenile stages experienced an early onset of water column stratification. There was no evidence that the latter effect was related to or modified by the abundance of pollock predators. Models based on an index of cannibalism potential, which reflects the spatial overlap between juvenile and adult pollock, explained a similar proportion (30-50%) of the overall variability in recruitment than models based on the best environmental predictors. Clearly, both bottom-up and top-down effects are important in regulating pollock recruitment, but are difficult to separate.

PICES XIII S2-2106 Oral
Who is regulating zooplankton production (or How to resolve issues of control)?

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Who or what controls marine biological production has been a common question for generations of marine scientists. The marine zooplankton community, which contains secondary, tertiary, and quaternary producers, is often cited as pivotal in the transfer of energy from primary production to higher trophic levels which are harvested and/or conserved by humans. On first inspection, the preponderance of writing and research appears to expound the view of control from below (*e.g.* models by G.A. Riley and J.H. Steele). There is also evidence, however, of control from within the zooplankton community (cannibalism of the young and predation by gelatinous zooplankton) as well as evidence of control by higher trophic levels (planktivorous fishes, mammals, and birds).

We will present a brief history of evidence for control of zooplankton populations: what are the leading arguments, what is the strength of the evidence, are the arguments generally applicable or are they unique to certain systems? We will then focus on control of North Pacific Ocean and Bering Sea zooplankton production. High production by the zooplankton community is often cited as a reason for high standing stocks of living and protected marine resources within those regions.

PICES XIII S2-2068 Oral
Top-down and bottom-up linkages among climate, growth, competition, and production of sockeye salmon populations in Bristol Bay, Alaska, 1955-2000

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Bristol Bay supports one of the largest and most valuable salmon fisheries in the world. Bristol Bay populations more than doubled after the 1976/77 marine climate-shift. Salmon production was unexpectedly reduced during a major El Niño event (1997/98). The biological mechanisms leading to survival at sea are poorly understood. We tested several hypotheses linking climate to salmon growth, interspecific and intraspecific competition, and salmon production by measuring seasonal and annual marine scale growth of sockeye salmon. Increase in sockeye salmon abundance during the late 1970s was associated with greater salmon growth during the first and second years at sea, but not with growth during the third year. The 1976/77 climate-shift led to greater prey production, greater early marine growth and survival of sockeye salmon. We found density-dependent growth was not readily apparent until the last year at sea when reduced growth typically has less affect on survival. The 1997/98 El Niño led to significantly smaller size of adult salmon and lower survival, further supporting the hypothesis that growth at sea is strongly associated with climate. We also discovered evidence of interspecific competition between Asian pink salmon and Alaska sockeye salmon in the North Pacific Ocean. This competition effect, influenced by the unique two-year cycle of pink salmon, led to reduced growth, and a 35% reduction in survival with a loss of 59 million

salmon or $310 million (1997-2000). This finding provides the first clear evidence that interspecific competition at sea can lead to reduced growth and survival of salmon.

PICES XIII S2-2173 Invited
Food webs, fluxes, and flow paths: A fluvial perspective

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Longitudinal (downstream) gradients in productivity, disturbance regimes, and habitat structure exert strong effects on organisms and energy sources to river food webs, but their effects on species interactions are just beginning to be explored. Even less is known about how network structure per se (*e.g*. hierarchical structure, confluence nodes) influences river and riparian food webs and their members. I will discuss research on algal-based food webs in a coastal California river system to illustrate how landscape features and shifts in spatial sources of energy can potentially alter interactions in food webs. In less obviously structured habitats, like the open ocean, discerning features that change regimes in food webs is even more challenging, yet impressive progress is being made. Tracers, increasingly available, can reveal flow paths through space and time of organisms or their elemental or molecular constituents. Concurrently, new mapping technologies based on remote sensing are being used to characterize landscape or seascape features (*e.g.* watershed divides, thermal cells) that contain and constrain these fluxes and the food webs they support. These tools are providing glimpses of spatial and temporal scales linking fluxes and food web interactions in terrestrial, marine, and freshwater habitats, and should greatly advance our understanding of context dependent controls on interaction strengths in webs.

PICES XIII S2-1991 Oral
Possible mechanisms underlying latitudinal abundance changes of Pacific sardine in the California Current system during the last warming regime (1980-1997)

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A recent large-scale long-term analysis of the California Current system (CCS) suggests that climatic regime shifts in the northeast Pacific appear to have forced changing population size associated with major geographical variations in the position of the center of distribution and bulk of the biomass of Pacific sardine. This finding permits explaining the disappearance of the sardine population about 60 years ago at the northern part of the CCS, and also its return after the 1980s. This differs from theories suggesting that environmental regime shifts lead to progressive changes in population growth rates within assumed geo-stationary stocks. To improve the understanding of that large-scale change may require understanding of critical, smaller scale variabilities. The challenge is to determine which of the multiple meso- or small-scale processes is critical, and how to link those pertaining to different temporal scales. We are showing supporting evidence on a meso-scale basis for the last warming period (1980-1997), reinforcing conclusions drawn from that regime scale study. We present a view of seasonal spatial dynamics of Pacific sardine population (with emphasis on the juvenile stages) along the California and Baja California coasts and their interannual variability as a result of environmental changes during 1980 -1997. Sardine relative abundance seems to be related to the ocean front where the California Current (CCal) and the inshore California Countercurrent (CcC) converge alongshore. As a result of the seasonal advection changes, there is a section along the front with favourable feeding conditions for young sardine. Interannual variations in seasonal patterns of sardine distribution and abundance suggest changes in the latitudinal position of the optimal feeding conditions along the front. Recruitment increases where optimal levels are found. Our results suggest a progressive interannual increase of the northward CcC advection after the 1976-1977 regime shift, whereas the CCal southward advection weakened.

PICES XIII S2-1939 Invited
Why do ommastrephid squids increase in abundance during warm regimes?

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Ommastrephid squids are commercially important, however, their annual catches have fluctuated widely, as seen in the decrease in catches of *Todarodes pacificus* and *Illex illecebrosus* in the 1980s, the increase of *T. pacificus* after the late 1980s, and the recent "collapse" of *I. argentinus* fishery. Their recruitment success depends largely on environmental conditions in the spawning and nursery grounds. Ommastrephid squids generally produce gelatinous, nearly neutrally buoyant egg masses that contain large numbers of small eggs. The egg masses are thought to occur within or above the pycnocline at suitable temperatures for egg development (*e.g.* 15-23˚C for *T. pacificus*). The pycnocline region may also provide 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 (18-21˚C) in the Tsushima Current using a ROV (Remotely Operated Vehicle). We also estimated from laboratory studies that hatchlings will ascend to the surface at temperatures between about 18-24˚C. A previous study by our laboratory suggested that the increase in annual catch of *T. pacificus* during the mid-1980s to mid-1990s was attributed to increased recruitment when winds were weak and the air temperature was warm (*i.e.* the strength of winter wind stress determines recruitment). Thus the optimum temperature range for survival of *T. pacificus* hatchlings may be more limited than that of the temperature range for normal egg development in other ommastrephid squids.

PICES XIII S2-2023 Poster
Interannual variability in chum salmon (*Oncorhynchus keta*) growth in relation to environmental change during the 1980s-1990s

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Decadal-scale climate change has been reported in the North Pacific, and interannual variability in age-specific growth of chum salmon was investigated in relation to environmental change during the 1980s-1990s. Returning adult salmon were collected along the eastern coast of Korea during 1984-1998, and scales were obtained. Assuming proportionality between scale and fish length, (*i.e.* distance between scale rings indicates growth of the fish at a given age), the absolute distances between scale annuli were converted to relative distances. Age-specific growth patterns were determined, which in turn represented the growth of salmon in coastal and oceanic areas. In brackish and coastal areas, growth of young salmon (age-0 and age-1) was greater in the mid 1990s than in the early 1980s. In Korean waters, the seawater temperature and zooplankton abundance increased from the late 1980s, which might have provided favorable growth condition for young salmon growth. However, in the open ocean, salmon growth from age-2 to age-5 was higher in the 1980s than in the mid 1990s. Also, zooplankton biomass in the eastern Bering Sea was higher in the 1980s than in the 1990s. The increased size of the salmon populations due to the salmon enhancement programs resulted in density-dependent processes that affected salmon growth (*e.g.* reduction in length at age and an increase in recruitment were evident in 1990s). Therefore, the analysis of the distance between scale rings can be a useful technique in interpreting climate/ocean variability in remote oceanic areas.

PICES XIII S2-2148 Oral

Phase relationships and controls of the upwelling-dominated central California Current ecosystem

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Currently there is great interest in physical and biological controls of marine ecosystem structure and function as it applies to fisheries conservation and ocean management. The purpose of this study is to examine the role of "bottom-up" climate forces in structuring the coastal ecosystem, from phytoplankton to top predators, in the upwelling-dominated central California Current System (~35-38° N, ~122-123°W). To accomplish this task, we compiled time series on basin-scale and local climate (SOI, SST, winds, upwelling, *etc.*), nutrients, macrozooplankton (krill), forage fish (juvenile rockfish, herring, anchovy, sardine), and mid and top level predators (salmon, whales, seals and sea lions, marine birds, and white sharks). We created both biomass/abundance and sub-population level life history/demographic biological indices to examine multi-dimensional responses to climate variables. We used de-trended and whitened cross-correlation analyses, complex EOFs, and wavelet analyses to characterize the frequency and amplitude of ecosystem variation and to investigate time lags in bio-physical relationships. We found substantial and more or less simultaneous variation across multi-trophic levels at the ENSO time scale, and some co-variation at lower frequencies, though differences in time series duration and history of animal populations (*e.g.* recovery from exploitation) limited similarities. For long-lived top predators with deferred maturity, life history/demographic parameters were most closely correlated with relatively short-term environmental indices (*e.g.* SOI, at a lag of 6-8 months, SST at 2-3 months). Time lags between environmental variability and population abundance for some species, (*e.g.*, cormorants) indicated climatic controls of upper trophic level species. This portion of the California Current ecosystem, from roughly Monterey Bay to Bodega Bay, is apparently strongly influenced by "bottom-up" forcing mechanisms that reverberate throughout the pelagic food web to apex predators.

PICES XIII S2-1956 Oral

Differential optimal temperatures for growth of larval anchovy and sardine: A potential mechanism for regime shifts?

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An unresolved mystery of the oceans is the out-of-phase stock oscillations of sardine and anchovy. This phenomenon has been explained by climate change (ocean regime shift), however, the biological processes governing regime shifts are unknown. Why do Japanese anchovy, *Engraulis japonicus,* flourish and Japanese sardine, *Sardinops melanostictus,* collapse during the period of presumably lower food availability? The relationships between recent growth rates and environmental factors (water temperature and food availability) were examined for larval Japanese anchovy in different regions through otolith microstructure analysis. The growth-environment relationship for the Japanese anchovy seemed to differ among regions; however, a definite dome-shaped relationship was detected between growth rates and sea surface temperature (SST) when all regions were combined. Overall, growth rates increased with SST until they reached the peak *ca*. 21°C ("the optimal temperature'). They then declined at higher temperatures. A similar analysis suggested that the optimal growth temperature for larval Japanese sardine was lower than that of larval anchovy. Small variations in growth during early life history stages can lead to large recruitment fluctuations. In the western North Pacific, the warm anchovy regime has shifted to a cool sardine regime and back. Here we propose a hypothesis for biological regime shifts

based on optimal temperatures for larval growth. We believe this hypothesis provides a plausible mechanism for regime shifts of small pelagic fishes.

PICES XIII S2-2000 Oral

Long-term changes in fisheries production of the Japan Sea with emphasis on the impacts of fishing and climate regime shifts during the last three decades

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Japanese fisheries production in the Japan Sea increased to a peak in late 1980s (1.76 million tons), and then decreased abruptly with the collapse of Japanese sardine. During the late 1980s the Japanese sardine contributed 60 percent of the total production in the Japan Sea. Production by other small pelagic species was higher during 1970s and 1990s, but lower in 1980s. Large predatory fishes also had higher production during the 1970s and 1980s indicating a possible oceanic regime shift. Production of both demersal fishes and invertebrates showed sharp declines during 1970s and 1980s suggesting impacts of fishing. Mean Trophic Level (MTL) and Simpson's Diversity Index (DI) showed similar patterns ─ higher in 1970s and 1990s, but considerably lower in late 1980s suggesting that dominant species such as sardine have a large effect on the structure of the fish community in the Japan Sea. There was no evidence of "fishing down food webs" in the Japan Sea, however, in addition to the impacts of abrupt shifts in the oceanic conditions occurred in late 1980s, the large predatory and demersal fishes seem to be facing stronger fishing pressure in spite of the declining trend in fishing effort with the collapse of sardine.

PICES XIII S2-1821 Oral

Bottom-up forcing and the decline of Steller sea lions in Alaska: Assessing the ocean climate hypothesis

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Declines of Steller sea lions (*Eumetopias jubatus*) in the Aleutian Islands and Gulf of Alaska could be a consequence of physical oceanographic changes associated with the 1976-77 climate shift. Changes in ocean climate are hypothesized to have affected the quantity, quality and accessibility of prey, which in turn affected the rates of birth and death of sea lions. Recent studies of the spatial and temporal variations in the ocean climate system of the North Pacific are consistent with this hypothesis. Ocean climate appears to have created different adaptive opportunities for species that are preyed upon by Steller sea lions at mid trophic levels. Climate forcing and the details of the mean and eddy oceanic response can explain both the temporal aspect (populations decreased after the late 1970's) and the spatial aspect of the decline (western, but not eastern, populations decreased). The basin-wide climate differences noted in the North Pacific also correspond with regionally sensitive biogeographic structures in the Aleutians and Gulf of Alaska, which include a transition point from coastal to open-ocean conditions at Samalga Pass westward along the Aleutian Islands. Paleological records spanning 4000 years further indicate that sea lion populations have experienced major shifts in abundance in the past. Shifts in ocean climate are the most parsimonious underlying explanation for the broad suite of changes that have been noted in the North Pacific Ocean.

PICES XIII S2-1802 Oral

Changes of net phytoplankton in Sanggou Bay, Northern China: Evidence for consumer regulation of primary producer

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Sanggou Bay is a semi-enclosed shallow bay in the west coast of the Yellow Sea. The bay has a long history of kelp mariculture. Here we report the significant changes in the phytoplankton community after the culturing of filter-feeding shellfish started, using data from three different years of monthly surveys in the bay. Data were collected in 1983/1984 and 1989/1990, which were years immediately before and immediately after introducing scallop-suspension mariculture. Data were collected in 1999/2000, when polyculture of scallops and oysters approached maximum production levels. At the whole ecosystem level, annual average density of 77-μm-mesh retained microalgae and primary productivity decreased, though not statistically significantly, from the first set of surveys to surveys conducted in 1989/1990 and 1999/2000. Further, bay level annual averages of 77-μm-mesh retained flagellates' density and their percentage occurrence in microalgae were significantly lower during 1989/1990 and 1999/2000. By contrast, bay level annual averages of the inorganic nutrients (nitrogen, phosphorus and silicate) increased and average density of 505-μm-mesh harvested zooplankton decreased during 1989/1990 and 1999/2000. During the same survey periods, kelp production remained unchanged while production of shellfish, which feed on microalgae, increased. At the level of culture units (landings with different culture species), annual average density of microalgal decreased only in shellfish culture units during 1989/1990 and 1999/2000. These data indicate that at the observed resource (nutrients) level the 77-μm-mesh retained primary producer is regulated by its consumer, filter-feeding shellfish.

PICES XIII S2-1929 Oral

Recruitment variation of eastern Bering Sea crabs: Density-dependent, "climate-control", or "top-down" effects?

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During the last three decades, population abundances of eastern Bering Sea crab stocks fluctuated greatly, driven by highly variable recruitment. During recent years, abundances of these stocks have been very low compared to historical high levels. Data from bottom trawl and pot surveys and commercial fisheries were used to derive relative recruitment series and effective spawning biomass for seven stocks of red king *(Paralithodes camtschaticus)*, blue king *(P. platypus)*, Tanner *(Chionoecetes bairdi)*, and snow *(C. opilio)* crabs in the eastern Bering Sea. Recruitment to crab stocks is periodic and strongly autocorrelated. Stock-recruitment relationships are generally weak with an exception of Bristol Bay red king crab; however, periods of strong winter Aleutian Lows also coincide with periods of weak recruitment for Bristol Bay red king crab. Spatial distributions of three broadly distributed crab stocks (eastern Bering Sea snow and Tanner crabs and Bristol Bay red king crab) have changed over time, possibly related to the regime shift in climate and physical oceanography that occurred in 1976-1977 and likely affecting recruitment strengths. Relationships among crabs and groundfish are complex; few statistically significant linear relationships between groundfish and crab abundances or recruitments exist in the eastern Bering Sea. In this study, we discussed the causes of crab recruitment variations and generated hypotheses as potential areas for more comprehensive future research.

S3 BIO Topic Session
Role of gelatinous zooplankton in coastal and oceanic ecosystems

Session Convenors: Richard D. Brodeur (U.S.A.) and Jun Nishikawa (Japan)

Recent increases in gelatinous zooplankton in a number of ecosystems in the North Pacific and elsewhere have demonstrated the importance of these organisms in energy transfer in coastal and oceanic environments. Gelatinous zooplankton exhibit rapid individual and population growth rates and have been shown to be major consumers of phytoplankton, zooplankton and early life stages of fishes. They are competitors with adult fishes and serve as conduits of energy transfer to the deep ocean. Despite their importance to the ecosystem, there are substantial gaps in our knowledge of basic life history, ecology, and environmental responses, even for many of the dominant species. This session will bring together information on such diverse gelatinous taxa as cnidarians, ctenophores, siphonophores, salps, and appendicularians and examine their role in marine ecosystems and their responses to variable environmental conditions.

Wednesday, October 20, 2004 8:30-12:10

08:30-09:00 **William M. Hamner** (Invited)
Gelatinous animals at sea: Convergent evolution and sampling problems (S3-2095)

09:00-09:20 **Jennifer E. Purcell**
Climate effects on jellyfish populations: A review (S3-1899)

09:20-09:40 **Mary Needler Arai**
Predation on pelagic coelenterates (S3-1824)

09:40-10:00 **Cynthia L. Suchman, Elizabeth Daly, Julie E. Keister, William T. Peterson and Richard D. Brodeur**
Predation by the scyphomedusa *Chrysaora fuscescens* in the northern California Current (S3-1865)

10:00-10:30 **Coffee break**

10:30-10:50 **Evgeny A. Pakhomov**
Long-term changes in salp distribution in a polar ecosystem: Some like it hot (S3-1898)

10:50-11:10 **Russell R. Hopcroft and Cheryl Clarke**
Community composition and production of larvaceans in the Northern Bering Sea (S3-1883)

11:10-11:30 **Kiyotaka Hidaka and Kaoru Nakata**
Appendicularians around Kuroshio in winter-spring (S3-1961)

11:30-11:50 **Michael Dagg, H. Liu, R. Sato, J. Armstrong and L. Haldorson**
Trophic roles of larvaceans in the coastal regions of the Gulf of Alaska (S3-1979)

11:50-12:10 **Marsh Youngbluth, Charles Jacoby, Francesc Pages, Franz Uiblein and Per Flood**
A comparison of predatory habits of the physonect siphonophore *Nanomia cara* in coastal basins (Wilkinson and Georges, Gulf of Maine) and deep-water canyons (Oceanographer and Hydrographer) (S3-1930)

Posters

Pei-Kai Hsu, Wen-Tseng Lo and Ming-An Lee
Seasonal distribution of siphonophores in relation to the water masses in the East China Sea, north of Taiwan (S3-1908)

Atsushi Kaneda and Hidetaka Takeoka
Relationship between short-term increases of gelatinous zooplankton and physical environments in the near shore area of Iyo-Nada, Japan (S3-1916)

Young Shil Kang, Hye Eun Lee, Soo Jung Chang and Min Ho Son
Predation pressure of some fishes on *Aurelia aurita* (Scyphozoa: Semaeostomeae) (S3-2129)

Young Shil Kang, Min Ho Son, Soo Jung Chang and Hye Eun Lee
New finding on young *Nemopilema nomurai* (Scyphozoa: Rhizostomeae) in the western coastal area of Korea (S3-2127)

Takeshi Kohama, Shinya Nagano, Noboru Okuda, Hitoshi Miyasaka and Hidetaka Takeoka
Estimation of ecological role and trophic level of jellyfish *Aurelia aurita* using stable isotope ratios in the Uwa Sea, Japan (S3-1921)

Shinya Magome, Tomohiro Yamashita, Takeshi Kohama and Hidetaka Takeoka
A study on jellyfish patch formation using aerial photography (S3-1923)

Shwu-Feng Yu, Wen-Tseng Lo, Wei-Cheng Su and Don-Chung Liu
Winter distribution of siphonophores (Cnidaria) in the waters surrounding Taiwan (S3-1909)

Evgeniy N. Ilynskiy and Alexander V. Zavolokin
Abundance and distribution of jellyfishes in epipelagical of the Okhotsk Sea (S3-1838)

PICES XIII S3-1824 Oral
Predation on pelagic coelenterates

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Coelenterates (cnidaria and ctenophores) are well recognized as predators in food webs of marine ecosystems but are less often considered as prey. This is partly because they are digested very rapidly. In studies based on predator stomach contents the measured masses of different organisms are rarely scaled by their relative rates of digestion. Predators that are frozen and thawed, or for which whole stomachs are placed in preservatives, may have already lost much of their coelenterate content when they are examined. There is also a tendency to assume that gelatinous organisms, with their high water and salt content relative to organic content, are poor food. However, given the high rates of digestion (and presumably of assimilation) coelenterates may provide sources of energy comparable to better recognized prey such as arthropods. It is already becoming well documented that a number of cnidaria and ctenophores as well as fish utilize gelatinous organisms as prey. Data is more slowly accumulating on predation by a wide range of other carnivores such as annelids, chaetognaths, molluscs, arthropods, reptiles and birds.

PICES XIII S3-1979 Oral
Trophic roles of larvaceans in the coastal regions of the Gulf of Alaska

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During July/August 2003, larvaceans and juvenile salmon were collected from different vessels but from similar locations along the GLOBEC-Seward line in coastal shelf waters of the Gulf of Alaska. Concentration of all larvacean species was 95 - 1328 individuals m^{-3} and was highest above the thermocline, between 24-0 m and 10-0 m depending on location. The feeding rate of the most abundant species in the inner shelf, *Oikopleura dioica*, was measured on shipboard. Clearance rate averaged 308 ml $individual^{-1}$ d^{-1} (sd = 283) and the *O. dioica* population cleared up to 7.7% of the water column d^{-1}. Measurements were combined with additional laboratory data on *O. dioica* and other species to calculate the grazing impact of the total larvacean community on phytoplankton. Larvaceans consumed much more phytoplankton than the entire crustacean community. Juvenile pink salmon, *Oncorhynchus gorbuscha*, are abundant on the inner shelf during July-October. Preliminary analysis of stomach contents of juvenile salmon collected in July/August 2003 indicated larvaceans were important prey items at many stations. In July, they comprised 95% (by volume) of the stomach content of pink salmon at one inner shelf station but < 1% at another. In August, values at three inner shelf stations were 22%, 8% and 35% but < 1% at three stations farther offshore. Larvaceans in coastal Gulf of Alaska are a direct and efficient trophic link between small phytoplankton and juvenile pink salmon.

PICES XIII S3-2095 Invited
Gelatinous animals at sea: Convergent evolution and sampling problems

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There is no cover in the open ocean, no place to hide from visual predators during the day. In epipelagic communities, convergent evolution has selected for a limited number of anti-predatory adaptations for survivorship, with surprisingly similar strategies dominating guilds of remarkably dissimilar taxa. Animals in the open sea are 1) large, fast nekton, 2) schooling fish, squid and krill, 3) transparent, gelatinous invertebrates, 4) neuston, 5) small mesozooplankton below visual resolution, 6) micronekton and/or vertical diurnal migrators, 7) protists and members of microbial loops, and/or 8) cheaters. When apex predators in pelagic food webs are eliminated or reduced in number by over-fishing or environmental change, carnivores from other predatory guilds compensate with increased

population sizes. Populations of gelatinous predators have increased in some pelagic ecosystems and one suspects that micronekton have increased in others. Neither of these guilds have been well investigated, partly because fisheries biologists do not sample appropriately for species in these assemblages. Evaluating the biology of many of these species may require use of non-traditional sampling techniques, such as *in situ* direct observation by divers or remote vehicles, traps, species-specific acoustics and tracking of individual animals. Selected aspects of the history of pelagic ecosystems are reviewed, and examples of how gelatinous animals can impact fisheries food chains in unsuspected ways are presented.

PICES XIII S3-1961 Oral
Appendicularians around Kuroshio in winter-spring

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Appendicularians are one of dominant mesozooplankton groups in the planktonic food web around Kuroshio, which supports growth of larva/juveniles of many pelagic fishes. To evaluate their importance, we have examined samples collected from upper 150 m of the region in winter-spring during the main spawning period of pelagic fish. Samples were collected by vertical hawls of a conical plankton net, specimens were identified to species and body sizes were measured. The appendicularian biomass was about 10% of copepod biomass, but their production amounts to 30% or more, since their biological productivity is much higher than copepods. Appendicularians are famous for their "house", a mucous bag generally with duplex filters to collect food particles of appropriate size. The appendicularian community around Kuroshio was strongly dominated by *Oikopleura longicauda*. The "house" of *O. longicauda* is equipped with only one filter and has ability to collect large particles like diatoms and thus can utilize the diatom bloom in winter-spring. The body and "house" of appendicularians have appeared in the gut contents of larvae of sardine and anchovy, which verifies the existence of trophic mediation by appendicularians from primary producers to pelagic fish in Kuroshio region.

PICES XIII S3-1883 Oral
Community composition and production of larvaceans in the Northern Bering Sea

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The larvacean community from north of St. Lawrence Island through Bering Strait was surveyed during early July 2002. The community was composed of *Oikopleura vanhoeffeni*, *O. labradoriensis*, and *Fritillaria borealis*, with relative related to water mass origin. Biomass was typically ~10% that of the copepod community. Populations were reproductively mature: Fecundity by *O. vanhoeffeni* ranged from 1700-4900 eggs per females, with egg hatching time of several days. House production ranged from 3-5 houses per day. Preliminary growth rates for just hatched individuals were successfully determined by the artificial cohort method for *Oikopleura* spp. and *F. borealis*: they ranged from 25-50% increases in body weight per day. These numbers suggest they have the ability to both outgrow and out-reproduce copepod populations, explaining their ability to bloom under favourable conditions.

PICES XIII S3-1908 Poster

Seasonal distribution of siphonophores in relation to water masses in the East China Sea, north of Taiwan

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The species composition and seasonal distribution of siphonophores associated with water masses in the East China Sea, north of Taiwan, were studied during four seasonal cruises from April 1996 to February 1997. A total of 47 zooplankton samples were taken along a transect from 26.5°N, 120.5° E to 25.0°N, 123.0° E across the East China Sea. In all, 47 species belonging to eight families and 22 genera were identified. The mean numerical abundance of siphonophores was 285 ± 257 ind./100m^3. *Muggiaea atlantica*, *Lensia subtiloides*, *Chelophyes appendiculata*, *Bassia bassensis* and *Diphyes chamissonis*, were the five most dominant species and together they comprised 77% of the total count of siphonophores. The abundance and number of species of siphonophores showed apparent seasonal changes, with higher abundances but fewer species in spring compared to the summer. Siphonophore assemblages exhibited clear spatial and seasonal succession: *Muggiaea atlantica* dominated most sampling sites during winter and spring seasons, *Bassia bassensis* were common in summer and in the Kuroshio Current, while *Lensia subtiloides* was abundant in autumn and in both the Taiwan Strait Warm Water and Kuroshio Current. From the results of MDS analysis, two seasonal groups were distinguished: summer-autumn and winter-spring.

PICES XIII S3-1916 Poster

Relationships between short-term increases of gelatinous zooplankton and physical environments in the near shore area of Iyo-Nada, Japan

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In several recent studies, the occurrences of dense aggregation of the scyphomedusa, *Aurelia aurita*, have been frequently reported in the coastal area of the Seto Inland Sea, Japan. However, physical factors that cause the aggregation of gelatinous zooplankton have not been resolved sufficiently in the area. Hence, based on results of data analyses, we discuss the mechanisms leading to aggregations of gelatinous zooplankton near shore region of Iyo-Nada located in the western part of the Seto Inland Sea. In this study, jellyfish data, which were sampled at a power plant located at the shore of the Iyo-Nada, were analyzed. In the power plant, large volumes of seawater are pumped as cooling-water for a turbine. Jellyfish existing within the seawater are carried into the water gate of the power plant and the daily amount of jellyfish (mainly *Aurelia aurita*) caught at the water gate has been recorded since 1998. Time series data of the gelatinous zooplankton showed that jellyfish near the shore repeatedly showed a sudden increase and was classified mainly into the following three cases. One is the periodic increase during the spring tidal period. We deduced that the size of a tide-induced topographic eddy which develops nearshore relates to the periodic increase. The second is the rapid increase caused by strengthening of the shoreward wind by a typhoon. The third is based on a change of direction of a monsoon. The overall quantity of jellyfish increased with the occurrence of the northwestern wind (shoreward wind) in autumn.

PICES XIII S3-2127 Poster

New findings on young *Nemopilema nomurai* (Scyphozoa: Rhizostomeae) in the western coastal area of Korea

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Young *Nemopilema nomurai* (1.5 ~ 4 cm bell size) were first found on 29 May 2004 at Gunsan located in the western coastal area of Korea. Their umbrellas were slightly reddish- brown in color. The complex branches on the mouth arm were a deep reddish brown. There were several reddish spots and eight rhopalia on the umbrella edge. A sensory pit was located on exumbrella just above each rhopalium. The radial canals consisted of 8 rhopalar and 8 inter-rhopalar canals. The mouth-arms were divided into eight arms with two wings. The young *N. nomurai* had no long whip-shaped terminal appendages. As compared to adults, there are differences in number of wings of mouth-arm and the lack of a long whip-shaped terminal appendages. Adults had three wings and long whip-shaped terminal appendages.

PICES XIII S3-2129 Poster

Predation pressure by some fishes on *Aurelia aurita* (Scyphozoa; Semaeostomeae)

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An experiment in predation pressure of two species of fishes, *Navodon modestus* (black scraper, Tetraodontiforms; Monacanthidae) and *Stephanolepis cirrhifer* (thread-sail filefish, Tetraodontiforms; Monacanthidae), on *Aurelia aurita* was carried out to determine whether there are species-specific differences in feeding on jellyfish and how much jellyfish are consumed if they are eaten. One individual fish was kept in a small aquarium (volume = 34 L) with *A. aurita* for one day. This experiment was performed three times. The weight of *A. aurita* was estimated before and after each experiment. The weights of *N. modestus* and *S. cirrhifer* were 80~120 g and 60 g, respectively. *S. cirrhifer* ate 40~160 g of *A. aurita* per day, whereas *N. modestus* did not eat any. There was no difference in feeding rate relative to the weight of *S. cirrhifer*. The habitat of *S. cirrhifer* is in the coastal area, while *N. modestus* inhabits the offshore area. Considering these habitat differences, it is possible that *S. cirrhifer* overlaps more with and thus is more familiar with eating *A. aurita* than *N. modestus*.

PICES XIII S3-1921 Poster

Estimation of ecological role and trophic level of jellyfish *Aurelia aurita* using stable isotope ratios in the Uwa Sea, Japan

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In recent years, there has been a spate of publications noting unprecedented explosions of jellyfish populations which have been increasing in frequency and expanding in geographic coverage. Some publications have also reported that these jellyfish cause direct damage to fish populations. The Uwa Sea located at the east coast of the Bungo Channel in the southern part of Japan, is well known as an important fishery ground. The moon jellyfish, *Aurelia aurita*, is one of the most common scyphomedusae in the world's coastal waters and frequently forms large blooms in this area. This megagelatinous carnivorous zooplankton has recently received a great deal of interest from the scientific community since it may play a significant role in the food chain dynamics in the pelagic marine ecosystem. In this study, we attempt to estimate its ecological role and trophic level in the marine ecosystem using

stable-isotope ratios of carbon and nitrogen, which reflect the material flow through the food web. We found that the trophic level of *Aurelia aurita* was lower than or equal to copepods or fish larvae, which have been previously shown to be a main food of jellyfish. It should be expected that *Aurelia aurita* is not strong grazer but instead is a strong competitor of copepods or fish larvae. The main food of *Aurelia aurita* might be lower trophic level and smaller size plankton such as mesozooplankton.

PICES XIII S3-1923 Poster
A study on jellyfish patch formation using aerial photography

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Populations of jellyfish are increasing globally in recent years. Jellyfish blooms have a large impact on marine ecosystems. They form aggregations called patches which are often associated with negative effects such as lost of fish freshness in set nets or blockage of cooling water intakes in power plants. Two dominant factors are hypothesized for the patch formation: Reproductive strategy or avoidance of predation (active cause) and convergence of water (passive cause). In this study, we took aerial photographs of floats and jellyfish patches on the sea surface from various angles for about an hour. The distribution of horizontal divergence at the sea surface is calculated from the time rate-of-change of areas of triangles composed of floats. Consequently, the patchiness of jellyfish was highest in the region of convergence (minus divergence). This result suggests that passive aggregation is the dominant factor of the patch formation in the horizontal direction.

PICES XIII S3-1898 Oral
Long-term changes in salp distribution in a polar ecosystem: Some like it hot

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The pelagic tunicate *Salpa thompsoni* is one of the most important large filter feeders of the Southern Ocean channelling biogenic carbon from surface waters into the ocean's interior and seafloor. *S. thompsoni* has the ability to undergo an explosive population development outcompeting other zooplankton species and dramatically altering the Antarctic pelagic food web economy. This tunicate is well adapted to oceanic, low Antarctic (45-60°S) latitudes and generally not found in coastal seas surrounding the continent. Recently, it has been hypothesized that the salp distribution might have changed over the past half a century by shifting southward. Since *S. thompsoni* is a cold-temperate species, the above may indicate a large-scale environmental shift in Antarctic regions. The salp expansion to the areas previously considered as the Antarctic krill domain may, however, be damaging to their populations. There is evidence indicating that salps might experience deformations in their reproduction at high latitudes. Furthermore, elevated particle concentrations, which are relatively normal at the marginal ice zone, may lead salp populations to collapse. In the light of possible climate change, it is critical to understand patterns in salp life cycle changes in the Southern Ocean if modellers want to better understand their contribution to the high Antarctic biological pump. This presentation will discuss latitudinal distribution patterns in *S. thompsoni* biological and some demographic parameters in the Southern Ocean based on historical and most recent data sets spanning between 1989 and 2004.

PICES XIII S3-1899 Oral
Climate effects on jellyfish populations: A review

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Jellyfish often occur in large numbers worldwide and are important predators of zooplankton and ichthyoplankton. Jellyfish populations are known for great inter-annual variations in abundance, but the causes of "blooms" are generally unknown. Long-term records have shown that increases in jellyfish populations are correlated with environmental indices and warm ocean conditions. I review correlative and experimental data on climate factors that may increase jellyfish populations: Ctenophore *Mnemiopsis leidyi* (Narragansett Bay, warm temperature), hydromedusa *Moerisia lyonsi* (Chesapeake Bay, warm temperature, mid-salinity), and scyphomedusae *Pelagia noctiluca* (Mediterranean Sea, warm temperature, low rainfall, high atmospheric pressure), *Chrysaora quinquecirrha* (Chesapeake Bay, mid-salinity, warm temperature, negative North Atlantic Oscillation Index (NAOI)), *C. melanaster* (Bering Sea, warm stable water column), *Cyanea lamarkii* and *Aurelia aurita* (North Sea, negative NAOI), and *A. labiata* (NE Pacific, warm temperature, mid-salinity). Temperature and salinity both are significant; they may act directly on the physiology of the jellyfish and on feeding success, and indirectly on prey availability. In warming ocean conditions, jellyfish could increase in numbers, have longer seasons, and change geographic distributions. Jellyfish populations also may be enhanced by other human-induced changes in marine ecosystems, such as eutrophication, over-fishing, species introductions, and augmentation of substrates, such as marinas, for the benthic stages. Large jellyfish populations are generally considered detrimental to fish populations through competition for zooplankton prey, predation on fish eggs and larvae. Abundant jellyfish also clog fishing gear, disrupt power plant operations, and reduce tourism. Therefore, increases in jellyfish populations probably are undesirable for human interests.

PICES XIII S3-1865 Oral
Predation by the Scyphomedusa *Chrysaora fuscescens* in the northern California Current

Cynthia L. **Suchman**[1], Elizabeth Daly[2], Julie E. Keister[2], William T. Peterson[3] and Richard D. Brodeur[3]

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The scyphomedusa *Chrysaora fuscescens* is abundant inshore of the upwelling front off the coasts of Oregon and Washington (USA) each summer and fall, yet no quantitative data have yet been published on their trophic impact. Our goal was to assess predation by *C. fuscescens* on co-occurring zooplankton in the northern California Current. During August 2002, we quantified medusae and mesozooplankton in shelf and slope waters from central Oregon to northern California. During summer 2002 and 2003, medusae were dip-netted from surface waters or collected by divers at 8 locations off the central Oregon coast for gut evacuation experiments or analysis of gastric contents; concurrently, we estimated zooplankton availability using vertical hauls of a 0.5-m, 202 μm-mesh net. In 2002, early stages of euphausiids dominated the diet, with medusae exhibiting exceptionally strong selection for euphausiid eggs. In 2003, when early-stage euphausiids were less abundant, copepods and bivalve larvae comprised the largest proportion of medusan diet. During both years, relatively rare yet large or non-evasive prey such as fish eggs, larvaceans, ctenophores, polychaete larvae, and cladocerans were also ingested. Although *C. fuscescens* do ingest copepods, predation impact on these populations was minimal. However, *Chrysaora fuscescens* could cause significant mortality to early-life stages of euphausiids during years of high ecosystem productivity. Along with physical factors such as climatic regime, strength of summer upwelling, and onshore retention, we suggest that predation may play a role in mediating euphausiid population dynamics in nearshore regions of the northern California Current.

PICES XIII S3-1930 Oral

A comparison of predatory habits of the physonect siphonophore *Nanomia cara* in coastal basins (Wilkinson and Georges, Gulf of Maine) and deep-water canyons (Oceanographer and Hydrographer)

Marsh **Youngbluth**[1], Charles Jacoby[2], Francesc Pages[3], Franz Uiblein[4] and Per Flood[5]

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Regulation of prey populations results from the interplay of biological and physical processes that operate on various spatial and temporal scales. Unfortunately, reliable assessments of the distribution, abundance, and trophic transfer by midwater gelatinous predators are sparse, primarily because these fauna are extremely fragile. As a first step toward quantifying the role of predation by a prominent physonect siphonophore, *Nanomia cara*, we conducted *in situ* investigations (=observations, transects and collections) to depths of 1000 m with a JSL submersible and performed digestion and respiration experiments on freshly collected colonies within controlled (=temperature and light) environments of shipboard laboratories. Results from September periods (2001-2004) provided a strong foundation for predicting predator-prey dynamics. Two populations of *Nanomia* exist in Northwest Atlantic coastal waters, judging from differences in morphology, behavior and diet. Colonies in the basins (ca. 300 m depth) were smaller (mean =25 gastrozooids per colony), had simpler nematocyst batteries, performed extensive diel vertical (220 to 20 m) migrations, and fed (mean=20% gastrozooids with prey) exclusively on the copepod, *Calanus finmarchicus* (stage IV-V), at night. *Nanomia* (mean=35 gastrozooids per colony) from canyon habitats (1000 m depth) along the southern margin of Georges Bank resided in deeper water (500-600 m), migrated upward less frequently (50-200 m) each night, and fed (mean=28% gastrozooids with prey) day and night on *C. finmarchicus* most often (70%) but also consumed krill, *Meganyctiphanes novegica,* (25%) and myctophid and gonostomatid fishes (5%). Digestion varied (3-4.5 h) with the size of the prey. Respiration rates averaged 3.1 µl O_2/mgC/h.

PICES XIII S3-1909 Poster

Winter distribution of siphonophores (Cnidaria) in the waters surrounding Taiwan

Shwu-Feng **Yu**[1], Wen-Tseng Lo[1], Wei-Cheng Su[2] and Don-Chung Liu[2]

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This study is a part of the TaiCOFI program conducted by the Taiwan Fisheries Research Institute. TaiCOFI is a newly established log-term and large-scale survey of the hydrography and plankton at 60 stations in the waters surrounding Taiwan to study and evaluate the relationship between the distribution of plankton (particularly ichthyoplankton) and water masses. This study presents preliminary results of siphonophores collected from the FRI cruise during 13-22 February 2003. Zooplankton samples were taken with an ORI plankton net (160 cm mouth opening with 333µm mesh), hauled obliquely from 200 m (or 10 m above the bottom at shallower stations) to the surface at 28 stations. In total, 64 species belonging to 28 genera and 8 families of siphonophores were identified, with the mean abundance of 478.9 ± 858.5 ind./100 m^3. The number of species of Calycophorae (48) was greater than that of Physonectae (16). *Muggiaea atlantica* was the most abundant species (28% of the total catch). Other common species included *Chelophyes appendiculata* (11%), *Lensia subtiloides* (8%), *Chelophyes contorta* (7%), and *Diphyes chamissonis* (7%). Siphonophores showed higher abundance in the waters of northwestern Taiwan than off eastern Taiwan, while the species diversity was higher in the waters of southern Taiwan than off northern Taiwan. Different dominant siphonophores showed different distribution patterns and were associated with different water masses.

PICES XIII S3-1838 Poster

Abundance and distribution of jellyfishes in epipelagical of the Okhotsk Sea

Evgeniy N. Ilynskiy and Alexander V. **Zavolokin**

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We analyzed the distribution, number and biomass of jellyfish based on data from five trawl surveys of the epipelagic zone of the Okhotsk Sea carried out in fall of 1998 – 2003. Scyphozoa dominated the jellyfish biomass (73 – 99% of the total). In this period the biomass varied dramatically among the different years from 0.7 to 3.0 mmt in the northern part of the Okhotsk Sea, and from 212 to 1912 kg per square km in the southern part. Biomass trends of different species of jellyfishes showed different patterns. In 1998 – 2003, two species, *Cyanea capillata* and *Chrysaora melanaster*, alternated as the dominant species by biomass. The size distribution of scyphomedusae also strongly differed interannually. Apparently, the growth and death rate of jellyfishes in the Okhotsk Sea showed considerable annual variations and the predation intensity of jellyfishes on zooplankton varied greatly. While large catches of medusae occurred in all areas of the sea, there are annual distinctions in distribution of jellyfishes, especially in the northern part of the Okhotsk Sea. There were also some constant features of the distribution of species. For example, large catches of *C. capillata* occur in shelf or nearby waters of a shelf, whereas *C. melanaster* is abundant in the central part and near western Kamchatka.

S4 FIS/BIO Topic Session
Hot spots and their use by migratory species and top predators in the North Pacific

Session Convenors: Churchill B. Grimes (U.S.A.), Yukimasa Ishida (Japan), Hidehiro Kato (Japan) and William J. Sydeman (U.S.A.)

There are specific areas, "hot spots" of biological activity, where migratory species, including especially marine mammals, sea birds, sharks and tunas, are abundant in the North Pacific Ocean. Some probably persist through time due to the influence of topographical features (*e.g*., seamounts) on biological productivity. Some persist due to relative stability of oceanographic features such as currents and eddies, and some may be more ephemeral, changing in time or location owing to variability in wind patterns. However, little is known about the dynamics of these potentially important hot spots as habitats that may support increased biodiversity or as regions that support fisheries. This session seeks to identify and compare the physical and biological features of "hot spots" where migratory species and top-predators tend to concentrate among the western and eastern North Pacific Ocean. It also requests reports of studies that analyze topographic control, oceanographic mechanisms, the ecology of plankton, nekton and pelagic fishes in these hot spots, and methods to determine the degree of association of organisms within the communities inhabiting hot spots. Motivating questions include: How persistent are these sites in time and space? What oceanographic mechanisms support high levels of biological activity? How do predators associate with and functionally respond to oceanographic and community structure and variability? And what is the role of these hot spots in reproduction, growth and survival and life history strategies of migratory top predators?

Tuesday, October 19, 2004 8:30-17:30

Introduction by Session Convenors

08:30-09:00 **Franklin B. Schwing, Steven J. Bograd, Cara Wilson, Petra M. Stegmann, Barbara Block and Daniel Costa** (Invited)
An oceanographic basis for identifying biological hot spots (S4-2097)

09:00-09:20 **Cara Wilson**
Chlorophyll hot spots in the oligotrophic North Pacific Subtropical Gyre (S4-2073)

09:20-09:40 **Sukyung Kang, Suam Kim, Kevin Telmer, David Welch and Youn-Ho Lee** (Invited)
Configuration of migratory history based on analyses of stable isotopes and trace elements in otolith of the North Pacific chum salmon (S4-2011)

09:40-10:00 **Robert Suryan, David Hyrenbach, Fumio Sato, Kiyoaki Ozaki, Gregory Balogh, Paul Sievert, Daniel Roby and David Anderson**
Foraging destinations of short-tailed albatrosses (*Phoebastria albatrus*) in the Northwest Pacific Ocean, Gulf of Alaska, and Bering Sea (S4-2058)

10:00-10:20 **Coffee break**

10:20-10:40 **Peter Etnoyer, D. Canny, B. Mate and L. Morgan** (Invited)
Persistent pelagic habitat in the Northeast Pacific (S4-2168)

10:40-11:00 **Daniel Costa, Barbara Block, Steven J. Bograd, Randy Kochevar and TOPP Science Team** (Invited)
Tagging of Pacific Pelagics (TOPP): Using electronic tags to discover hot spots in the pelagic realm (S4-2020)

11:00-11:20 **Rogelio Gonzalez-Armas, A. Muhlia-Melo, A. Trasviña-Castro, G. Gutierrez De Velasco, A. Valle-Levinson and R. Funes-Rodriguez**
Differences in large pelagic fish larvae and zooplankton volumes over and around a seamount in the Gulf of California (S4-1942)

11:20-11:40 **Anatoliy Ya. Velikanov**
Seasonal frequency of pelagic fish species in some micro-regions of the southwestern Okhotsk Sea (S4-1787)

11:40-12:00 **Shingo Kimura and Katsumi Tsukamoto**
Landmark for the spawning of Japanese eel (S4-1951)

12:00-13:00 **Lunch**

13:00-13:20 **Youn-Ho Lee, Geoyoung Kang, Woongsic Jung, Ki-Baek Seong, Suam Kim and Gisic Min** (Invited)
How to discriminate the aggregated stocks of migratory species according to their origins: A simple and quick PCR method utilizing stock-specific single nucleotide polymorphisms (S4-1913)

13:20-13:40 **Brian K. Wells, Churchill B. Grimes and Jim Waldvogel**
The effects of ENSO events on California chinook salmon (*Oncorhynchus tshawytscha*) as revealed by scale increment analysis (S4-2071)

13:40-14:00 **Hiroshi Ohizumi and Hikaru Watanabe** (Invited)
Stomach contents of toothed whales in relation to prey distribution in the North Pacific (S4-1977)

14:00-14:20 **Scott M. Gende and Mike Sigler**
Persistence of prey "hot spots" in southeast Alaska (S4-1793)

14:20-14:40 **Ivonne Ortiz and Kerim Y. Aydin**
Hot spots for dining - A groundfish's view (S4-2143)

14:40-15:00 **K. David Hyrenbach, William J. Sydeman, Ken H. Morgan and Peggy P.W. Yen**
Upper-trophic predator hot spots in the California Current system: A retrospective analysis of marine bird and mammal communities (S4-1885)

15:00-15:20 **Coffee break**

15:20-15:40 **Robert S. Schick and Molly Lutcavage**
Using GIS to locate pelagic hot spots for bluefin tuna (S4-1989)

15:40-16:00 **Takashi Kitagawa, Andre Boustany, Chris Perle, Charles Farwell, Tom Williams, Heidi Dewar and Barbara Block**
Horizontal and vertical movements of juvenile bluefin tuna (*Thunnus orientalis*) in relation to seasons and oceanography in the eastern Pacific (S4-2105)

16:00-16:20 **Douglas C. Reese and Richard D. Brodeur**
Identifying biological hot spots within the northern California Current (S4-2046)

16:20-16:40 **Mukti Zainuddin, Katsuya Saitoh and Sei-ichi Saitoh**
Detection of high productive area of albacore fishing ground and migration route using multi-sensor satellite remote sensing (S4-1940)

16:40-17:00 **Yoshihiro Fujise, Koji Matsuoka, Hiroto Murase, Shigetoshi Nishiwaki and Hidehiro Kato**
Existence of hot spots of large sized baleen whale concentration in pelagic zone of the western North Pacific; its biological and oceanographical features (S4-1983)

17:00-17:20 **Vincent F. Gallucci and Gordon H. Kruse** (Invited)
Recent advances in knowledge of cold water sharks in the North Pacific Ocean (S4-2034)

17:20-17:30 **Synthesis by Session Convenors**

Posters

Sachihiko K. Itoh and Shingo Kimura
Transport and migration of larval and juvenile fishes through oceanic fronts (S4-1947)

Patrick D. O'Hara, Peggy P. Yen, Chris Rintoul, Ken H. Morgan, K. David Hyrenbach and William J. Sydeman
Pelagic habitat hot spots as revealed by replicate seabird surveys in the NE Pacific (S4-2115)

John E. Richert, Salvador J. Jorgensen, Arturo Muhlia Melo and A. Peter Klimley
Seamounts as hot spots of pelagic fish diversity in the Eastern Pacific Ocean (S4-1897)

Victor R. Foux and Eugene V. Samko
Transport of fodder plankton in low-frequency waves and eddies: Favorable conditions for fishing grounds formation (S4-1815)

Robert Suryan, David Anderson, Daniel Roby, David Hyrenbach, Scott Shaffer, Yann Tremblay, Jill Awkerman, Mark Westbrock, Karen Fischer, Fumio Sato and Kiyoaki Ozaki
Wing loading and prevailing winds: Their relative importance to the at-sea distribution of four species of Pacific albatrosses (S4-2060)

Galina A. Vlasova
Zone of "hot spots" of the surface temperature for the NW Pacific (S4-1797)

Doug Yelland
Backscatter variability within a Haida Eddy (S4-2206)

PICES XIII S4-2020 Invited
Tagging of Pacific Pelagics: Using electronic tags to discover hot spots in the pelagic realm

Daniel P. **Costa**[1], B.H. Block, Steven J. Bograd[2], R. Kochevar and the TOPP Science Team

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In an effort to understand and locate biological hot spots in the North Pacific Ocean, the Tagging of Pacific Pelagics (TOPP) program is using biologging technology to simultaneously map the location of marine vertebrates including sharks, tuna, albatrosses, seals and whales. Hot spots are regions of high biological activity where linkages occur between physical forcing, primary production, secondary consumers and top pelagic predators. Although it is generally accepted that these hot spots occur and are important, surprisingly little is known about these congregating spots for marine organisms in the open ocean. Our lack of understanding of the aggregating forces in the pelagic ocean ecosystem stems largely from limitations of available technology. Prior studies have focused on single species tracking and few have attempted to examine interactions among top pelagic species. TOPP is coupling electronic tagging data with satellite remote sensing technologies to simultaneously map the movements of diverse pelagic species and link their movements to oceanographic processes. To date we have tagged and tracked mako, salmon and white sharks, elephant seals, bluefin and yellowfin tuna, black-footed and Laysan albatross, California sea lions and leatherback sea turtles. Preliminary analysis indicates that frontal features associated with the North Pacific Transition zone and the California Current comprise a region of common habitat utilization for many of these species.

PICES XIII S4-2168 Invited
Persistent pelagic habitat in the Northeast Pacific

Peter **Etnoyer**[1], D. Canny[2], B. Mate[3] and L. Morgan[4]

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We present analytical methods that define pelagic habitat in the Northeast Pacific based upon the density of steep temperature gradients, or fronts, and we quantify their spatial and temporal persistence over a single ENSO cycle (1996-1999) to benefit marine conservation and marine management strategies. We find less that than <1% of the Northeast Pacific ocean exhibits a persistent (> 8 mo/yr) concentration of temperature fronts (>.2 km/km^2) within and between years. The Baja California Frontal System (BCFS) is the largest concentration within federal waters, between 20 km and 300 km east of Baja California Sur. The BCFS appears more active under La Nina conditions, while the next largest persistent concentration, the high-seas North Pacific Transition Zone, appears more active under El Nino conditions. We demonstrate habitat functions associated with the BCFS for Blue Whales (*Balaenoptera musculus*), Swordfish (*Xiphias Gladius*), and Striped Marlin (*Tetrapturus audax*). Distinct residential periods were identified in telemetry data, punctuated by intermittent direct transits. In the Channel Islands, the Blue whales are foraging on krill, but off Baja they feast upon large concentrations of pelagic tuna crabs, *Pleuroncodes planipes*, known to occur within BCFS waters. Concentrations of density fronts aggregate prey, reducing foraging effort for a broad assemblage of species. We recommend more research, management, and protection for this pelagic "hot spot" off Baja California Sur.

PICES XIII S4-1983 Oral

Existence of hot spots of large sized baleen whale concentration in pelagic zone of the western North Pacific; its biological and oceanographical features

Yoshihiro **Fujise**[1], Koji Matsuoka[1], Hiroto Murase[1], Shigetoshi Nishiwaki[1] and Hidehiro Kato[2]

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Large-scale ecosystem studies on baleen whales and sperm whales have been conducted under the scientific permit since 1994 in pelagic zone of the western North Pacific. Based on cruises, we found a "hot spot" in occurrence for large baleen whales, such as blue whale (*Balenoptera musclus*), fin whales (*B. physalus*), sei whales (*B. borealis*) and sometime right whales (*Eubalaena glacialis*) at around 44ºN-46ºN, 157ºE-160ºE. The area is well known as a traditional whaling ground. The present study investigates biological and oceanographic features for this "hot spot". A number of characteristic features were found.

PICES XIII S4-2034 Invited

Recent advances in knowledge of cold water sharks in the North Pacific Ocean

Vincent F. **Gallucci**[1] and Gordon H. Kruse[2]

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The endemic North Pacific shark species include: sleeper shark (*Somniosus pacificus*), salmon shark (*Lamna ditropis*), sixgill shark (*Hexanchus griseus*), and the dogfish shark (*Squalus acanthias*). This paper focuses on these sharks which occur from Washington State to the Arctic Ocean and are known to occur in the western part of the North Pacific Ocean. The sixgill shark has made a new appearance in Puget Sound and vicinity, Washington. Ecological hypotheses include that Puget Sound is a nursery ground. Primarily a deep benthic feeder, it comes near to, and below, the surface at night to feed. They appear to be rather localized and do not travel great distances. The sleeper shark is found more northerly than the sixgill shark but seems to occupy the same niche. The salmon shark carries out long-distance movements from Alaska to California (the oceanic transition zone), likely associated with reproduction. Capable of diving to great depths, it also actively feeds virtually at the surface. The species is endothermic, thus increasing the efficiency of muscular action. Movement was quantified via satellite pop-off tags. These three sharks are over two meters long at maturity. In contrast, the spiny dogfish is about a meter at maturity and is actively harvested. It occupies pelagic and benthic ecosystems. It is known to make long east-west and north-south migrations over the Pacific, but this feature does not appear to be a part of the normal life cycle.

PICES XIII S4-1793 Oral

Persistence of prey "hot spots" in southeast Alaska

Scott M. **Gende**[1] and Mike Sigler[2]

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Marine foraging vertebrates face many constraints in finding patchily distributed prey in a three-dimensional water space. Particularly for vertebrates that cannot sample large areas (*e.g.*, seals and sea lions that sample the prey field by visually searching for fish), the relative costs of encountering high-density prey aggregations ("hot spots") may be high unless the density of hot spots are high or persist through time. Should these hot spots persist, marine predators can use previous experience (long-term area-concentrated search methods) to minimize search costs and maximize foraging efficiency. We examined the quantity and location of pelagic forage fish species in southeast Alaska, including Pacific herring and walleye pollock, to determine (1) the density of prey hot spots over a 24-month period, (2) whether the location of these hot spots persisted over several months or across seasons. The density of hot spots varied across months and seasons. Large schools of Pacific herring were the most important

prey that determined the location and density of these hot spots. Perhaps more importantly, several hot spots persisted over time, although persistence was highest during the winter months, November-February. Large and medium sized schools of herring were consistently found in certain areas at relatively small (1 km) spatial scales. Ongoing work quantifying hot spot density and persistence on smaller time scales (days, weeks), will help further elucidate the relative 'costs' of finding prey, in addition to the rewards, and enhance our ability to link foraging behavior of marine foraging vertebrates with fitness ramifications.

PICES XIII S4-1942 Oral

Differences in large pelagic fish larvae and zooplankton volumes over and around a seamount in the Gulf of California

Rogelio **Gonzalez-Armas**[1], A. Muhlia-Melo[2], A. Trasviña-Castro[3], G. Gutierrez De Velasco[3], A. Valle-Levinson[4] and R. Funes-Rodriguez[1]

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To explore the influence of a seamount on the accumulation of plankton, we obtained data on hydrography and zooplankton in the vicinity of El Bajo Espiritu Santo (EBES) in the Gulf of California, Mexico. Hydrographic data consisted of conductivity-temperature-depth (CTD) profiles, underway velocity profiles, and underway surface temperature and salinity observations; measurements were carried out during June 20 to 22, 1999. Zooplankton was sampled by surface tows of a plankton net on four fine-scale grids located over and around the seamount. The circulation pattern showed a northwestward flow with magnitudes between 0.2 and 0.8 m s^{-1}. The influence of the relatively cooler and less saline waters from the Bay of La Paz was marked by a thermal front. The zooplankton volume distribution was linked to the sea surface temperature and salinity as the highest biomass was found over the seamount and to the west, within the cooler and less saline waters coming from the Bay of La Paz. Fish larvae of 39 taxa belonging to 26 families, 32 genera and 30 species were determined, with the grid over the seamount having the highest abundance and number of taxa. Large pelagic fish larvae of *Thunnus albacares, Euthynnus lineatus, Coryphaena hippurus and Auxis* sp. were recorded. The presence of several species with different habitat affinities appeared to reflect physical processes around the seamount which enhanced vertical mixing and induced re-circulations. These results indicate that the EBES seamount is an area of accumulation of zooplankton and retention of larval fishes.

PICES XIII S4-1885 Oral

Upper-trophic predator hot spots in the California Current system: A retrospective analysis of marine bird and mammal communities

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Marine mammals and birds are not distributed uniformly across the world's oceans. Instead, species distributions frequently mirror bathymetric domains, water mass distributions, and mesoscale hydrographic features. Nevertheless, relatively little is known about the mechanisms that restrict these upper-trophic marine predators to specific oceanic domains, and the extent to which species distributions are influenced by spatial habitat gradients and temporal oceanographic variability. Yet, thorough understanding of the patterns of biodiversity and species abundance is a necessary foundation for effective management and conservation of marine systems. We quantified the spatial and temporal patterns of marine bird and mammal distributions along a 1600-km stretch off the West Coast of North America, extending from Point Conception (34°N) to south of Vancouver Island (49°N), and from

the coast to 200 km offshore. More specifically, we analyzed a dataset of monthly marine bird and mammal sightings, collected along a series of standardized aerial survey lines in the 1980s (1980-83 and 1989-90) for the entire CCS. We found distinct bird – mammal communities associated with specific oceanic habitats, and identified several seasonal "hot spots" on the basis of upper-trophic predator concentrations (standing stocks) and community structure (species diversity). Our results suggest that, in spite of seasonal and interannual variability, there exist spatially-predictable upper-trophic predator communities in the California Current System. Moreover, these communities are associated with specific bathymetric and oceanographic habitats. In particular, this analysis highlights the ecological significance of productive continental shelf and slope regions, especially during the season of coastal upwelling (March – August).

PICES XIII S4-1947 Poster
Transport and migration of larval and juvenile fishes through oceanic fronts

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Aggregation of larvae and juvenile coastal pelagic fish, such as sardine, anchovy, and mackerels, are often observed around oceanic fronts in the Kuroshio-Oyashio Transition Region. This distribution expands eastward to the central North Pacific when stock abundance is high, corresponding to a spawning area over the Kuroshio. However, in periods of low abundance, the distribution shrinks around Japanese coastal waters, with a narrowing of the spawning area. As survival through the early life stages is responsible for the stock abundance of these species, both physical and biological characteristics of these distributions have been studied through hydrographic observations and net sampling. In this study, transport and migration processes are examined by a newly developed physical-biological coupled model for understanding the life history strategies of these fish. Physical characteristics of the oceanic fronts inhabited by the fish are compared to those of coastal fronts (*e.g.,* shelf break front). The impacts of hydrographic variation on patterns of transportare discussed, including primary/secondary production and migration behavior.

PICES XIII S4-2011 Invited
Configuration of migratory history based on analyses of stable isotopes and trace elements in otolith of the North Pacific chum salmon

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To understand the migratory history of chum salmon (*Oncorhynchus keta*) in the North Pacific Ocean, we conducted chemical analyses of otoliths. We obtained salmon otoliths from 4 places along the Asian and North American coasts during the 1997-1999 spawning seasons. Stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) and trace elements (calcium, strontium, and zinc) were determined/compared with respect to region and life history. The $\delta^{18}O$ values of Asian salmon appeared higher than North American salmon, while the $\delta^{13}C$ isotope showed opposite patterns over three consecutive years. The high $\delta^{18}O$ and low $\delta^{13}C$ values of Asian salmon may represent a lower temperature and productivity of ocean habitat than North American salmon. Stable isotope values increased with age, showing a high correlation with salmon size. Such differences in stable isotope values indicate different migration routes and habitat distributions with respect to originations and life stages. Trace elements of otolith were examined by laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Sr/Ca ratios, an indicator of salinity, were low during the freshwater stage, increased suddenly at a certain point, and oscillated periodically to a margin corresponding to the year-rings. These oscillations might reflect the movement of fish within salinity gradients between onshore/offshore or north/south migrations during their ocean life period. Zinc profiles also oscillated and

corresponded to the annual growth rings. However, the profiles of Sr and Zn oscillated oppositely after salmon migrated to saline water and the zinc uptake declined toward the rim of the otolith while strontium uptake increased.

PICES XIII S4-1951 Oral
Landmark for the spawning of Japanese eel

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Spawning areas for the Japanese eel (*Anguilla japonica*) are located in the North Equatorial Current (NEC), west of the Mariana Islands, 3000 kilometers from nursery rivers in East Asia. In 2002, we found that the larval distribution of Japanese eel was related to a salinity front, generated by two distinct water masses in the NEC. The salinity front moved southward during El Niño. Large numbers of smaller larvae (~ 10 d old) were collected just south of the salinity front during the 2002 El Niño event. El Niño events, represented by negative values of the Southern Oscillation Index (SOI), correspond with low catches of glass eel in Japan. According to analyses of carbon and nitrogen stable isotope ratios of leptocephali and particulate organic matter in seawater obtained during 2002 and 2004 surveys, the composition of larvae are different to the south and north of the NEC salinity front. We suggest that during their initial life stage leptocephali do not inhabit waters north of the salinity front, but do inhabit waters to the south to feed on particulate matter. Differences of the water properties represented by salinity are apparently related to spawning behavior. The NEC salinity front may function as the landmark for the spawning of Japanese eel.

PICES XIII S4-2105 Oral
Horizontal and vertical movements of juvenile bluefin tuna (*Thunnus orientalis*) in relation to seasons and oceanography in the eastern Pacific

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Juvenile Pacific bluefin tuna tagged with archival tags were released off Baja California in the eastern Pacific in the summers of 2002-2003. Thirty tags have been recovered with up to 677 days of time-series data on pressure, ambient and peritoneal temperature. Geolocations of tagged fish were calculated based on light-based longitude and sea surface temperature based latitude. Using this geolocation data in conjunction with oceanographic information, it was possible to examine the differences in horizontal and vertical movement patterns among seasons in relation to the oceanographic conditions. In summer, fish were found primarily in the Southern California Bight and along the continental shelf of Baja California. In these regions bluefin made use of the top of the water column undertaking frequent, brief forays to depths below the thermocline. In autumn bluefin migrated to the central California coast in the region of Monterey Bay where thermal fronts formed as the result of weakened equatorward wind stress. The timing of this movement towards the central California coast coincided with an increase in primary productivity in this region. An examination of peritoneal temperatures revealed that bluefin tuna fed frequently during this period along the frontal boundaries. In mid-winter, strong downwelling along the central California coast caused a decrease in the productivity in this region. At this time the bluefin returned to Southern California and Baja California continental shelf suggesting that prey species may have decreased in the central California region at this time. In addition to these latitudinal movements, several bluefin made trans-Pacific migrations along the transition zone to Japan during the winter. The migration involved movements to known seamounts including the Emperor Seamount and the Shatsky Rise.

PICES XIII S4-1913 Invited

How to discriminate the aggregated stocks of migratory species according to their origins: A simple and quick PCR method utilizing stock-specific single nucleotide polymorphisms

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Migratory fishes often intermix in the open ocean among stocks of different origins sometime during their life. The chum salmon (*Oncorhynchus keta*), an anadromous fish that distributes in the North Pacific is one of such examples? The fish reproduces in the river, migrates into the open ocean for growth and becomes intermixed. To study stock-specific migratory routes and other ecological characteristics, it will be necessary to develop a method discriminating each stock. Here, we present a simple polymerase chain reaction (PCR) method utilizing single nucleotide polymorphisms (SNPs) observed in the COIII-ND3-ND4L region of the mitochondrial DNA. From a 744 nucleotide-long sequence of the region, several stock-specific SNPs were observed (*e.g.*, positions 57, 70, 246, 303, 307, 534, 591) among 141 chum salmons of Korea, Japan, Canada, and the United States. Based on these SNPs, 20-25 nucleotide-long stock-specific PCR primers were designed in a way that the most 3'end nucleotide becomes identical to the SNPs and that the second to the 3'end mismatches the conserved nucleotide? With primer pairs designed as such, PCR amplified DNA distinctively among the Korea, Japan, Canada and the United States chum salmons: *e.g*. primer pairs of SF0 and SR1 for Korea and of SF1 and SR2 for America salmons. Because of its simplicity, this method would be useful for processing many specimens of aggregated stocks collected during any open ocean sampling cruise.

PICES XIII S4-2115 Poster

Pelagic habitat hot spots as revealed by replicate seabird surveys in the NE Pacific

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Identifying elevated oceanic productivity and upper trophic level predator aggregations (pelagic 'hot spots'), and quantifying spatio-temporal persistence of these hot spots at different scales is critical for effective marine conservation ranging from species to ecosystems. For seabird conservation, it has proven difficult to develop effective management programs based on empirically derived at-sea distributions, because of the nature of these distributions, and the enormous costs and support necessary for adequate spatio-temporal data collection. Developing models of seabird distributions at-sea using data from satellites may provide a cost effective approach for understanding and predicting seabird distributions at sea. Here we present data collected during seasonally and annually replicated Line P cruises (1996-2003), from the entrance of the Strait of Juan de Fuca (south-western British Columbia, Canada: 48.5° N, 124.4° W) to Ocean Station Papa (subarctic North Pacific Gyre, 50° N, 145° W). Consistent cruise timing among years and standardized at-sea survey techniques facilitated long-term comparisons across different oceanographic domains. We correlated the distribution and abundance of select seabird species with oceanic fronts as determined by concurrent remote sensing data for sea-surface temperature (SST: AVHRR), and Chlorophyll *a* (Sea -WiFS), as well as, testing for the presence of fronts and other discontinuities using ship-board data collected during the cruises (*i.e.* CTD and surface CUDLS). We discuss the persistence of identified seabird-pelagic hot spot associations at different spatio-temporal scales, in the context of species specific foraging tactics and life history strategies.

PICES XIII S4-1977 Invited
Stomach contents of toothed whales in relation to prey distribution in the North Pacific

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Stomach content analyses of toothed whales in the North Pacific have revealed details of their feeding ecology. Information on prey species composition, size of prey and diet composition by mass is available. Some dietary studies of toothed whales used data of fish composition and size spectrum obtained from trawled samples to discuss prey-predator overlap and prey selection. Baird's beaked whales (*Berardius bairdii*) in the western North Pacific off northern Honshu, Japan are distributed along the 1000 m isobath in summer. They feed primarily on demersal fish, especially rat-tails. In this area, potential prey species varies depending on the bottom depth. Prey species composition in the stomach contents resembles that net samples taken from waters 1000-1300 m deep. In summer, short-beaked common dolphin (*Delphinus delphis*) in the western North Pacific feed mainly on *Ceratoscopelus warmingi* which is distributed along a front of the Kuroshio Current facing the subarctic boundary. The prey species composition in the stomach contents and that net samples are nearly identical. Dall's porpoise (*Phocoenoides dalli*) is a widely distributed subarctic species, and feeds mainly on myctophids although prey species vary geographically. Comparison of stomach contents of Dall's porpoises and trawl samples show crude consistency. These examples suggest potential correlation between distributions of toothed whales and their prey. Prey availability may be a factor determining distribution pattern of toothed whales.

PICES XIII S4-2143 Oral
Hot spots for dining – A groundfish's view

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A look at over 20,000 stomachs from Pacific Ocean perch (1,417), Atka mackerel (2,236), Pacific cod (6,153), and Walleye pollock (11,179) tell a story of diverse feeding habits, with step-like gradients along a longitudinal track. The sample covers the area between 170˚E and 166˚W, for the period 1982-2000; most stomachs were collected during summer. Results show that areas with the highest prey diversity do not necessarily match those where stomachs were the fullest. The areas do not match among species either. For example, while prey diversity in POP seems to increase around Buldir and at Seguam Pass, the opposite trend is observed in Pollock. For Atka, higher diversity was observed around Buldir and Tanaga Pass. For Pacific cod, the areas of lowest diversity Amchitka, Seguam and Amukta Pass coincide with those where stomachs were the fullest. The longitudinal trends in the feeding habits show euphasiids made up 50-90% of the diets of walleye pollock, Atka mackerel and Pacific Ocean perch east of Samalga Pass. In contrast, euphasiids generally made up less than 50% of the diets of these fish west of Samalga Pass. Copepods and myctophids dominated the remaining portion of the diets to the west. For cod, pollock were more common as prey items towards the east, while Atka mackerels prevailed towards the west. These changes in the diversity and availability of ingested preys by groundfish provide evidence for biogeographic boundaries such as Samalga Pass, and other potential ones further west, around Buldir Island.

PICES XIII S4-2046 Oral
Identifying biological hot spots within the northern California Current

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Understanding how marine animals utilize their environments and identifying important habitats is crucial for our continued understanding of oceanic ecosystems. This information will yield better-informed management decisions and have implications for the design of marine reserves. The goal of the present study is to identify biologically rich areas within the northern California Current and elucidate patterns of habitat use by species occurring within the areas. Sampling was conducted during June and August of 2000 and 2002 as part of the GLOBEC mesoscale surveys. Stations were sampled along both regular transects and also in areas of special biological interest extending from Newport, Oregon in the north to Crescent City, California in the south. At each station a CTD cast, surface zooplankton tow and pelagic nekton trawl were made and a chlorophyll sample collected. Given the high degree of spatial and temporal variability in the northern California Current, the goals of the study are to 1) identify regions of high levels of phytoplankton and surface zooplankton productivity, 2) identify regions of persistent high levels of surface zooplankton and nekton biodiversity, 3) identify dominant members and the structure of the nektonic communities within these regions, and 4) examine the habitat characteristics associated within these areas. To accomplish these objectives, the spatial distributions and abundances are examined using geostatistical analyses and GIS. Results will be presented.

PICES XIII S4-1897 Poster
Seamounts as hot spots of pelagic fish diversity in the Eastern Pacific Ocean

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Migratory pelagic fishes aggregate at seamounts because of greater opportunities to feed or because topographic features provide landmarks during migration. Such aggregation of diverse species reflects the potential of seamounts as vital marine protected areas and emphasizes our need to understand the role they play among Pacific fish populations. We integrate fisheries observation, underwater visual census, ultrasonic tagging, and diet analyses to examine how pelagic fish utilize seamounts in the southern Gulf of California. Fisheries catch data has been used to track species' seasonal migrations into the Gulf and arrival at seamount hot spots, while visual census has delineated distinct winter and summer fish assemblages at seamounts due to fluctuating sea temperatures. To further determine residence patterns at seamounts, twenty-three *Thunnus albacares* were ultrasonically tagged at Espiritu Santo Seamount in 1998. Two ultrasonic monitoring stations recorded tagged tunas swimming within their range of reception, and showed tunas stayed at this seamount for time periods ranging from 0 to 18 months. Monitors were redeployed in 2002 to investigate the residence of multiple species across trophic levels, and five *Caranx caballus*, five *Seriola lalandi*, and two *Sphyrna lewini* were tagged. Records of these species have shown short-term residence patterns that are currently being analyzed. We also use stable isotopes and gut contents to determine trophic structure and interactions among diverse pelagic species at seamounts and depict how resource utilization at seamounts compares with open ocean areas. Using these techniques, we have developed an effective method for analyzing ecological processes among pelagic fishes in complex seamount ecosystems.

PICES XIII S4-1815 Poster

Transport of fodder plankton in low-frequency waves and eddies: Favorable conditions for fishing grounds formation

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The distribution of plankton in dynamic systems is important both for fundamental biology and fisheries. Plankton distribution may confer information on of the relative value of fishing grounds. The process of plankton concentration in eddies and low-frequency waves is particularly interesting, as these features dominate formations on a synoptic scale. However, the role of eddies and waves in aggregating plankton is not clear.

Plankton is transported by currents; this process can be described as "transport of a passive impurity". Thus, on the one hand, cyclones have favorable conditions for primary production generation (due to upwelling of nutrients-rich deep water), but on the other hand, this new production is carrying out on periphery of these dynamic systems because of divergence of currents. In opposite, plankton concentrates in anticyclones due to convergence of currents.

In gradient-eddy waves, the divergence mode is replaced by the mode of convergence with period equal to the period of a wave. Therefore, waves may confer more favorable conditions for realization of trophic connections and, accordingly, more favorable conditions for formation of commercial fish concentrations.

We used analytical models of low-frequency waves and eddies (Belonenko *et al.*, 1998) to describe plankton distribution in dynamic formations. A simple analytical solution was not possible for distribution of plankton biomass in the case of moving bell-shaped vortex-like disturbance. However, numerical estimations allow to us to conclude that plankton concentrates on the back slope of low-frequency waves, in the rear part of a moving anticyclonic eddies, and in the forward part of a moving cyclonic eddy. These dynamic formations are well identified on satellite altimetery maps. The application of determining plankton and fish concentrations with altimetry maps is discussed.

PICES XIII S4-1989 Oral

Using GIS to locate pelagic hot spots for bluefin tuna

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Using sample data from a previous study on the relationship between bluefin tuna and sea surface temperature (SST) fronts, we used model output to document previously unknown good-habitat areas in the Gulf of Maine, Northwest Atlantic Ocean. To locate these ephemeral habitat envelopes, we used the relationship between tuna presence and the following environmental variables: SST, distance to SST fronts, kernel-smoothed density of SST fronts, bottom depth, and slope. To quantify this relationship between bluefin tuna presence and oceanographic features in the Gulf of Maine, we fit a Generalized Linear Model (GLM) to the data using a logit link to our presence-absence data set grouped together across all years. The full model was run through a stepwise selection procedure using Bayes Information Criteria as the penalty criteria. Using raster processing with the GIS, we mapped spatially explicit raster cells that satisfy conditions of the GLM. Once located, we used GIS to further document the persistence of these features by calculating the ratio of how many times a cell was a habitat cell to how many times it was an absence cell. Using the output, we explore events at multiple spatial and temporal scales, and note how the method is scale and location independent. Though the results are specific to the Gulf of Maine, the techniques can be easily applied to other pelagic systems.

PICES XIII S4-2097 Invited
An oceanographic basis for identifying biological hot spots

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Marine predators, including large pelagic fish, marine mammals, sea birds, and fishing vessels, recognize that fish and other organisms congregate at ocean fronts and other features. Thus biological hot spots in the ocean are likely created by physical processes and have distinct physical signatures. Until recently, however, our understanding of the relationship between physical ocean structure and the distribution and behavior of large pelagics was largely limited to anecdotal reports and opportunistic sampling. The technologies of biologging and remote sensing now provide continuous basin-wide coverage of ocean conditions, and specifically the physical characteristics of the hot spots that animals frequent. Instrumented tags allow for animals to be tracked spatially and temporally, and provide a high-resolution record of their environment. Changes in their behavior can be correlated to changes in physical conditions, thus giving clues about the oceanographic basis for hot spots. Animal tracks can be mapped upon images from multiple satellites that provide information on ocean structure, circulation, and production, which collectively define the attributes of biological hot spots. Our approach is to identify candidate hot spots based on the physical attributes of the areas where tagged animals aggregate or change behavior, then conduct a hot spot "census" of satellite fields. The results of this analysis will be compared for different species (*e.g.*, tuna, elephant seals) to differentiate the preferred pelagic habitats and hot spots of each species.

PICES XIII S4-2058 Oral
Foraging destinations of short-tailed albatrosses (*Phoebastria albatrus*) in the Northwest Pacific Ocean, Gulf of Alaska, and Bering Sea

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We used satellite transmitters and oceanographic remote sensing data to determine the distribution, movement patterns, and characteristics of foraging areas of short-tailed albatrosses during May to November 2002 and 2003. Transmitters were deployed on birds immediately prior to their final departure from the breeding colony at Torishima (n = 11), or after capture at-sea in the Aleutian Islands (n = 3), and thus represent non-central-place foraging trips. Tracking durations ranged from 51 to 138 days for a total of 7,400 location fixes after filtering (131 – 954 locations per bird). Albatrosses ranged along much of the North Pacific rim above 30 degrees north latitude and most often remained over continental shelf break and slope regions at a median depth of 2030 m. High use areas in the western Pacific basin included productive waters of the Kuroshio and Oyashio current regions off Japan, and the Kurile Islands, Russia. In the Aleutian Islands, birds most often occurred within straits, particularly along the western part of the chain (*e.g.*, Near Strait, Buldir and Seguam Passes), and in the Bering Sea, they occupied waters along the northern continental shelf break (200 m depth) and the Kamchatka Currrent region. These results indicate that non-breeding short-tailed albatrosses concentrate their activities in oceanic areas characterized by specific bathymetric and hydrographic features.

PICES XIII S4-2060 Poster

Wing loading and prevailing winds: Their relative importance to the at-sea distribution of four species of Pacific albatrosses

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The four species of albatrosses that inhabit the Central and North Pacific Ocean exhibit markedly different distributions at-sea. The short-tailed albatross (*Phoebastria albatrus*) nests in the northwest Pacific within close proximity (< 500 km) to the continental margin and productive feeding grounds of the Kuroshio Current region. The waved albatross (*Phoebastria irrorata*) in the equatorial, eastern Pacific, travels moderate distances (< 1,500 km) from its nesting area in the Galápagos Islands to the adjacent feeding grounds within the Humboldt Current region. In contrast, the Laysan albatross (LAAL, *Phoebastria immutabilis*) and black-footed albatross (BFAL, *Phoebastria nigripes*) travel over large expanses of open ocean (> 3,000 km) when foraging along continental shelf regions of the California Current and Alaska Current systems. In addition to differences in proximity to continental margins, these four albatrosses also differ morphometrically, with the two smallest species nesting furthest from productive coastal regions, indicating potential adaptive significance to body size and flight energetics. We obtained measurements of body and wing morphologies pertinent to flight performance and calculated power curves and glide polars based on equations of mechanical flight. Preliminary results indicate that wing loading (body mass/wing surface area) varies up to 30% among species, resulting in up to 20% differences in minimum sink and best glide velocities (the two smallest and furthest ranging albatrosses, LAAL and BFAL, being most similar in all measures). We hypothesize that these differences in flight mechanics may be important in navigating prevailing wind systems within the respective foraging ranges of the four albatross species.

PICES XIII S4-1787 Oral

Seasonal frequency of pelagic fish species in some micro-regions of the southwestern Okhotsk Sea

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The frequency of eight pelagic fish species in three micro-regions of the southwest Okhotsk Sea was considered. I conducted investigations in a zone of deep water near southeast Sakhalin from July – early November, 1999. The maximal frequency was observed for walleye pollock (*Theragra chalcogramma*), minimal – for Pacific lancetfish (*Alepisaurus ferox*). Large concentrations of Japanese anchovy (*Engraulis japonicus*) and saury (*Cololabis saira*) were observed in August and September. On the whole, seasonal peaks of different pelagic fishes were found. Characteristics of species catches and biological parameters of fishes are presented, as well as data of the seasonal occurrence of marine mammals and seabirds and water surface temperature in the study area. The highest frequency and maximum duration of pelagic fish species occurrence were observed in the northwest micro-region, an area characterized by higher biological productivity in general.

PICES XIII S4-1797 Poster
Zone of "hot spots" of the surface temperature for the NW Pacific

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The NW Pacific is a unique and specific area for investigating complex thermodynamic processes. A major component – ocean surface temperature is a key parameter for models and experimental studies. The main objective is to study the peculiarities of thermodynamic structures in the region. We used regional data archives of the Meteorological Agency of Japan for the period 1960-1985 to evaluate thermodynamic processes. Our focus is an analysis of the ocean surface temperature anomalies as the major characteristics predetermining the dynamics of the temperature background in the NW Pacific.

On the basis of the archived data, the following quantitative characteristics were calculated: the ratio of the area of positive anomalies of the ocean surface temperature to the total area of the region - S_{+a} %; the ratio of the area of the most heated waters (>3^0C) to the total area of the region - $S_{a>3}$ %; maximums of the temperature anomalies (extremums) - T^0_{am}. As a result, it is ascertained a quasi-stationary zone of the most heated waters located in the band of 36^0-46^0 N to the east of 140^0 E. That confirms a stationary state of the main source of the exceeding heat energy in the considered study area.

Consequently, the NW Pacific is a region of the increased temperature background and considerable energy where the temperature of the ocean surface is the main indicator of its thermodynamic processes.

PICES XIII S4-2071 Oral
The effects of ENSO events on California chinook salmon (*Oncorhynchus tshawytscha*) as revealed by scale increment analysis

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We correlate the strength of El Niño - Southern Oscillation (ENSO) events, regional upwelling, and sea surface temperatures to growth patterns in scales from returning ocean-type chinook salmon, *Oncorhynchus tshawytscha*, from California, U.S.A. waters collected over a more than 20 year period. Additionally, to determine the effects of environmental variation on early growth we examined increment patterns from a collection of scales from estuarine resident juveniles collected over 15 years. The impact of ENSO events at larger and regional scales is apparent on the growth patterns during estuarine residence and while at sea with obvious reductions in growth occurring during ENSO years. The effects of the ENSO event of 1982/83 were particularly dramatic. These negative impacts affect fish of any given age and may have a bearing on early mortality, return size, and age at maturation. Our approach of examining the effects of large and regional scale events across years, and hence distribution, is an essential step for proper adaptive management.

PICES XIII S4-2073 Oral
Chlorophyll hot spots in the oligotrophic North Pacific Subtropical Gyre

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Satellite observations of sea surface chlorophyll show that large blooms of phytoplankton sometimes develop in late summer in the oligotrophic North Pacific Subtropical Gyre near 30°N and between 130°-160°W. These blooms have been observed by multiple ocean color satellite (CZCS, OCTS, SeaWiFS and MODIS). The blooms do not occur every year; they have been observed in nine of the fifteen years of available ocean color data. The largest

blooms covered more than 350,000 km^2 and lasted as long as 4 months. They are distinct from the surface seasonal cycle of chlorophyll in both timing and amplitude. The blooms are not associated with either SSH or SST anomalies indicative of changes in subsurface structure, nor do they appear to be forced by nutrient fertilization from dust deposition or rainfall. These blooms are compared with phytoplankton blooms that have been previously observed in this region by *in situ* studies, and the potential causes for them are discussed.

PICES XIII S4-2206 Poster
Backscatter variability within a Haida Eddy

Doug **Yelland**

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Haida Eddies are known to carry productive coastal waters into the HNLP area of the North Pacific and Gulf of Alaska. Satellite images of surface chlorophyll levels often show distinct annular banding of pigment content along sea surface height contours, especially as the eddies are forming. A set of transect lines through a recently-formed 2004 Haida Eddy also shows evidence of a similar banding in the acoustic backscatter data, probably due to zooplankton biomass density variations. This observation is investigated over the width of the eddy for both spatial and depth variations, and in addition to the satellite imagery, is compared to geostrophic and ADCP-derived current estimates, and to net tow estimates of zooplankton abundance.

PICES XIII S4-1940 Oral
Detection of high productive area of albacore fishing ground and migration route using multi-sensor satellite remote sensing

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We linked remotely sensed data from multi-sensor satellite images of sea surface temperature (SST, TRMM/TMI), sea surface chlorophyll concentration (SSC, SeaWiFS) and sea surface height anomalies (SSHA, AVISO grid data) with fisheries catch to analyze dynamics of albacore. We investigate albacore fishing ground formation, migration routes, and impacts of El Niño 1998 and La Niña 1999 on albacore fisheries in the northwestern North Pacific. We observed that fishing grounds tended to form near the anticyclonic eddy and fronts around the Shutsky Rise, an area known as a "hot spot" in November 1998 and 2000. In November 1999, when the eddy formation around the area appeared to be weak, the fishing grounds shifted to frontal regions near the Kuroshio Extension (KE). These fronts were indicated by the confluence of two contour lines of 20°C SST and 0.3 mg m^{-3} SSC. The north-south migration route of the fish seems to be associated with the dynamics of these isotherms, particularly in winter (November-March). It is likely that the formation of the fishing grounds and migration route for albacore were strongly related to eddies and front formation. During the first half of 1999 (a strong La Niña period), formation of fishing ground appears more developed than during El Niño period (the first half of 1998) near the meeting of the contours where fronts were likely formed well particularly near the southern edge of KE (31-34ºN and 160-175ºE). As a result, CPUE was higher during La Niña than El Niño period.

S5 MEQ Topic Session
Introductions of marine species

Co-sponsored by the International Council for the Exploration of the Sea (ICES)

Session Convenors: William P. Cochlan (U.S.A./PICES), Stephan Gollasch (Germany/ICES) and Yasuwo Fukuyo (Japan/PICES)

Species introductions are among the most prevalent of human activities affecting natural ecosystems. In the marine environment, introductions, including most aquaculture initiatives, have resulted in both positive and negative effects. The transport of invasive species such as phytoplankton, is thought to stem from range extensions associated with fluctuating oceanographic conditions (*e.g*., El Niňo), severe storm events (*e.g.*, typhoons), and human activities (*e.g.*, ballast water). The impact of transport processes on species distributional changes in North Pacific waters is not fully understood. Relative to the terrestrial environment, the study of introductions, and the potential for new species to become invasive, is in its infancy in marine systems. Emerging work includes introduction vectors, life history characteristics of invasive species, ocean conditions responsible for invasions, ecosystem resistance to invasion, and potential for eradication or mitigation of introductions once established. This session will seek to answer three fundamental questions: 1) What is known about different transport mechanisms? 2) What is the magnitude of ecological and economic effects arising from the transport of species? and 3) What steps can be taken to minimize real or potential effects of existent and future invasive species?

Wednesday, October 20, 2004 08:30-17:00

08:30-08:40 **Introductory remarks by Session Convenors**

08:40-09:10 **Gustaaf M. Hallegraeff** (Invited)
Range extensions and ship ballast water transport of harmful algal bloom species in the Australian region (S5-2022)

09:10-09:30 **Shinya Uwai, Wendy Nelson, Luis E. Aguilar-Rosas, Sung Min Boo and Hiroshi Kawai**
Introduced seaweeds - Genetic diversity of introduced and native *Undaria pinnatifida* (S5-2139)

09:30-09:50 **Keiji Iwasaki and The Committee for the Preservation of the Natural Environment, The Japanese Association of Benthology**
Range expansion and speed of spread by introduced marine benthos in Japan (S5-2135)

09:50-10:10 **Tatyana A. Belan**
Anthropogenic invasion of some benthic species in the coastal areas (S5-1777)

10:10-10:30 **Coffee break**

10:30-11:00 **Marjorie J. Wonham and Elizaveta Pachepsky** (Invited)
What do temporal trands in invasion records really mean? (S5-1928)

11:00-11:30 **Stephan Gollasch** (Invited)
Ballast water - The key vector for aquatic species invasions? (S5-1969)

11:30-11:50 **Dan Minchin, Anna Occhipinti, Oliver Floerl and Dario Savini**
Small craft as a vector of exotic species (S5-1795)

11:50-12:10 **Yasuwo Fukuyo**
The Ballast Water Convention and its inherent, but inevitable incompleteness for the prevention of biological invasion (S5-2178)

12:10-13:50 **Lunch**

13:50-14:10 **Jennifer Boehme and Mark Wells**
Ballast water exchange verification using the optical characteristics of dissolved organic matter (S5-2094)

14:10-14:30 **Yasuwo Fukuyo, Takeaki Kikuchi, Katsumi Yoshida and Seiji Kino**
Onboard ballast water treatment using the special pipe to terminate aquatic organisms (S5-2163)

14:30-14:50 **L. Scott Godwin**
Marine invasive species transported by vessel hull fouling: Potential management approaches (S5-1901)

14:50-15:10 **Coffee break**

15:10-15:30 **Stephan Gollasch**
ICES and biological invasions - introduction to the work of ICES Working Group on Introductions and Transfers of Marine Organisms and ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (S5-2191)

15:30-17:00 **Discussion and concluding remarks**

Posters

Alexei M. Orlov
Ichthyofaunal exchange between northwestern and northeastern Pacific: Possible directions and mechanisms (S5-1775)

PICES XIII S5-1777 Oral
Anthropogenic invasion of some benthic species in the coastal areas

Tatyana A. **Belan**

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Negative environmental impacts caused by introduced exotic species are considered as problematic for coastal ecosystems. Since the 1980s the ctenophore *Mnemiopsis leidyi* has invaded the Azov and Black Seas. Further, species native to Japan, appeared along southeastern Australia (starfish *Asterias amurensis*), in San Francisco Bay (clam *Potamocorbula amurensis*) and in Atlantic coastal waters (shore crab *Hemigrapsus sanguineus*).

Other problems are caused by the invasion of small local opportunistic species is their spread and the replacement of common benthic organisms. Since the 1970s and 1980s some species (considered to be rare in the middle of the last Century) were spreading and are abundant today in urban and industrial regions of different geographical zones. Polychaetes of the Genus *Schistomeringos* became dominant in coastal waters of the Black Sea, Japanese Sea and NE Pacific (Losovskaya, 1977; Kiseleva *et al.*, 1984; Levings, 1985; Burd *et al.*, 1990; Bagaveeva, 1992). In some Black Sea bays the polychaete *Polydora limicola* became widespread with a high density since 1970s. In the middle of 1980s, the polychaete *Tharyx pacifica* was dominant in coastal urban regions of the Japanese Sea. From the 1940s to 1960s these species were not observed or occurred in very low numbers.

As a rule, the highest abundance of these species was recorded in ecologically stressed areas with high concentrations of contaminants, low dissolved oxygen content and where other anthropogenic impacts are registered. One of the reasons for the wide distribution of these species is their ecological flexibility and persistence under different kinds of environmental disturbances.

PICES XIII S5-2036 Oral
Is mid-ocean exchange effective in preventing the invasion of estuaries by zooplankton from ships' ballast water?

Jena M. **Bills**, G. Smith, K.H. Choi, W.J. Kimmerer and G.M. Ruiz

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The number of non-indigenous invasive species (NIS) in North American estuaries has dramatically increased over the last century. Ships' ballast water has been identified as one of the major vectors of transport of NIS between estuaries worldwide. Various ballast water management strategies have been suggested to reduce the likelihood of high-impact invasions such as the zebra mussel. Mid-ocean exchange of ballast is relatively inexpensive, and is the only management strategy currently being applied routinely to reduce the influx of NIS. Surveys of ballast water entering North American ports suggest that exchange does not remove all estuarine organisms. We conducted experiments aboard container ships to assess the efficacy of mid-ocean ballast exchange for the removal of estuarine zooplankton. Samples were collected from paired tanks at the beginning and end of eight voyages of container ships, in which one tank underwent an exchange and the other was left unexchanged (as a control). The tracer dye used in these studies showed that mid-ocean exchange removed 75-98% of the original ballast water. The removal rate of estuarine zooplankton was, on average, proportional to the removal of rhodamine dye. Exchange efficiency however, varied as a function of the population dynamics in the control tanks. These results could help us to understand how efficient mid-ocean exchange is and whether it is an acceptable means of eradicating potential invaders from ballast water.

PICES XIII S5-2094 Oral

Ballast water exchange verification using the optical characteristics of dissolved organic matter

Jennifer **Boehme**[1] and Mark Wells[2]

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The release of ballast water carried by international shipping traffic into freshwater and marine ports has previously resulted in ecosystem devastation and substantial economic costs from the invasion and establishment of exotic species transported within ballast tanks. The International Maritime Organization established voluntary guidelines in 1991 employing mid-ocean ballast water exchange (BWE) to minimize ballast-mediated species invasions. The U.S. Coast Guard currently recognizes BWE as the only accepted method to control the spread of exotic species, and soon mandatory ballast exchange will be required and monitored for ships entering U.S. ports from outside the exclusive economic zone. Given that BWE will remain the leading method of invasive species control for at least the next decade, there is critical need to establish reliable and practical verification methods. Current monitoring methods employ salinity measurements as benchmarks for different water masses, but its usefulness as a tracer is not universal.

The optical character and intensity of colored dissolved organic matter (CDOM) has been explored as a more sophisticated tracer for the origin of ballast water. CDOM is strongly influenced by biotic and abiotic input and removal processes tied to ecosystem structure and terrestrial forcing. Results from preliminary surveys of nearshore and offshore CDOM optical properties shows there are distinct features in these disparate environments that become readily discernable statistically. We build from these data to propose a novel but practical ecosystem-based approach for developing the instrumentation and associated database needed to achieve the projected verification requirements of the U.S. Coast Guard.

PICES XIII S5-2163 Oral

Onboard ballast water treatment using the Special Pipe to terminate aquatic organisms

Yasuwo **Fukuyo**[1], Takeaki Kikuchi[2], Katsumi Yoshida[2] and Seiji Kino[2]

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The special pipe system was designed to terminate aquatic organisms in ballast water during water uptake and/or discharge, using shear stress and cavitation produced by special plate structures of the system. At land-based tests the termination efficacy, which was judged by the change in organisms' appearance, was 91.4% for phytoplankton and 99.9% for zooplankton at a one-time passage through the pipe. A two-time passage resulted in an phytoplankton inactivation of 99.4% and 100% for zooplankton. The results showed also that higher flow rates and multiple passages had a higher efficacy.

Further tests were conducted onboard a container vessel of 53,822 gross tonnage equipped with 33 ballast tanks with a total ballast capacity of 21,219.9 tonnes. The vessel routinely cruises along China, Japan, U.S.A., Canada, Japan and China in a round-trip of 35 days duration. Data of organisms and environmental parameters were collected during two round-trips in November 2003 and February 2004. The treatment efficacy of the organisms was calculated according to the ballast water discharge quality standard of the IMO Ballast Water Management Convention: (1) organisms of 10-50 μm in minimum dimension could be reduced to meet the IMO standard (<10 ind./ml), (2) organisms larger than 50 μm could be reduced in some cases, but not in the others to meet the IMO requirement (<10 ind./m^3), (3) in some coastal areas more than 100,000 ind./m^3 larger than >50 μm were found. 4) *Vibrio cholerae* was not detected. *Escherichia coli* was found 1-3 cfu/100 ml at Los Angeles, Seattle and Vancouver.

PICES XIII S5-2178 Oral

The Ballast Water convention and its inherent, but inevitable incompleteness for the prevention of biological invasion

Yasuwo **Fukuyo**

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The International Convention for the Control and Management of Ships' Ballast Water and Sediments was adopted at a Diplomatic Conference at the International Maritime Organization in February 2004. This convention aims to prevent and ultimately eliminate risks to the environment, human health, property and resources arising from the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments. It looks like aiming to terminate harmful species only, but the real target is all organisms taken in tanks together with ballast water, because all organisms in tanks will be discharged at ports, and potentially settle and proliferate. Proliferated groups of organisms occupy a certain ecosystem niche and eventually change the environment, regardless of direct harmfulness to human and natural resources.

The maximum allowable number of organisms in water to be discharged at ports is defined as follows; 1) viable organism of the size larger than or equal to 50 µm in its minimum dimension shall be less than 10 individuals in one cubic meter, 2) viable organisms smaller than 50 µm and larger than or equal to 10 µm in the minimum dimension shall be less than 10 individuals in one milliliter, 3) three indicator pathogenic bacteria. These criteria are challenging not only to the maritime industry, but also to marine science. Because the first criterion mentioned above is difficult to achieve by the industry and also difficult to prove or confirm by scientists at approval experiments. The second criterion is too lax to prevent invasion of organisms.

PICES XIII S5-1901 Oral

Marine invasive species transported by vessel hull fouling: Potential management approaches

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Ocean-going vessels can be thought of as biological islands for species that dwell in harbors and estuaries around the world. Maritime vessel activity acting as a vector for marine alien species is a complex issue involving ballast water, ballast water sediments, and hull fouling. Ballast water is the pathway that has been the major focus of investigations concerned with marine invasion vectors, and the biofouling that occurs on the surfaces of vessel hulls has been given less attention. Recent compilations of marine alien species in Hawaii include some 343 species, which includes 287 marine invertebrate species. The mechanism of transport for more than 70% of these marine invertebrate species is considered to be hull fouling. Pending administrative rules focused on management efforts for ballast water have recently moved toward mandatory exchange for all United States ports. Hull fouling is a new management issue, and will require expert opinions from various stakeholders connected to maritime shipping, marine resource management, and marine alien species problems. Such an effort was recently undertaken in Hawaii and the goal was to develop initial ideas that could be used to develop a formal management strategy. It was shown that it could be more important to focus management efforts on stochastic events instead of regular arrivals to minimize marine invasive species introductions through hull fouling.

PICES XIII S5-1969 Invited
Ballast water – The key vector for aquatic species invasions?

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The major vectors for unintentional species introductions in aquatic habitats are shipping and species introductions for aquaculture. Inventories of aquatic invaders in many regions have shown that shipping is the predominant vector of species invasions. Historically hull fouling was the most important introducing vector. Nowadays, ballast water becomes more into focus. The global merchant fleet of more than 40,000 vessels discharges approx. 3 billion tonnes of ballast water annually. It is estimated that more than 4,000 species are in transit with ships in high individual numbers at any one time. As a result each single vessel carries an enormous number of organisms and therefore all coastal regions receiving ballast water discharges are at high risk of new species introductions. This account compares the relative importance of vectors for species introductions with an emphasis on shipping.

PICES XIII S5-2191 Oral
ICES and biological invasions - introduction to the work of ICES Working Group on Introductions and Transfers of Marine Organisms and ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors

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As a fishery-oriented inter-governmental organisation, ICES has been confronted early on with issues related to the introductions of non-indigenous species, in particular diseases and parasites transferred with live transport of fish and shellfish for relaying, stocking, ranching and for immediate human consumption. During the early 1970s, decisions on recommendations regarding introductions and transfers were mainly discussed in the ICES Consultative Committee. Consequently the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) was launched at held the first meeting as reconvening working group in 1979. The 25th meeting was held in 2003. In the beginning the group dealt with intentional introductions only. In the beginning 1990s unintentional, ship-mediated introductions came more into focus and WGITMO suggested to establish a new stand-alone working group to focus on ships as transport vector. The Study Group on Ballast Water and Sediments (ICES/IOC/IMO SGBWS) was established by ICES Council Resolution in 1996. To address the growing concern of other shipping vectors the Study Group was renamed to Study Group on Ballast and Other Ship Vectors (ICES/IOC/IMO SGBOSV) in 1999. In 2003 the status of this group was changed and the group was re-established as the Working Group on Ballast and Other Ship Vectors (ICES/IOC/IMO WGBOSV). Both groups substantially contributed to various ICES publications, including the ICES Code of Practice on Introductions and Transfers of Non-indigenous Marine Organisms (most recent version published in 2003), Alien Species Alert Reports, Status Report of Introductions of Non-Indigenous Marine Species into North-Atlantic Waters 1981-1991 published as ICES Cooperational Research Report (the 1992-2002 version is in preparation). Comprehensive meeting reports of both groups are available at the ICES homepage www.ices.dk.

PICES XIII S5-2022 Invited
Range extensions and ship ballast water transport of harmful algal bloom species in the Australian region

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The role of ship's ballast water in the spreading of harmful marine microalgae is examined, with a focus on diatoms and dinoflagellates which can impact human health, fisheries, aquaculture and the environment. In extensive Australian ship ballast water surveys, 80% of ships contained culturable diatom species (including potentially toxic

Pseudo-nitzschia, causative organisms of Amnesic Shellfish Poisoning) and 5% of ships contained the Paralytic Shellfish Poisoning producing dinoflagellates *Alexandrium catenella, A. tamarense* and *Gymnodinium catenatum* (up to 300 million viable cysts in a single ship). The potentially ichthyotoxic dinoflagellate *Pfiesteria piscicida* has also been cultured from ballast water entering Australian ports. While the presence of harmful marine microalgae in ballast water thus has been firmly established, to prove that a particular species of microorganism has been introduced is complex and relies on the study of dinoflagellate cysts in dated sediment cores (*Gymnodinium catenatum* in Tasmania) and increasingly the application of sophisticated molecular sequencing. To reduce the risk of ballast water introductions by these microorganisms (mostly 10 to 100 m size) represents a very significant scientific and technological challenge, which cannot yet be adequately achieved with best currently available technologies (*e.g.* 95% ballast water exchange). Examples of promising but expensive higher standard treatment technologies include heating, mechanical removal of organisms in combination with UV treatment, as well as chemical treatment of ballast water. By contrast, we have no control over range extensions resulting from *e.g.* climate induced shifts in ocean conditions. Increasing red tide blooms by the dinoflagellate *Noctiluca scintillans* in Tasmanian waters (2001-2004) thus are thought to represent a recent East Australian Current driven range extension from Sydney coastal waters into Tasmanian waters, where it now has established permanent overwintering populations.

PICES XIII S5-2135 Oral
Range expansion and speed of spread by introduced marine benthos in Japan

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To investigate the invasion history and current geographic distribution of marine benthos introduced to Japan, the Committee for the Preservation of the Natural Environment, the Japanese Association of Benthology, conducted a questionnaire survey on their occurrence in the field, including both published and unpublished records in 2002-2003. In total 88 taxa were reported by 94 respondents. Taxa were categorized according to three criteria (1) known or unknown geographic origin, (2) established invasion history and (3) presumed dispersal mechanisms associated with human activities. As a result 42 taxa were designated as non-indigenous species introduced to Japan through human activities, 26 taxa as indigenous species which are known from Japan and other countries but are introduced from abroad to Japan for fisheries or as fish bait, and 20 cryptogenic taxa. The analysis of the first record years of the 42 non-indigenous species revealed that the invasion rate has increased over the past century, with seven or eight species being introduced per decade after 1960. Data on the temporal distributional change revealed that many non-indigenous species have become widespread recently, from the Pacific coasts of central Japan to the coasts of the Sea of Japan or northwards. Their rate of spread was calculated through the regression analyses of (a) the distance between the area of first record and the most distant site of known occurrence and (b) against the time after the year of first record. The calculation resulted in a rate of spread ranging from 10 – 26 km $year^{-1}$. In unintentionally introduced species the first record site was considered as starting point for the dispersal in Japan.

PICES XIII S5-1795 Oral
Small craft as a vector of exotic species

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Small craft are potential vectors for the distribution of aquatic organisms in freshwater, brackish and marine environments. Such craft vary in design from small open boats, yachts and cruisers to small working vessels. Fouling of biota on hull surfaces, engine components, abstraction ports, tunnels and projections result in varying numbers of non-indigenous species being transported but it is possible that contained water could also result in transmissions. In this account we demonstrate that the number of small craft continue to increase in temperate,

Mediterranean and semi-tropical environments and that the spread of some exotic species by small craft to local and distant regions can take place. Some vessels such as yachts can range widely and may be capable of transmissions across oceans. However, movements of yachts tend to be limited according to the availability of favourable trade winds and avoidance of areas during months when tropical storms occur. Marina sites in port regions are considered to be vulnerable areas should shipping result in exotic species introductions.

PICES XIII S5-1775 Poster
Ichthyofaunal exchange between northwestern and northeastern Pacific: Possible directions and mechanisms

Alexei M. **Orlov**

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Until today only the continental slope of the Bering Sea is considered as migration pathway for pelagic eggs/larvae of American ichthyofauna to Asian coasts (Pacific halibut *Hipposlossus stenolepis*, sablefish *Anoplopoma fimbria*, shortraker rockfish *Sebastes borealis*, arrowtooth flounder *Atheresthes stomias*, rex sole *Glyptocephalus zachirus*). Recent studies showed that an exchange of Asian and American ichthyofaunas occurs along the Kuril and Aleutian Islands. Some species significantly extended their ranges westwards from the Aleutian to Kuril Islands and southeastern Kamchatka due to recent climatic changes (northern rockfish *Sebastes polyspinis*, light dusky rockfish *Sebastes ciliatus*, arrowtooth flounder, and rex sole). Some species described from the Aleutian Islands (blacktip snailfish *Careproctus zachirus*, longfin Irish lord *Hemilepidotus zapus*, scaled sculpin *Archaulus biseriatus*, sponge sculpin *Thyriscus anoplus*, and roughskin sculpin *Rastrinus scutiger*) were recently found abundant or common in Pacific waters off the Kuril Islands. Off the Aleutian Islands the species listed above are very rare (and mostly small-size immature specimens are found) while off the Kuril Islands the adults are very common. It is suggested that pelagic eggs or larvae of these species may be transported from Kuril Islands to the Aleutians by the Western Pacific Gyre.

PICES XIII S5-2157 Oral
Effect of UV radiation exposure on marine microplankton: Results of a mesocosm study simulating ballast water treatment

Gretchen **Rollwagen-Bollens**[1,2], Stephen M. Bollens[1,2], Jeffery R. Cordell[3]and Anne M. Slaughter[1]

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Introduction of non-indigenous species in aquatic ecosystems is a growing area of research, as evidence of negative effects of non-indigenous taxa has increased in recent years. For example, several copepod species have been introduced into NE Pacific estuaries, with some showing significant impacts on the ecology of the invaded systems (*e.g.* Tortanus dextrilobatus has become a major predator on smaller native copepods in the San Francisco Estuary). With the realization of important ecological impacts of invasive species has come the desire to find treatment and/or mitigation approaches to reduce or eliminate the effects of these introductions. One approach is to treat ballast water with UV radiation in an attempt to eradicate planktonic organisms before they are released into new environments. In order to evaluate the feasibility of such an approach, we undertook well-replicated and controlled mesocosm experiments over a three-week period, to examine the effects of UV radiation on micro- and mesozooplankton from Puget Sound, WA, USA. UV exposure of 60-200 mJ proved effective in reducing overall microplankton abundance relative to controls, but did not effect chl a concentrations. Moreover, the microplankton community composition changed substantially, with free-living dinoflagellates (*e.g.* Protoperidinium) eventually replaced by aloricate ciliates (*e.g.* Euplotes, Uronema) and several types of (presumably) dinoflagellate cysts. These experiments demonstrate the potential utility of UV treatment to reduce plankton abundance, however the observed compositional changes and cyst formation remain important issues to be addressed if this treatment approach is to be implemented.

PICES XIII S5-2139 Oral
Introduced seaweeds – Genetic diversity of introduced and native *Undaria pinnatifida*

Shinya **Uwai**[1], Wendy Nelson[2], Luis E. Aguilar-Rosas[3], Sung Min Boo[4] and Hiroshi Kawai[1]

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[3] Instituto de Investigaciones Oceanológicas Universidad Autónoma de Baja California, Km. 103 carretera Tijuana-Ensenada, 22830, México
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More than 100 seaweeds are considered to have expanded their geographic range supported by human activities, and are called "introduced seaweeds". Some of them are known to have proliferated vigorously and show hazardous impacts to coastal ecosystems of the recipient site (*e.g. Sargassum muticum*, *Undaria pinnatifida* and *Caulerpa taxifolia*). The native area of *U. pinnatifida* is the coastal Northwestern Pacific (Japan, Korea and eastern China). However, this species is now introduced to Europe, Pacific North America (California to Mexico), southeastern Australia, New Zealand, and Argentina. Seed populations are believed to be transported with oysters for mariculture in Europe, and by ballast water in Oceania, although actual vectors and secondary spread pathways are not well understood. To elucidate the origin of American and southern hemisphere populations of *U. pinnatifida*, and to discuss the pathways of the secondary spread, we investigated the genetic diversities among the populations around the world using mitochondrial *COX3* DNA sequence. For the native area, *U. pinnatifida* populations of western Japan showed relatively high genetic diversity (six haplotypes), whereas, those of northeastern Japan showed only a single haplotype. This haplotype was also found from the mariculture strain and in some areas in western Japan where *Undaria* mariculture is ongoing. Introduced populations in Europe, America, and Oceania also share this haplotype, suggesting their origin from the Northern Japan (or mariculture) populations. However, New Zealand populations included a second haplotype, implying multiple introductory events for the New Zealand populations.

PICES XIII S5-1928 Invited
What do temporal trends in invasion records really mean?

Marjorie J. **Wonham**[1] and Elizaveta Pachepsky[2]

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Biological invasions in many marine systems appear to be increasing and perhaps even accelerating, but these trends are notoriously difficult to interpret. Hypotheses to account for the apparent increase in invasions include an increase in introduction rates, invasion success, and reporting. Distinguishing among these hypotheses requires a clear distinction among their null expectations. To this end, we introduce a simple probabilistic framework for considering the number of successful invaders over time as a function of introduction rates and survival probabilities, and compare the model's predictions to empirical data. We show that empirical data are best analysed as a non-cumulative distribution of introduction times, that an increasing distribution of introduction times does not necessarily indicate an increasing introduction rate or survival probability, and that simple variation in introduction rates and survival probabilities can generate apparently linear, quadratic, exponential, or sigmoid distributions of introduction times.

S6 MEQ Topic Session
Marine Protected Areas

Session Convenors: Glen Jamison (Canada) and Chinese scientist (TBD)

Marine protected areas (MPAs) are increasingly being recognised as both a fishery management tool and as means to re-establish reference areas of relatively undisturbed biodiversity and productivity. There are proposals to declare substantial (20-30%) portions of all habitats as fully protected as is possible, and some studies suggest that this action may enhance local fisheries. The goals of this session are: (i) to review the nature and characteristics of existing and proposed MPAs in PICES countries; (ii) to review scientific data as to the utility of MPAs in improving our understanding of marine ecosystems and in fishery enhancement; and (iii) to compare experiences with MPAs in both tropical and temperate waters.

Thursday, October 21, 2004 13:30-16:20

13:30-14:15 **Peter Taylor** (Invited)
Offshore MPAs: The opportunities and the challenges (S6-2123)

14:15-14:35 **Lance E. Morgan, Sara Maxwell, Fan Tsao, Tara Wilkinson and Peter Etnoyer**
Identifying priority conservation areas for the Baja California to Bering Sea region (S6-2098)

14:35-14:55 **Qiulin Zhou and Chris Cosslett**
Biodiversity management in the coastal area of China's South Sea (S6-1792)

14:55-15:20 **Coffee break**

15:20-15:40 **Elizabeth A. Logerwell and Susanne F. McDermott**
The utility of trawl exclusion zones for protecting local aggregations of Atka mackerel in the Aleutian Islands, Alaska (S6-1938)

15:40-16:00 **Glen S. Jamieson and Jeff Ardron**
Marine protected areas in Pacific Canada; an approach for network design (S6-1869)

16:00-16:20 **William de la Mare**
Methods for evaluating the potential effects of MPAs on adjacent fisheries (S6-2203)

Posters

G.V. Moyseychenko and G.S. Borisenko
Ecologic and fishery studies in marine protected areas establishing (S6-2104)

PICES XIII S6-2203 Oral
Methods for evaluating the potential effects of MPAs on adjacent fisheries

William **de la Mare** and Nina Barton

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Marine protected areas (MPAs) have been proposed as a direct means of meeting a range of ecosystem objectives in fisheries management, including as tools for stock recovery via protection of spawning grounds and nursery areas, and for direct protection of critical benthic habitat. However, it is now well established that MPAs are not fully effective in ensuring a minimum level of escapement for mobile fish species, although their effectiveness increases with the size of area covered. Proposals to establish MPAs of any substantial size are usually opposed by commercial and recreational harvesters. Their resistance is driven by the concern that establishing MPAs will reduce both catch rates and total catch. Although there are a number of studies that have addressed the long-term benefits of MPAs to fisheries in terms of increased catches and catch rates, many harvester concerns arise from the apprehension that establishing MPAs will have severe effects in both the short and long term. Establishing the likely effects on catches and catch rates over both short and long time scales will be key information in reducing harvester dissent over the establishment of MPAs. We develop a spatial model of a groundfish population that allows for fish movement due to processes of diffusion, directed movement and density dependent habitat selection. We then use this model to develop and evaluate some methods for predicting the potential effects on fisheries of establishing MPAs of differing sizes and locations. We examine the potential roles of information derived from both fisheries and independent scientific surveys. The aim of the study is to develop predictive methods that will help the various stakeholders evaluate the costs and benefits of establishing MPAs on fisheries for representative groundfish species.

PICES XIII S6-1869 Oral
Marine protected areas in Pacific Canada; an approach for network design

Glen **Jamieson**[1] and J. Ardron[2]

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Existing legislated marine “protected” areas are now widely distributed throughout temperate waters, but the nature of human activities actually restricted in any area varies from none to all resource exploitation. This ambiguity about what “protected” really means makes it difficult to evaluate the benefits and costs of marine protected areas. In Pacific Canada, most existing legislated marine protected areas are not currently associated with any fisheries restrictions. We summarise the history of marine resource protection in Pacific Canada; protected area rationales include conservation and protection of commercial and non-commercial fishery resources, endangered and threatened species, unique habitats and areas of high biodiversity or biological productivity; and representation of habitat types. Rationales such as replication, rarity, and issues relating to connectivity have yet to be used. Currently, only 0.02% of BC’s marine environment is protected within no-take areas.

To demonstrate how a marine protected area network might be designed, we considered representative, rare, and distinctive marine features in an analysis that minimizes the total area required to achieve desired objectives. Model suggestions for hypothetical marine protected areas were based on 93 physical and biological data layers for the continental shelf waters of British Columbia, excluding the Strait of Georgia. Regardless of whether reserves were many and small, or few and large, specific high “conservation utility” areas were consistently identified for protection in the different scenarios.

PICES XIII S6-1938 Oral
The utility of trawl exclusion zones for protecting local aggregations of Atka mackerel in the Aleutian Islands, Alaska

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Trawl exclusion zones were established throughout the Gulf of Alaska, Bering Sea and Aleutian Islands in 2001 as a means of mitigating competition between commercial fisheries and endangered Steller sea lions. Although the exclusion zones were not specifically designed for fisheries enhancement, they have the potential to protect local aggregations of fish. In order for the zones to be effective there should be little movement of fish from inside to outside the zones and the abundance of fish within the zones should be high. We used tag release-recovery methodology to investigate the effectiveness of trawl exclusion zones in the Aleutian Islands for protecting local aggregations of Atka mackerel, the primary prey of Steller sea lions in this region. We estimated local abundance and movement probability inside and outside the trawl exclusion zones with an integrated model that uses maximum likelihood to estimate all parameters simultaneously. Results to date suggest that in some areas there is little Atka mackerel movement from inside to outside the exclusion zones and abundance inside a given zone is high. In other areas, the opposite appears to be true – movement is high and abundance is low. We suggest that these differences are due to differences in the size and location of trawl exclusion zones relative to Atka mackerel habitat. The implication of these results is that marine protected areas should be designed with consideration of the habitat requirements of fish as well as the local abundance and movement relative to MPA boundaries.

PICES XIII S6-2098 Oral
Identifying priority conservation areas for the Baja California to Bering Sea region

Lance E. **Morgan**[1], S. Maxwell[2], F. Tsao[2], T. Wilkinson[3] and P. Etnoyer[4]

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Interest in networks of marine protected areas (MPAs) for conserving marine biodiversity and recovering exploited commercial populations has increased dramatically in the last few years because the dominant paradigm–command-and-control regulation–has failed to stop biodiversity loss and fisheries collapse. In the sea, as on land, successful place-based strategies require identifying and focusing on conservation priorities because of limited political opportunity and resources. The first step of a rational MPA strategy is producing a map of the highest priority places to protect. Priority in this case reflects not only the conservation, but also the threats and opportunities to protecting these sites. To arrive at a fully integrated ecological network requires in depth research of biodiversity patterns and connectivity. Working in cooperation with the North American Commission for Environmental Cooperation, Marine Conservation Biology Institute has produced a map of priority conservation areas from Baja California to the Bering Sea (B2B). Here we describe our approach to delineating priority areas in the Northeast Pacific Ocean based on development of a broad-scale geographic information system, and selected analyses of unique benthic and pelagic features using GIS technology. The development of this GIS also provides a framework for incorporating many diverse databases, and aids in identifying poorly known areas based on their similarities in bathymetry and remotely sensed satellite data to areas with better known species diversity and abundance. In total 28 areas have been identified as priority conservation areas in the B2B region. These areas will be focal points for further action to develop a North American continental network of MPAs.

PICES XIII S6-2104 Poster
Ecologic and fishery studies in marine protected areas establishing

G.V. **Moyseychenko** and G.S. Borisenko

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Establishing new marine protected areas (MPAs) in the most biologically vulnerable parts of Russia's Far Eastern seas is now suggested as necessary. In MPA establishing, the following factors need to be considered: oceanographic regime, local peculiarities of water and pollution exchange, degree of pollution, presence of valuable or sensitive-to-pollution species, presence of vulnerable ontogenic stages of high biomass or valuable species, locations of spawning area or nursery grounds, *etc*. Although MPAs may have fisheries banned in them, the closures of any other industrial activity should be considered, particularly in the following areas: the area of the existing Magadan preserve; the north-eastern part of the Okhotsk Sea; areas around the Shantar, Yamskie, and Tyuleniy Islands and the Pyagina Peninsula, and where the spawning and growing of pollock, herring, halibut, and crabs occur.

In particular, in the north part of the Okhotsk Sea, it is suggested all industrial activities should be prohibited in the following areas:

1. Shantar Island area, including Kashevarov Bank, as it is the area of pollock spawning and juvenile occurrence;
2. Shelekhov Bay and links to the shelf of Kamchatka, as it is an important area of pollock and sole spawning, and the main habitat of halibut, herring, and Kamchatka crab;
3. The area off the Tauya River mouth, an important area for pollock spawning and habitat for herring and groundfish.

The ecological importance of the north Kamchatka shelf has been well described, and a preserve zone has been established since the 1950s in "Fishing Rules" between 56-57^{o}N. However, to protect Kamchatka crab (*Paralithodes camtschatica*) spawning area, fishing and any other industrial activity should also be banned an additional 50 km to the North of the closure area.

PICES XIII S6-2123 Invited
Offshore MPAs: The opportunities and the challenges

Peter **Taylor**

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There are only a few countries in the world that have taken on the challenge of establishing a comprehensive, adequate and representative system of marine protected areas for their entire marine jurisdiction. All Australian Governments that have responsibilities for marine and coastal areas are committed to establishing a National Representative System of Marine Protected Areas.

This paper describes how the Australian Government is embracing the challenge of establishing MPAs in its jurisdiction (seaward of three nautical miles to the limit of its Exclusive Economic Zone) based on a comprehensive marine bioregionalisation being developed as part of Australia's Oceans Policy. The MPA program is being implemented through large provincial scale regional marine planning. The marine environment covered by the Government's jurisdiction ranges from shallow shelf and tropical habitat systems including rocky and coral reef systems through to dramatic shelf break and continental shelf slopes, steep canyons, seamounts, and deep water ecosystems.

Very little systematic marine research has been undertaken within the offshore marine regions of Australia. Geomorphic and bathymetric mapping has been one of the most consistent tools available for MPA development in these offshore regions. While some good biological and oceanographic data is available, its value to MPA selection and identification has been limited.

The paper outlines the types and scale of scientific information being used to underpin decision making for MPA development in the Southeast marine region and the challenges this generated. Recognizing the limitations on scientific information the Government has established mechanisms to blend stakeholder expertise and knowledge of these offshore marine regions through a collaborative approach to MPA design. In addition to building confidence and trust with stakeholders, a number of 'unintended' consequences are emerging that will ultimately improve the integrity of the MPA outcomes and will directly impact on long term research and compliance issues. This long-term view will be critical given the remoteness of these prospective MPAs and the cost of research and compliance.

The paper will summarize the key challenges in balancing the role science and the role of stakeholders in this large regional scale offshore MPA development program. It will also outline some of the important scientific challenges that have emerged as a consequence of open dialogue with industry groups. Some of these include:

- The adaptation of fisheries ecological risk assessments for multiple use decision making
- The building of GIS based decision-making tools to assist all stakeholder groups to contribute to the design of MPA options
- The emerging commitment from the oil and gas industry and the fishing industry to contribute to biological surveys (in the form of both financial and boat time) to further assess prospective MPAs
- A recognition that offshore MPAs will require adaptive approaches to management as further information is sought and analyzed. Management zoning for example may need to be adjusted, as biodiversity values of MPAs are better understood.

PICES XIII S6-1792 Oral

China: Biodiversity management in the coastal area of China's South Sea

Qiu-Lin **Zhou**

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A United Nations Development Programme (UNDP) project is helping to ensure long-term conservation and sustainable use of marine biodiversity in China's South Sea coastal area through an innovative cross-learning process among multiple sites. Participation and co-operation of all relevant Governmental and non-Governmental stakeholders is critical to the project's success. Activities are concentrated within five coastal provinces where conservation of renewable resources at four existing Marine Protected Areas (MPAs) will be strengthened. At the same time, key issues and management options applicable to both the local MPAs and the broader seascape area will be assessed. The issues and tools to address them were selected for study because of their relevance at both local sites and other coastal locations. Reduction and removal of threats and impacts and application of tools for conservation and sustainable use will be the focus of the first stage of the project, with intensive cross-site learning for managers and officials from relevant project sites. In the project's final stage, successful procedures will be applied at other MPAs within the project area, with the goal of deriving best practices from project experience and encouraging their widespread usage.

S7 POC/MONITOR Topic Session
Application of Global Observing Systems to physics, fisheries, and ecosystems

Co-sponsored by Argo

Session Convenors: Michael G. Foreman (Canada), Vyacheslav B. Lobanov (Russia), Phillip R. Mundy (U.S.A.) and Sei-Ichi Saitoh (Japan)

Problems such as global climate change, carbon cycling, ocean circulation forecasting, and variability in biomass and fish abundance have necessitated a great increase in the variety and quantity of ocean measurements. In response to these growing demands, the last two decades have seen a proliferation of new technologies for remotely sensing the physical and chemical properties of oceans and the biological characteristics of organisms living in them. Noteworthy examples include the TOPEX/Poseidon/Jason and ERS/Envisat satellites for sea surface heights, SeaWiFS and MODIS for ocean colour, and Argo profiling floats for deep ocean velocities, temperatures, and salinities. Technologies such as these allow interdisciplinary, near-realtime sampling of the global ocean with unprecedented resolution in time and space. In this session we welcome papers on the application of global observing systems to the description and better understanding of important physical, fishery, and ecosystem processes in the North Pacific Ocean.

Tuesday, October 19, 2004 8:30-17:20

08:30-09:00 **W. John Gould and Dean Roemmich** (Invited)
The Argo Project: New observations of the physical state of the ocean and their potential application to climate, including fisheries and ecosystems impacts (S7-1981)

09:00-09:20 **William Crawford, Peter Sutherland and Peter van Hardenberg**
Origin and persistence of anomalously cold water in the halocline of the Eastern Gulf of Alaska, 2002 to 2004 (S7-2160)

09:20-09:40 **Toshiyuki Sakurai, Yukio Kurihara and Tsurane Kuragano**
A new daily SST product of JMA (merged satellite and *in-situ* data Global Daily SST) (S7-1911)

09:40-10:00 **Fan Wang, Pengfei Lin and Yongli Chen**
Seasonal cycle of topography in the Bohai Sea and Yellow Sea and its relationships with atmospheric forcing and oceanic adjustment (S7-2176)

10:00-10:20 **Coffee break**

10:20-10:50 **Masafumi Kamachi, Shiro Ishizaki, Norihisa Usui, Yosuke Fujii and Toshiya Nakano** (Invited)
Data assimilation in the Pacific Ocean as an application of an observing system to physical oceanography and climate research (S7-2029)

10:50-11:10 **George Shevchenko and Alexander Romanov**
Seasonal variations of Okhotsk Sea circulation from Topex/Poseidon satellite altimetry data (S7-1860)

11:10-11:30 **Michael Foreman, Josef Cherniawsky and Patrick Cummins**
A high-resolution assimilating tidal model for the Bering Sea (S7-1870)

11:30-11:50 **Gennady A. Platov and Elena N. Goloubeva**
Seasonal variation of the salinity belt structure off the Primorie coast: A numerical study (S7-1803)

11:50-13:00 **Lunch**

13:00-13:30 **Donald R. Kobayashi** (Invited)
Application of satellite remotely sensed environmental data to pelagic larval transport, growth, and survival (S7-2002)

13:30-13:50 **P. Ted Strub, Corinne James and Andrew C. Thomas**
Comparison of climatic signals (winds, satellite SSH, SST and surface chlorophyll-a pigment concentrations) in the NE and SE Pacific: 1993-2004 (S7-2044)

13:50-14:10 **Kosei Sasaoka, Sei-ichi Saitoh, Hiroaki Sasaki, Tsuyoshi Miyamura and Tsutomu Yoshida**
Bio-optical properties and in-water algorithm validation for ocean color remote sensing in the sub-arctic North Pacific (S7-1946)

14:10-14:30 **Hiroki Takemura and Sei-ichi Saitoh**
Temporal and spatial variability of phytoplankton biomass and productivity in the Eastern Kamchatka Current region and along the Kuril Islands (S7-2027)

14:30-14:50 **Angelica Peña and William Crawford**
Phytoplankton distribution in the Queen Charlotte Basin: Regions of high productivity (S7-2164)

14:50-15:20 **Coffee break**

15:20-15:40 **David Welch**
POST: The development of a permanent continental-scale acoustic tracking array for west coast fisheries research (S7-1832)

15:40-16:00 **Claudio Silva, Eleuterio Yáñez, Karen Nieto, María Angela Barbieri and Guillermo Martínez**
Spatial anchovy availability index for northern Chile (S7-1854)

16:00-16:20 **Sonia Batten, David Hyrenbach, William Sydeman, Ken Morgan, Mike Henry, Peggy Yen and David Welch**
Characterising meso-marine ecosystems of the North Pacific (S7-1819)

16:20-16:40 **Konstantin Rogachev, Eddy Carmack and Natalya Shlyk**
The impact of the wind stress curl on the sea level and boundary currents in the Pacific western subarctic (S7-1782)

16:40-17:00 **Gleb Panteleev, Dmitri Nechaev and Motoushi Ikeda**
Summer circulation in the Bering Sea derived as a variational inverse of climatological data (S7-1926)

17:00-17:20 **Mao-Chang Cui and Mo Jun**
El Niño Phenomenon in SODA data (S7-1801)

Posters

Yury N. Volkov, Igor E. Kochergin, Alexey F. Scherbinin, Pavel A. Fayman, Sergey I. Rybalko and Mikhail V. Mishchenko
Diagnostic simulation of Peter the Great Bay (Japan Sea) currents (S7-1967)

Pavel A. Fayman
Diagnostic simulation of the Japan Sea currents (S7-2010)

Pavel A. Fayman
Diagnostic simulation of the Okhotsk Sea currents (S7-2009)

E. Godínez-Domínguez, C. Franco-Gordo, G. Lucano-Ramírez, S. Ruíz-Ramírez, J. Rojo-Vázquez and J. Freire
Main effects of the 1997-1998 ENSO event in the tropical coastal ecosystem in the Mexican Central Pacific (S7-2189)

Victor I. Kuzin
North Pacific surface temperature fields analysis (S7-2090)

Michelle Li and Paul Myers
Mixed layer depth variability in the Gulf of Alaska from Argo and from ship-based observations (S7-2202)

Vyacheslav B. Lobanov
Regional implementation of GOOS in the Northwestern Pacific: Second phase of the NEAR-GOOS project (S7-2054)

Nikolai A. Maximenko and Pearn P. Niiler
Improved decade-mean sea level of the North Pacific with mesoscale resolution (S7-1810)

Sung Hyun Nam, Jong Jin Park, Yun-Bae Kim, Young Ho Kim, Duk-Jin Kim, Kyung-Ae Park, Jae-Yul Yun, Woo-il M. Moon and Kuh Kim
Observing systems in the East (Japan) Sea: A monitoring buoy with moored instruments, surface and subsurface drifting floats, and satellite measurements (S7-2006)

George Novinenko and George Shevchenko
Satellite data based determination of SST spatial structure and the forecast of seasonal changes in the Okhotsk Sea (S7-1861)

Jong Jin Park, Kyung-Ae Park, Kuh Kim and Yong-Hoon Youn
Upper ocean response to typhoons and tropical storms (S7-2007)

Dmitry D. Kaplunenko, Vladimir I. Ponomarev, Young J. Ro, Olga O. Trusenkova and Serge T. Trusenkov
Climate variations during the 20th century in the Northwest Pacific region (S7-1974)

Roberto M. Venegas, P. Ted Strub, Emilio Beier, Ricardo Letelier and Andrew Thomas
Interannual and seasonal variability of satellite-derived chlorophyll pigment, sea surface height, temperature and wind stress in the northern California Current system (S7-2196)

PICES XIII S7-1819 Oral
Characterising meso-marine ecosystems of the North Pacific

Sonia **Batten**[1], David Hyrenbach[2], William Sydeman[3], Ken Morgan[4], Mike Henry[5], Peggy Yen[3] and David Welch[6]

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Living marine resource management and oceanic conservation are increasingly moving towards ecosystem-level approaches yet our ability to fully characterise and monitor multi-trophic ecosystem constituents and processes remains limited. Remote sensing imagery and advances in underway sampling technology available to survey physical and biological distributions concurrently have facilitated studies from high-speed vessels. Our study, using a commercial vessel as a platform, was designed to examine meso-scale physical and biological variability across a vast expanse of the sub-arctic North Pacific Ocean, from BC (Canada), through the southern Bering Sea, to Hokkaido (Japan). Plankton samples were collected with a Continuous Plankton Recorder (CPR) towed behind the vessel and a trained observer recorded seabird distributions. Physical properties along the survey track were examined using a temperature logger mounted on the CPR and XBTs deployed by the ship. Additionally, sea surface height, temperature and chlorophyll *a* concentrations were available from satellite imagery. Using community composition analyses, we first allowed the biological communities to define distinct geographic regions, which we term 'meso-marine ecosystems' (MMEs). Subsequently we examined the physical characteristics of each region to interpret the processes responsible for the observed biological patterns. There are ten distinct communities of co-occurring lower-trophic and upper-trophic ecosystem constituents, occurring in multiple years, which are associated with different bathymetric domains and the current system of the sub-arctic North Pacific, also influenced by mesoscale features of the circulation. These MMEs differ in the composition and abundance of their fauna and, therefore, almost certainly their productivity. An understanding of how spatial and temporal oceanographic variability forces the physical properties, biological communities and productivity of these MMEs will enhance our ability to detect episodic (regime shifts) and long-term (global warming) environmental change across the North Pacific Ocean. It is our hope that this study, and the ongoing acquisition of seasonal data on this transect since 2003, will contribute to this enhanced understanding.

PICES XIII S7-2160 Oral
Origin and persistence of anomalously cold water in the halocline of the Eastern Gulf of Alaska, 2002 to 2004

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A patch of anomalously cold and fresh oceanic water appeared in the ocean off the west coast of British Columbia, Washington State and Oregon during the summer of 2002. The coldest anomaly resided near 100 to 150 metres below surface, and was the coldest ever measured in summer in this region. Using observations from Argo profilers we were able to track the motion of this water mass through the Gulf of Alaska during the previous six months and into the following years. It may have formed to the northwest near the centre of the Alaskan Gyre during anomalously strong Aleutian Low Pressure Systems between 1999 and 2002, and advected onto the continental margin and then through the coastal waters of the British Columbia inside passage. This anomaly persisted in the Eastern Gulf of Alaska into early 2004, and maintained cool waters at 100 to 150 m depth while the surface waters increased in temperature in late 2002 and into 2003. Therefore, surface dwelling species experienced warmer conditions in 2002 to early 2004, while species below 100 m depth experienced anomalously cooler waters.

PICES XIII S7-1801 Oral
El Niño phenomenon in SODA data

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To study how the air and sea interact with each other during the El Niño onset, the Extended Associate Pattern Analysis (EAPA) is adopted with the Simple Ocean Data Assimilation (SODA) data in the present paper. It has been proven that the associated pattern is actually (more than 90%) the 'absolute' mean state of the climate parameter field with a constant ratio when the Nino3 Index reaches all of its El Niño and La Niña extrema. Therefore, EAPA is skillfully equivalent to the composite analysis of statistical climatology. Results show that as El Niño's parents, the behavior of the air and the sea are quite different. There does not exist a relatively independent tropical atmosphere but does exist a relatively independent tropical Pacific because the air is heated from the bottom instead of from the surface and has much stronger baroclinic instability than the sea. It also has a very large inter-tropical convergence zone covering the most tropical Pacific. It is the western burst and wind convergence, coming directly from the middle latitudes, instead of Kelvin waves, that cause seawater to move eastward and produce a meridional convergence in the upper levels. This results in the typical El Niño sea surface temperature warm signal in El Niño regions.

PICES XIII S7-1967 Poster
Diagnostic simulation of Peter the Great Bay (Japan Sea) currents

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A 3D field of Peter the Great Bay (hereinafter referred to as PGB) currents is calculated for different months of the year using a non-linear diagnostic baroclinic model that takes into account bottom adherence and free surface effects. Input data include a 3D density field, bottom relief, a surface wind field, and water transport at the PGB water boundaries. Water density data were obtained from the FERHRI marine cruises made in the bay in August and November 2001 and in August and October 2003. Wind data were obtained from six meteorological stations located south of Primorsky region (Russia) and from shipboard measurements. Boundary conditions were obtained from linear diagnostic simulations of PGB currents.

Modeling results suggest that the influence produced by the Primorsky current on water movement in the bay is most strongly felt in the open part of the bay. Water circulation in small bights of PGB is dependent on wind and water transport at water boundaries and represents an aggregate of eddies of different scales and directions. The current velocity within the eddies varies between 15 and 30 cm/sec.

PICES XIII S7-2009 Poster
Diagnostic simulation of the Okhotsk Sea currents

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A 3D field of the Okhotsk Sea currents was calculated for June, August, and October using a non-linear diagnostic baroclinic model that takes into account bottom adherence and free surface effects. Input data included a 3D density field, bottom relief, sea level pressure, and water transport in the straits. Average monthly density fields were constructed based on data from RODC FERHRI, ODC RIHMI, and other Russian oceanographic organizations,

Levitus Atlas (on CD-R), and Japanese institutions (starting from the 1930s). Bathymetry data were obtained from the ETOPO5 5-minute grid. Sea level pressure data were obtained from the 1961-1990 monthly average Re-analysis data. Boundary conditions were obtained from the linear diagnostic simulation of the sea currents.

Sea currents were modeled for climatic conditions of June, August, and October. Diagnostic modeling results are in a good accord with existing circulation patterns of the Okhotsk Sea. Sea current simulations revealed the main elements of the water circulation and inter-seasonal variability.

PICES XIII S7-2010 Poster
Diagnostic simulation of the Japan Sea currents

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A 3D field of the Japan Sea currents was calculated for different months of the year using a non-linear diagnostic baroclinic model that takes into account bottom adherence and free surface effects. Input data included a 3D density field, bottom relief, sea level pressure, and water transport in the straits. Water density was calculated by water temperature and salinity data from RODC FERHRI. Bathymetry data were obtained from the ETOPO5 5-minute grid. Sea level pressure data were obtained from the 1961-1990 monthly average re-analysis data. Boundary conditions were obtained from the linear diagnostic simulation of the sea currents.

Sea currents were modeled for climatic conditions of every month of the year. Diagnostic modeling results are in a good accord with existing circulation patterns of the Japan Sea. Sea current simulations revealed the main elements of the Japan Sea water circulation such as warm sea currents in the southern part of the sea and cold sea currents in the northwestern part of the sea.

PICES XIII S7-1870 Oral
A high-resolution assimilating tidal model for the Bering Sea

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The Bering Sea plays a significant role in dissipating both semi-diurnal and diurnal global tidal energy. In this presentation a representer approach is used to assimilate M_2 and K_1 harmonics computed from TOPEX/Poseidon (T/P) altimetry into a high resolution finite element model of the Bering Sea and North Pacific Ocean. A preliminary model solution which employs a conventional drag coefficient for quadratic bottom friction is shown to produce elevation amplitudes and phases that differ significantly from the harmonics arising from analyses of T/P and tide gauge observations. The assimilation of satellite altimetry data not only rectifies this problem but it also identifies regions where dissipation beyond conventional bottom friction is needed to reconcile the model dynamics and the observations. Interesting features of the Bering Sea tides, such as shelf waves along the slope and internal tide generation from Aleutian Passes, will be illustrated and biological implications will be discussed.

PICES XIII S7-2189 Poster

Main effects of the 1997-1998 ENSO event in the tropical coastal ecosystem in the Mexican central Pacific

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The physical-biological coupling as main early effect of El Niño, represented by a decrease of nutrient availability, and a subsequent decrease of primary and secondary production were found in the eastern tropical Pacific coast. As biological indicators for the ecosystem approach, we estimate community multivariate indices (larval fish assemblage, soft bottom macroinvertebrate and coastal fish assemblages -from the first two axis of correspondence analysis-) and other univariate indicators as zooplankton biomass, larval fish, macroinvertebrate and adult fish abundances. An environmental index was constructed from (first two PCA) the ENSO index, upwelling index, local SST and salinity to comprise the regional and local variability under the ENSO event. The main effect of the 1997-98 ENSO event were recorded in pelagic than benthic-demersal communities. However no significant relation was found between fish and invertebrates indicating that there were no cascading effects. The declination of the zooplankton and larval fish biomass and abundance could be attributed to different causes. Two main factors could affect the larval fish abundance during the ENSO event: Changes in the abundance of adult fish community and changes in the reproductive patterns. The reproductive activity of fish community was analyzed and several single-species responses were found, while the reproductive stocks fluctuation could be due to changes in catchability. The larval fish abundances could be determined by mixed effects of an impoverished of the pelagic habitat during ENSO events and by changes in the reproductive activity.

PICES XIII S7-1981 Invited

The Argo Project: New observations of the physical state of the ocean and their potential application to climate, including fisheries and ecosystems impacts

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The international Argo project uses autonomous profiling floats to collect temperature and salinity data from the upper 2km of the ocean. Argo is building towards an array of 3000 floats (approximately 3° spacing) and is approaching 50% completeness. Much of the North Pacific now has full coverage.

Argo is now the major source of CTD profile data from the open ocean. Its data (that are freely available in real time) are being assimilated into models to provide ocean state analyses and forecasts.

Argo-based products, and the Argo data itself (together with satellite remote sensing data) can be used to provide a physical context within which problems of ocean ecosystems can be studied. Autonomous floats such as are used by Argo, have also demonstrated their ability to collect information on other (than CTD) parameters.

The paper will describe the Argo project and its potential to address issues of relevance to climate including ocean ecosystems.

PICES XIII S7-2029 Invited

Data assimilation in the Pacific Ocean as an application of an observing system to physical oceanography and climate research

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Sustained ocean observation and comprehensive analysis are crucial for understanding phenomena in physical oceanography and climate research. Using reanalysis products of the MRI ocean data assimilation system (MOVE), we examined ocean states in the Equatorial and North Pacific, and the value of different kinds of observations, such as in situ (ship and ARGO float) observations, and satellite sea surface height and temperature. The assimilation system, MOVE, estimates salinity (S) as well as temperature (T) fields. The system uses a three-dimensional variational method with a vertical coupled T-S Empirical Orthogonal Function mode decomposition with area partitioning (CTSA: Coupled T-S Assimilation). In the western Equatorial Pacific, fresh water is confined and a thick barrier layer develops in La Niña periods. The fresh water spreads to the central Equatorial Pacific and the thick barrier layer appears in the east in El Niño periods. The correlation between surface heat content and the barrier layer thickness is also confined. In the western North Pacific, salinity and temperature variabilities are also examined. The assimilation results show realistic structures of salinity minimum of the North Pacific Intermediate Water in the subtropical waters, and of temperature related to dichothermal and mesothermal structures in the subpolar gyres. We also report preliminary results about the impacts of salinity data on state variables (temperature, velocity and salinity itself). The CTSA is compared with conventional halfway assimilation (CHA: T-assimilation and S-climatology). The comparison shows the power of comprehensive analysis such as CTSA and the importance of each kind of observational data.

PICES XIII S7-2002 Invited

Application of satellite remotely sensed environmental data to pelagic larval transport, growth, and survival

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Larval transport and oceanographic conditions experienced by pelagic larvae were simulated using an individual-based approach to track daily larval movements in a Lagrangian modeling framework. These advection-diffusion models were configured with geostrophic currents estimated from satellite altimetry. Larval dispersal was simulated for each month of the year from 1993-2003 for 3, 6, and 12 month larval durations. Four release locations spanning the Hawaiian archipelago were evaluated, Midway Island, Maro Reef, Necker Island, and Oahu. Retention and the degree of larval influx from other areas were evaluated by tabulating successful settlement, which was scored based on larval proximity to release sites after completion of the pelagic duration. Sea surface temperature and chlorophyll concentration at each daily larval location were tabulated utilizing satellite remotely sensed data products, and these *in-situ* values were integrated over the entire larval duration for each larval track. These oceanographic variables are of critical importance in the early life history because of their hypothesized relationships to larval growth and feeding success, both critical determinants of larval survival and successful recruitment. The sea surface temperature and chlorophyll histories experienced by successfully settling larvae display strong seasonal and interannual patterns. These patterns may be useful towards understanding episodic recruitment events, as well as for posing hypotheses towards understanding the mechanisms underlying spawning seasonality. These transport dynamics and oceanographic patterns have general implications for a variety of vertebrate and invertebrate meta-populations.

PICES XIII S7-2090 Poster
North Pacific surface temperature fields analysis

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In the present paper two methods were used to analyze SST data from the ECMRF dataset. The first is the classical EOF analysis which allows a reconstruction of El Niño–La Niña events with good accuracy by using only the first few EOFs. However, the periods between these events need many more EOFs for their reconstruction. Variability in the mid-latitudes also is not separated because of strong signals in the tropics. Therefore, in order to separate these signals, the cluster method was used. The results show that, except for signals in tropics, there exist well-separated signals in the subpolar gyre and Kuroshio Extension with inter-decadal modulation.

PICES XIII S7-2202 Poster
Mixed layer depth variability in the Gulf of Alaska from Argo and from ship-based observations

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Mixed layer depths are computed, based upon a new method proposed by Kara et al. (2000), for historical measurements along line P, in the Gulf of Alaska. Forty-six years of data are used for the monthly climatological calculations. To examine variability, the data are divided into two periods, based around the changes that occurred in the 1970s, except at Station P, where a sufficient abundance of data permits the examination of the monthly mixed layer changes over 5 year pentads. These results are also compared with the main modes of climate variability in the Pacific, such as PNA, WP (west Pacific) to see which of those climate modes is driving our Station P MLD variability in a given season.

Mixed layer depths are also computed from Argo floats and mapped onto the Line P stations using an objective analysis method. Argo data from 2001, 2002 and 2003 are used. Using the historical measurements for validation, the mixed layer depths estimated from the Argo floats agree well with the shipboard observations. The 2003 data show the reduced mixed layer depths that occurred that winter. Finally, the objective analysis scheme is used to map the Argo mixed layer depths throughout the Gulf of Alaska.

PICES XIII S7-2054 Poster
Regional implementation of GOOS in the Northwestern Pacific: Second phase of the NEAR-GOOS project

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The Global Ocean Observing System (GOOS) has shown tremendous progress of both its open ocean and coastal modules over recent years. Calls by the WSSD and G8 for a global observation system as an important element for sustainable development have brought additional support for the GOOS project. Further implementation of GOOS is expected to be through developing and strengthening of GOOS Regional Alliances (GRA) network. Among the currently existing 14 GRAs, the NEAR-GOOS is aimed at developing a comprehensive and sustained ocean observing network in the North East Asian regional seas. In the initial phase of the project, a regional data management system (physical parameters only) connecting the data bases of China, Japan, Korea and Russia with real-time and delayed-mode components has been established. The objective of the NEAR-GOOS second phase (2004-2008) is an expansion toward the formation of a comprehensive regional monitoring system that will provide information on the past, present and future of the marine environment, ecosystem and climate. This should be accompanied by a pilot project entailing experiments, trials and demonstrations. Among particular actions, the

project is expected to develop new technologies for satellite data applications, coordination of drifting buoy activities in the region, and integration of a Yellow Sea monitoring system. A closer relationship with oceanographic organizations and programs in the area, and in particular with PICES, is of great importance for the success of the NEAR-GOOS plans.

PICES XIII S7-1810 Poster
Improved decade-mean sea level of the North Pacific with mesoscale resolution

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Recent data from the twin-satellite mission GRACE (Gravity Recovery and Climate Experiment Mission) corrected significant large-scale errors in previous models of the shape of the Earth's equipotential surface (geoid). Yet, new models of the mean sea level based on GRACE's data have a too coarse horizontal resolution of 300-500 km to adequately describe complex structures of frontal and boundary jets, which define the pattern of basin-scale circulation in the North Pacific. Improved mean sea level is obtained by combining this oversmoothed large-scale product with dynamical estimates of local mesoscale tilt of sea level obtained from joint analysis of concurrent drifter, satellite altimeter and wind data combined within the horizontal momentum balance equation. The hybrid product reveals complex structures of main currents even after averaging over the 1992-2002 decade and illustrates their places in the large-scale near-surface circulation. Complex dynamics of Ekman currents and contribution of higher order processes are discussed.

PICES XIII S7-2006 Poster
Observing systems in the East (Japan) Sea: A monitoring buoy with moored instruments, surface and subsurface drifting floats, and satellite measurements

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In order to understand the East Sea, we are collecting various time series data by developing a real-time monitoring buoy system with several moored instruments, and by applying new techniques for utilizing surface and subsurface drifting floats and for correcting satellite measured data. The buoy system, the East Sea Real-time Ocean Buoy (ESROB), has been deployed in the coastal ocean near the east coast of Korea. It collects meteorological and oceanographic data and transmits them to the laboratory in real-time. The time series data acquired from the ESROB are then analyzed together with other data observed from other moored arrays in the East Sea. We also are collecting Lagrangian time series data using surface and subsurface drifting floats. There are a number of surface drifters and Argo floats that have been drifting and profiling in the East Sea since 1997. These floats provide data on surface and deep (800 m) currents and profiles of temperature and salinity. From these data we are analyzing physical parameters such as current and water properties in the East Sea. We also have utilized and analyzed sea surface temperature, sea surface height, sea surface wind, surface gravity waves, and internal waves collected by NOAA/AVHRR, Jason-1 altimeter, QuikSCAT scatterometer, and the ERS/ENVISAT/RADARSAT synthetic aperture radar (SAR). The altimetric data have been corrected for high-frequency (2-20 days) barotropic motion in the East Sea. To improve our monitoring capability of physical parameters in the East Sea, we need to apply advanced technologies, for example, in telemetry, electronics, and mechanics.

PICES XIII S7-1861 Poster

Satellite data based determination of SST spatial structure and the forecast of seasonal changes in the Okhotsk Sea

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The influence of SST variations on marine ecosystems is high and has great effect on hydrobiology. The SST structure in the Okhotsk Sea has very complicated distinctive features and this is the objective of our research.

Two methods of research were chosen: the empirical orthogonal functions (EOF) method and the method of harmonic analysis. Both methods allow us to detect the bounds of oceanological structures in different ways, and were used cooperatively. Computations operated on 6 years of satellite data, reduced by 15' × 15' areas and averaged by 15 days.

Detected features included the well characterized known structures such as the Tsushima, Soya and Kuroshio Warm Currents; upwelling zones near the Middle Kuril Islands, Kashevarov Bank, and northeastern Sakhalin shelf. The amplitude of the first EOF vector is close to annual oscillation and the influence of semi-annual harmonics and other overtones is relatively small. In contrast to the first mode, the amplitude of the second vector has two main constituents: semi-annual (greater) and annual (a little smaller). This mode represents peculiarities of SST variability in the northwestern part of the Okhotsk Sea.

Harmonic analysis gives similar results. For example, areas with small annual harmonic amplitudes correspond to upwelling zones mentioned above. The phase of these harmonics increases from northwest to southeast which means earlier warming in the northwestern part of the Okhotsk Sea.

SST forecasting for the year ahead was also prepared and analyzed. Predicted SST values are in good correlation with real data. Areas with low correlation and which have a high dynamic character were contoured.

PICES XIII S7-1926 Oral

Summer circulation in the Bering Sea derived as a variational inverse of climatological data

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An estimate of the summer Bering Sea circulation is obtained as a 4-dimensional variational inverse of monthly hydrographic and atmospheric climatologies. The reconstructed evolution of temperature, salinity, and velocity fields provides the best fit to available observations and satisfies dynamical and kinematic constraints of a primitive equations ocean circulation model. The data-optimized Bering Sea state is in a general agreement with the existing schemes of circulation in the region. The reconstructed circulation allows us to derive quantitative estimates of volume transports along the major pathways and to compute water mass transformation rates typical for the summer season. The utilized technique provides also estimates of the uncertainties of the reconstructed circulation. Optimized estimates of surface heat and salt fluxes are more realistic compared with oversmoothed climatological fields and demonstrate a good agreement with independent observations. The utilized variational inversion technique can be considered as a basis for the development of a monitoring system in the region.

PICES XIII S7-2007 Poster
Upper ocean response to typhoons and tropical storms

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Profile data from Argo floats enable us to understand air-sea exchange of heat and fresh water during passage of typhoons and tropical storms in the North Pacific during the period 2000-2003. We made about 750 match-up Argo profiles before and after passage of the storms within ±10 days and 200 km distance from the typhoon center. Comparisons of the pre and post profile pairs demonstrate that the storms produce cooling of 1.0^{o}C and salinity freshening of 0.12 psu on average in the ocean mixed layer (ML). It is noted that the temperature cooling case and salinity freshening case are dominant by about 89% and about 78% of all the matching profiles, respectively. About 60% of the profiles show deepening of the ML during typhoon passage while in the other cases the ML remained the same or shoaled. We found that the change in ocean mixed layer depth (MLD) is negatively correlated with the initial value of the MLD prior to arrival of a storm. The salinity freshening in the ML has a positive correlation (with statistical significance of 99%) with cooling under weak wind gusts (less than 30 m/s), whereas salinity has a negative correlation under the strong wind gust (more than 50 m/s). We have also been monitoring other oceanic and meteorological parameters associated with characteristics of the typhoon using multi-satellite data, for example, sea surface temperature, sea surface wind vectors, precipitation, water vapor, and other variables from NOAA/AVHRR, geostationary satellite (GOES), QuikSCAT, Aqua/AMSR-E, and TRMM.

PICES XIII S7-2164 Oral
Phytoplankton distribution in the Queen Charlotte Basin: Regions of high productivity

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Sites and seasons in which phytoplankton are most abundant provide critical foraging habitat for zooplankton and higher trophic level predators. Information on phytoplankton distribution is needed to identify where and when the marine ecosystem is most vulnerable to environmental disturbance related to climate variability and to human activities. In this study, six years of SeaWiFS color satellite data (Sept. 1997- Dec. 2003) were examined to identify sites and seasons in which phytoplankton are most abundant within the Queen Charlotte Sound / Hecate Strait region. Phytoplankton aggregations were spatially related to physical forcing patterns (currents and bathymetry), but shifted location and intensity season to season and year to year. Patterns in satellite chlorophyll data were compared to local differences in wind forcing and tidal mixing to provide an indication of local versus remote forcing. Variability in the site, timing, and amplitude of peak plankton productivity should be considered when evaluating the vulnerability of this ecosystem to oil and gas exploration and extraction.

PICES XIII S7-1803 Oral
Seasonal variation of the salinity belt structure off the Primorie coast: A numerical study

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Seasonal variation of the Japan/East Sea (JES) circulation was studied by means of numerical modeling with implications for a simple assimilation technique. The main objective was to get a better understanding of the sea dynamics and thermodynamics on the basis of the GDEM dataset of monthly temperature and salinity climatology. The model developed at the ICMMG has proven to be capable of simulating the most prominent features of the JES circulation pattern. A particular problem of the salinity belt off the Primorie coast was investigated in connection with the Japan Sea intermediate water (JSIW) formation. It was found that the salinity belt structure experiences a seasonal variation due to the variation of the Tsushima Strait transport. The transport through the Tsugaru Strait is

almost constant over the whole year, while the Soya Strait transport varies over a wider range. This makes the Tsushima salty and causes warm water to flow further north and to produce an intrusion of this water type into the northern region. Entrained into the Liman Current, this water flows southward over the Primorie shelf break until it reaches the topographic shelf before broadening at around 44°N. An anticyclonic eddy formed this way involves a greater volume of Tsushima water at its southern end which makes it flow along the Primorie coast and which ends up with a salinity belt. The accumulation of this relatively salty water at this latitude brings about a deep convection during the winter season. During this period, when the intensity of the subpolar front is weak, this water penetrates further south to form the so-called JSIW.

PICES XIII S7-1974 Poster
Climate variations during the 20th century in the Northwest Pacific region

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There are many sources of observed daily/monthly mean data of the ocean - atmosphere system to study climate and its variability. The main difference between data from various sources deals with the methods applied to data augmentation. This is related particularly to filling gaps in missing data and their interpolation to regular bins, taking into account spatial and temporal variability of these data. Methods of augmentation can be based on knowledge about the structure of explored data (*e.g.* by the methods of statistical modeling), as well as on the application of hydrodynamic models for the reanalysis of the observed data.

It seems to be common practice to explore climate variability based on data from different information sources in order to compare results. Here, we study climate variations using the data of NCEP-NCAR and GHCN for the surface air temperature, and GLBSST and HadISST for ocean, Sea Surface Temperature (SST). Our main goal is to reveal the anomaly propagation of air temperature for North East Asia and SST for the Northwest Pacific. We use Complex Empirical Orthogonal Function (CEOF) decomposition, which allows us to reveal propagating signals, taking into account phase shifts between field points. The corresponding cores of the CEOF decomposition modes are situated in areas where the most significant positive or negative climatic trend takes place.

PICES XIII S7-1782 Oral
The impact of the wind stress curl on the sea level and boundary currents in the Pacific western subarctic

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During the past decades significant temporal variability in the Pacific western subarctic gyre has been reported. A major challenge is to understand the mechanisms that determine variability within the Pacific western subarctic boundary currents: the Kamchatka Current with its continuation, the Oyashio. CERSAT IFREMER satellite wind data, CTD and sea level observations are used to investigate large-scale changes in the high-latitude of the Pacific western subarctic gyre.

Sea level in the Kamchatka Current exhibits large seasonal and interannual variations (of order ~12 cm) superimposed on a pronounced decadal trend (~3cm/10 years); we focus here on the multiyear variations of sea level. Sea level in the Kamchatka Current had minimum values in 1990-91, rose through to 1997 and dropped to the year 2000. We show that interannual deviations of sea level are associated with variations of the depth of halocline. Along with the variations of sea level, the wind stress curl in the region significantly varied during the past decades ($\sim 2 \cdot 10^{-7}$ Pa/m). Wind stress curl anomaly was negative in 1993-1997 with minimum in 1995, and positive in 1998-2002 with maximum in 1999. We argue that wind stress curl forcing over the region is the most important factor in generating sea level variations within the Kamchatka Current. The ocean response on Ekman pumping is thus a major source of multiyear variability in the thermohaline structure and sea level in the Kamchatka Current. Such

anomalies in the Kamchatka Current are a response to the convergence or divergence of the anomalous Ekman fluxes. Interannual variability of the Kamchatka Current and Oyashio is thus determined by the ocean's baroclinic response to wind stress curl.

PICES XIII S7-1911 Oral
A new daily SST product of JMA (merged satellite and *in-situ* data Global Daily SST)

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Merged satellite and *in-situ* data Global Daily Sea Surface Temperature (MGDSST) analysis has been in operation at the Japan Meteorological Agency (JMA) since April 2004. SST grid point values with 0.25 degree resolution are generated in near real time. SSTs derived from AVHRR (Advanced Very High Resolution Radiometer) boarded on the NOAA-16, -17 and AMSR-E (Advanced Microwave Scanning Radiometer-EOS) on the AQUA are used in the analysis. AMSR-E Level2 data are provided by the Japan Aerospace Exploration Agency (JAXA) operationally in real time.

Satellite SST anomalies (SSTA), which are produced by subtracting daily SST climatology from satellite SSTs, are decomposed into two temporal-scale and three spatial-scale components : low- (σ> 10 days, σ; e-folding scale) and high- frequency (10>σ>5 days) for temporal; large- (σ> 100 km), middle- (100>σ>25 km) and small-(σ<25km) scale for spatial. In order to remove the biases, the decomposed low-frequency and large-scale SST fields are adjusted to *in-situ* data, by solving Poisson's equation with the similar method of Reynolds (1988). An optimal interpolation method is introduced to construct SSTA fields for each scale, and a daily anomaly is calculated as a sum of those fields. A comparison with moored and drift buoys shows the RMS and bias are about 0.6, and +0.04 degrees Celsius, respectively. The daily SSTs are available in the NEAR-GOOS Real Time Data Base (http://goos.kishou.go.jp/) and the JMA Japan-GODAE LIVE ACCESS SERVER (http://godae.kishou.go.jp/).

PICES XIII S7-1946 Oral
Bio-optical properties and in-water algorithm validation for ocean color remote sensing in the sub-arctic North Pacific

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The sub-arctic North Pacific represents one of the world's most biologically productive regions. The quantitative assessment of phytoplankton production in this region is very important to estimate global primary production. Recent development of ocean color sensors such as SeaWiFS, MODIS and GLI has been accompanied by an increased effort to establish algorithms for determining ocean optical properties, phytoplankton pigments, and primary production from ocean color imagery. However, there are still some problems of in-water algorithms for ocean color sensors in the sub-arctic North Pacific, and the bio-optical database in this region is very sparse. We carried out bio-optical measurements in the sub-arctic North Pacific from 1996 to 2003, including the sub-arctic marginal seas of the Okhotsk Sea, Bering Sea and Japan Sea. Chlorophyll-a concentrations (Chl-a) and the absorption coefficients of particulate matter, phytoplankton, detritus and colored dissolved organic matter (CDOM) were also measured in seawater samples. We examined the bio-optical properties and three kinds of bio-optical algorithms, the current NASA global algorithms, OC2, OC4 and JAXA global algorithm, GLI-OC4. Our measurements show that OC2 and OC4 algorithms tend to overestimate Chl-a in the Bering Sea and underestimate Chl-a in the northwestern North Pacific. The GLI-OC4 algorithm tends to overestimate Chl-a in the Bering Sea and Okhotsk Sea, and has higher accuracy in the northwestern North Pacific compared with OC2 and OC4. The

overestimation of chl-a in the Bering Sea with these algorithms was considered to be caused by the higher CDOM absorption in short wavelength.

PICES XIII S7-1860 Oral
Seasonal variations of Okhotsk Sea circulation from Topex/Poseidon satellite altimetry data

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Topex/Poseidon altimetry data (1993-2002) for the Okhotsk Sea and adjacent areas were collected with an along-track step of 0.25 degrees. All standard corrections, including inverse barometer (except GOT correction), were used. Tidal harmonics for 18 main constituents were estimated for each site separately using a special modification of the least squares method. Tides were predicted and subtracted from initial altimetry data. Residual series were grouped by month and used to investigate seasonal sea level changes in the Okhotsk Sea. The total range of monthly mean sea levels is about 20 cm. Geostrophic current velocities and direction were also estimated for each month. We found a well-expressed sea level minimum in the central part of the sea and a maximum in the coastal zone in winter. This indicates an amplification of the cyclonic circulation in the Okhotsk Sea in the winter season. This conclusion agrees with results of Hokkaido University long-term direct current measurements off-shore of the eastern Sakhalin shelf. (An amplification of southward-directed currents in winter was discovered.) Low sea level values and relatively weak current velocities were observed in spring. A weak maximum in the central part of Okhotsk Sea and correspondingly weak anticyclonic circulation was found in the summer as well as high sea levels along the northern coast. Probably, this maximum was induced by a so-called summer monsoon with southerly winds. Winter monsoons with stable and strong northwesterly winds are a cause of a well-expressed minimum in the northern part of the Okhotsk Sea in October and November. This result agrees with the estimation of large-scale upwelling that was made by the TINRO-Center from CTD-surveying.

PICES XIII S7-1854 Oral
Spatial anchovy availability index for northern Chile

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Historical anchovy (*Engraulins ringens*) fishery (catch, fishing effort, CPUE, characteristics and operation of purseiner fleet), environmental remote sensing (AVHRR and SeaWiFS) and oceanographic *in situ* sampling databases from northern Chile, were produced for analysis and validation purposes. Using geographical information system (GIS) and statistical software, a hindcasting analysis of relationships between anchovy distribution and the associated environmental conditions (sea surface temperature, thermal gradients, chlorophyll concentration and wind fields) was made. A model to estimate a Spatial Anchovy Availability Index (SAAI) was formulated based on fishery-environment hindcasting relationships and using GIS functions such as fuzzy logic, bayasian theory and multicriteria evaluation. The application and validation of the SAAI images in northern Chile was done during El Niño 1997-98 and La Niña 1999-2000.

PICES XIII S7-2044 Oral

Comparison of climatic signals (winds, satellite SSH, SST and surface chlorophyll-a pigment concentrations) in the NE and SE Pacific: 1993-2004

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In the NE Pacific, seasonal cycles and non-seasonal anomalies in the basin scale forcing, circulation and biological response are characterized by NCEP surface wind stress (WS), satellite altimeter sea surface height (SSH), satellite sea surface temperature (SST) and satellite (SeaWiFS) chlorophyll pigment concentrations (Chl). During the last twenty years, these show several moderate El Niño's (1986-87, 1991-92, 2002-03), a strong El Niño in 1997-98, La Niña's in 1996 and 1998-99, and a possible regime shift and intrusion of subarctic water into the California Current in 2002-03. Other papers presented in this session will describe some of the details of those events. In this paper, we identify similar events in the SE Pacific (the Humboldt and Cape Horn Currents). For example, the two pulses of high SSH during the strong 1997-98 El Niño left the Equatorial eastern Pacific and moved into each hemisphere simultaneously, but were modified differently as they traveled to mid-latitudes in each hemisphere. The other climatic signals will be examined for similar types of behavior. The motivation to link climatic signals in the eastern Pacific's two hemispheres comes from a number of studies, which find some level of synchrony in small pelagic fish populations in the Pacific and Atlantic eastern boundary currents (EBC's). Thus, we seek to link the climatic signals in the NE Pacific to other global EBC's. Our initial emphasis is on the Humboldt Current in the SE Pacific, which should be more closely connected to the same large-scale Pacific Ocean modes (atmosphere and ocean) that affect the NE Pacific. While wind and SST data sets allow us to look at a longer time period (1985-2003), emphasis will be on the shorter period covered by altimeter SSH (1993-2004), which includes the majority of the strong signals and also coincides with major field programs in the NE Pacific (GLOBEC, CoOP, NOPP, *etc.*).

PICES XIII S7-2027 Oral

Temporal and spatial variability of phytoplankton biomass and productivity in the Eastern Kamchatka Current region and along the Kuril Islands

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The temporal and spatial variability of phytoplankton biomass and productivity was investigated by multi-sensor remote sensing in the East Kamchatka Current region and along the Kuril Islands which are very important regions for various fisheries resources, such as the migration of Pacific saury. We applied ocean color (Chlorophyll-*a* (Chl-*a*), SeaWiFS), photosynthesis active solar radiation (PAR, SeaWiFS), sea surface temperature (SST, AVHRR), wind (SSM/I) and sea surface height anomaly (SSHA, AVISO) datasets to these regions. Monthly fields of primary production were calculated using the vertically generalized production model (VGPM) of Behrenfeld and Falkowski (1997). Phytoplankton biomass was higher in this study area than in the western sub-arctic gyre region. However, significant geographical differences of high biomass were identified around the Kamchatka Peninsula and along the Kuril Islands. Despite increased Chl-*a* in spring in both areas, the increase along the Kuril Islands was later than that around the Kamchatka Peninsula. Chl-*a* along the Kuril Islands was much lower than that around the Kamchatka Peninsula. Although our results showed that strong wind forcing in winter deepened the surface-mixed layer along the Kuril Islands, an increase in Chl-*a* was not observed in the same period. A possible reason for the late increase in Chl-*a* in spring may be due to the late surface stratification in spring. Our results will be an important step in clarifying the mechanism for the variability of phytoplankton biomass and productivity in the sub-arctic North Pacific.

PICES XIII S7-2196 Poster

Interannual and seasonal variability of satellite-derived chlorophyll pigment, sea surface height, temperature and wind stress in the northern California Current System

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The monthly seasonal climatology and interannual variability are examined in satellite-derived fields of surface chlorophyll pigment (CHL) concentration, sea surface height (SSH), sea surface temperature (SST) and wind-stress (TAU) in the northern California Current System between 1997 and 2003. The CHL concentrations in the study area show highest values (more than 8 mg/m3) next to the coast, especially north of the Columbia River, but decreasing in the offshore direction. The long-term mean dynamic topography comes from the Levitus hydrographic climatology and decreases next to the coast south of the Columbia River, especially south of Cape Blanco. This pattern is roughly consistent with the temporal mean of the scatterometer wind stress field, which is downwelling-favorable north of the Columbia River and upwelling favorable in the south, strongest south of Cape Blanco. SST values are also coldest next to the coast south of the Columbia River; the width of the cold coastal band increases as one move farther south. North of the Columbia River, there is a narrow band of colder water next to the coast, but also a general meridional cooling trend as one move to the north, caused by the latitudinal gradient in surface heating. Removing the harmonic seasonal cycles leaves the interannual variability, as summarized by the first 3 EOF's. El Niño conditions (1997-1998, low CHL concentrations, high SSH and SST) and La Niña conditions (1998-1999, high CHL concentrations, low SSH and SST) are observed in the 1st (and sometimes 2nd) modes of the EOF's. Maximum anomalies in CHL concentrations occurs at inshore locations north of the Columbia River during much of 1998-2000 and at inshore locations south of the Columbia River during spring and early summer of 2001-2003 (2nd EOF). Higher levels of CHL concentrations occurred along most of Pacific Northwest during 2002 (first and third mode), attributed to an intrusion of subarctic water.

PICES XIII S7-2176 Oral

Seasonal cycle of topography in the Bohai Sea and Yellow Sea and its Relationships with atmospheric forcing and oceanic adjustment

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The seasonal cycle is the most significant signal of topography and circulation in the Bohai Sea (BS) and Yellow Sea (YS). Though forced by the prevailing monsoon, it is still poorly understood due to the lack of data in the interior BS and YS. In the present study, the seasonal cycle of topography in the BS and YS and its relationships with atmospheric forcing and oceanic adjustment are examined and discussed using TOPEX/Poseidon and ERS-1/2 Sea Level Anomalies (SLA) data. The analyses revealed complicated seasonal cycles of topography mainly composed of 2 REOF modes, the winter-summer mode (WIM) and spring-autumn mode (SAM). The WIM with an action center in the BS displayed a peak and southward pressure gradient in July, and a valley and northward pressure gradient in January, which is obviously the direct response to the monsoon with about a 1-month response time. The SAM with an action center in the western south YS displayed a peak and northward pressure gradient in October and a valley and southward pressure gradient in April. After the mature period of the monsoon, the action center in the BS became weakened while that in the western south YS became strengthened because of regional convergence or divergence induced by seasonal variations of the Taiwan Warm Current and Yellow Sea Coastal Current. The direct response of topography to the monsoon resulted in the WIM, while oceanic adjustment of topography played an important role in the forming of the SAM.

PICES XIII S7-1832 Oral

POST: The development of a permanent continental-scale acoustic tracking array for west coast fisheries research

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The Census of Marine Life is helping to develop "POST", a permanent seabed acoustic array for tracking marine animals. Current plans involve the deployment of 30 or more permanent cross-shelf monitoring lines spaced along the west coast of North America, each consisting of autonomous seabed nodes spaced at roughly 1 km intervals, which would be capable of measuring direction, speed of movement, depth, and survival for tagged animals as small as 11 cm in length. Nodes would be modular and use an acoustic modem to periodically communicate with an overhead ship, which would upload data and download new programming. We are currently beginning a two-year demonstration phase for POST, involving tagging and tracking several thousand salmon smolts over a large-scale demonstration array. I will provide an overview of the results from the 2004 field season. The establishment of an acoustic array for fish tracking will also provide the data transmission and power supply backbone needed to host other ocean sensors. For example, temperature and salinity sensors could be placed on the seabed nodes, providing detailed fields of the changes in bottom temperature and salinity over time, while upward looking ADCPs and seabed current meters could provide detailed data on changes in current structure. These data could be meshed with the fish movement data to describe how animals move relative to changes in the three dimensional structure of the ocean. The ability to develop such a coastal-GOOS capability is an important aspect of the development that we must plan for.

S8 POC Topic Session
The impacts of climate change on the carbon cycle in the North Pacific

Co-sponsored by International Ocean Carbon Coordination Project (IOCCP)

Session Convenors: Kitack Lee (Korea) and Christopher L. Sabine (U.S.A.)

An important area of contemporary carbon cycle research is the linkage and response to climate change. Many recent studies have investigated carbon cycle variability in the Central and North Pacific. A significant number of these studies were related to the effects of El Niño-Southern Oscillation (ENSO) on upwelling regions of the Equatorial Pacific. Recently, there have been several studies indicating significant variability over other regions of the North Pacific and potential linkages to the Pacific Decadal Oscillation (PDO). Most of these studies covered a relatively short time frame, examined only a relatively small portion of the North Pacific, or considered only a limited number of parameters. What is often lacking is an overall picture of North Pacific carbon cycle that draws together all of these individual lines of investigation and looks for coherent patterns that may help us understand the regional significance of variability and the possible mechanisms controlling the observed spatial and temporal patterns. This session will provide a forum to present new insights into links between climate change and the carbon cycle in the North Pacific. It will showcase, in part, results from a synthesis and modeling workshop (co-sponsored jointly by NOAA, Global Carbon Project and PICES) planned for June 2004, and will bring together many scientists focusing on such phenomena in the North Pacific region. We encourage contributed papers and posters that present recent research into the carbon cycle of the North Pacific with particular emphasis on the following: climate induced inter-annual and decadal variability in air-sea CO_2 exchange; the role of the North Pacific in taking up anthropogenic carbon; changes in phytoplankton community structure and its consequences for the carbon cycle; and recent modeling and synthesis activities that aim to understand such linkages.

Day 1 Wednesday, October 20, 2004 13:30-17:10

13:30-14:00 **David M. Karl** (Invited)
Microbial biogeochemical processes in the North Pacific Subtropical Gyre (S8-2047)

14:00-14:20 **C.S. Wong, Shau-King Emmy Wong and Yukihiro Nojiri**
Carbon change during SERIES (Sub-arctic Ecosystem Response Iron Enhancement Study) (S8-1882)

14:20-14:40 **Debby Ianson, Christoph Voelker and Ken Denman**
Modelled carbon fluxes in the NE Pacific SERIES iron fertilization experiment (S8-2147)

14:40-15:00 **James Christian**
Modelling the impact of climate change on the carbon cycle: Redfield and non-Redfield models (S8-2005)

15:00-15:20 **Coffee break**

15:20-15:50 **Nicolas Gruber, Christopher L. Sabine, Richard A. Feely, Scott C. Doney, Robert M. Key, Jorge L. Sarmiento, Alexander Kozyr and the workshop participants** (Invited)
Interannual to decadal variability in the carbon cycle and biogeochemistry of the North Pacific - Highlights from the NOAA/GCP/PICES synthesis and modeling workshop (S8-2031)

15:50-16:10 **Sabine Mecking, Mark J. Warner and John L. Bullister**
Age and AOU increases at the North Pacific subtropical-subpolar gyre boundary (S8-2102)

16:10-16:30 **Hernan E. Garcia, Tim Boyer, Syd Levitus, Ricardo Locarnini and John Antonov**
Oxygen and Apparent Oxygen Utilization content variability in the upper North Pacific Ocean (1955 to 1998) (S8-1817)

16:30-16:50 **Curtis Deutsch, Steven Emerson and Luanne Thompson**
Attributing the causes of North Pacific oxygen changes (S8-1834)

16:50-17:10 **Terry E. Whitledge, Kathleen Crane, Vladimir Smolin, Kevin R. Wood and Mikhail Zhdanov**
Initial results of Russian-American Long-term Census of the Arctic (RUSALCA) Expedition: 2004 (S8-2174)

Day 2 Thursday, October 21, 2004 8:30-12:00

08:30-09:00 **Keith B. Rodgers, Richard A. Feely, Olivier Aumont, James Orr, Gurvan Madec, Nicolas Metzl, Raghu Murtugudde, Patrick Wetzel, Ernst Maier-Reimer, Corinne Le Quere, Eric Buitenhuis, Fei Chai, Galen McKinley, Yasuhiro Yamanaka, Holger Brix, Nicolas Gruber, Taro Takahashi, Rik Wanninkhof, Hisayuki Y. Inoue and Masao Ishii**
Interannual to decadal variability in Equatorial Pacific pCO_2 and surface CO_2 fluxes: An intermodel comparison (S8-2140)

09:00-09:20 **Richard A. Feely, C. L. Sabine, R. Wanninkhof, A. Murata, R. Key, C. Winn, M. F. Lamb and D. Greeley**
Decadal changes of CO_2 in the North Pacific Ocean (S8-1985)

09:20-09:40 **Hisayuki Y. Inoue, Masao Ishii, Takashi Midorikawa, Akihiko Murata and Kazuhiro Nemoto**
Variations and distributions of pCO_2^{sw} in the western North Pacific during 1990 to 2003 (S8-1876)

09:40-10:00 **Fei Chai, Lei Shi, Mingshun Jiang, Tsung-Hung Peng and Yi Chao**
Modeling decadal variability of carbon cycle in the Pacific Ocean (S8-2146)

10:00-10:20 **Coffee break**

10:20-10:40 **Chen-Tung Arthur Chen, Shu-Lun Wang, Wen-Chen Chou and David D. Sheu**
Carbonate chemistry of the South China Sea (S8-2055)

10:40-11:00 **Geun-Ha Park, Kitack Lee, Kyung-Ryul Kim and Dong-Jin Kang**
What controls the uptake of atmospheric CO_2 by the well-ventilated East/Japan Sea? (S8-2080)

11:00-11:20 **Jeong Hee Shim, Young Chul Kang, Dong Seon Kim, Jae Hak Lee and Chul Ho Kim**
Seasonal change in surface pCO_2 distribution in the East China Sea (S8-1893)

11:20-11:40 **Kathryn E. Fagan, Fred T. Mackenzie, Daniel W. Sadler and Justin Dilg**
Processes controlling air-sea exchange of carbon dioxide, Kaneohe Bay, Oahu, Hawaii (S8-2151)

11:40-12:00 **Andrey G. Andreev, C.-T. A. Chen and Nataliya Sereda**
Increases in calcium and total alkalinity in the Bering and Chukchi Seas (S8-2015)

Posters

Andrey G. Andreev and Viktoria Baturina
Interannual variability of dissolved oxygen and inorganic carbon in the Kuril Basin of the Okhotsk Sea (S8-2124)

Liqi Chen, Zhongyong Gao, Liyang Zhang and Suqing Xu
Spatial-temporal variations of pCO_2 and their driving forces in the western Arctic Ocean (S8-2180)

Masao Ishii, Shu Saito, Takeshi Kawano, Kazuhiko Matsumoto, Kazuhiro Nemoto, Hitomi Kamiya, Takashi Midorikawa and Hisayuki Y. Inoue
Decadal trend of the oceanic CO_2 in the western equatorial Pacific warm pool (S8-1915)

Shu Saito, Masao Ishii, Hidekazu Matsueda, Keizo Shutta, Masahiko Fujimura, Ikuo Kaneko and Takashi Midorikawa
Change in total inorganic carbon and dissolved oxygen along the 137°E meridian between 1994 and 2003 (S8-1918)

Kazuhiro Nemoto, Takashi Midorikawa, Hitomi Kamiya, Masao Ishii, Hidekazu Matsueda and Hisayuki Y. Inoue
Long-term trend and interannual variations of winter oceanic pCO_2 and air-sea CO_2 flux in the western North Pacific (S8-1895)

Christopher L. Sabine, Richard A. Feely, Nicolas Gruber, Robert M. Key, Kitack Lee, John L. Bullister, Rik Wanninkhof, C.S. Wong, Douglas W.R. Wallace, Bronte Tilbrook, Frank J. Millero, Tsung-Hung Peng, Alexander Kozyr, Tsueno Ono and Aida F. Rios
The oceanic sink for anthropogenic CO_2 (S8-1988)

Daniel W. Sadler
CO_2 is HOT: Fifteen years quantifying carbon dioxide in the subtropical Pacific Ocean (S8-2069)

Takayuki Tokieda and Masao Ishii
Variability in the degree of saturation for CFCs in the North Pacific Central Mode Water (S8-1917)

Nobuo Tsurushima, Yutaka W. Watanabe, Yukihiro Nojiri and Koh Harada
Temporal and spatial variation of dissolved inorganic carbon in the western North Pacific in recent years (S8-2134)

PICES XIII S8-2015 Oral
Increases in calcium and total alkalinity in the Bering and Chukchi Seas

Andrey G. **Andreev**[1], C.-T. A. Chen[2] and Nataliya Sereda[1]

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Increases in the surface air temperature and the arctic river discharge over the past century are likely to have an impact on the carbonate parameters of the seawater in the Arctic Ocean. The calcium (Ca) and total alkalinity (TA) distributions in the Arctic marginals seas are particularly interesting because this area receives much land runoff and is thus expected to undergo the greatest variations as a consequence of global climatic change. Data collected in August-September 2002 during the cruise of the R/V "*Professor Khromov*" and the historical data are used to demonstrate a significant increase of TA and Ca in the shelf areas of the northwestern Bering Sea (Anadyr Bay) and the western Chukchi Sea. Processes that may lead to the observed changes, such as the increased riverine flux of the calcium and carbonates, the salinification due to enhanced brine production related with ice grow in winter, as well as shoaling of the calcite and aragonite saturation horizons are discussed.

PICES XIII S8-2124 Poster
Interannual variability of dissolved oxygen and inorganic carbon in the Kuril Basin of the Okhotsk Sea

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Data collected between 1993 and 2003 are used to find the correlation between the temporal and spatial variations of the dissolved oxygen (DO) and inorganic carbon in the Kuril Basin of the Okhotsk Sea. Using a 60-year data set we have investigated the seasonal and interannual variability of the DO on isopycnals in the intermediate waters and its relationships with the temperature, the isopycnal depth and the upper-ocean salinity and stratification.

Our analyses revealed that the decadal oscillations and trends in the DO and temperature on isopycnals in the intermediate layer of the Kuril Basin can be explained by the increase/decrease of the supply of the Alaska Stream Current waters to the Okhotsk Sea. We find that the interannual variations in the upper-ocean salinity and density, Amur River discharge and excess precipitation over evaporation, and temperature and DO of the intermediate waters in the Okhotsk Sea are well correlated with the spatially averaged winter atmospheric pressure in the North Pacific (North Pacific Index).

The most likely scenario explaining these correlations is variability in the wintertime wind and ocean circulation regime which in turn are linked to atmospheric forcing (NPI).

PICES XIII S8-2146 Oral
Modeling decadal variability of carbon cycle in the Pacific Ocean

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To improve our understanding of physical variability and the carbon cycle response in the Pacific Ocean, especially on seasonal to decadal time scales, we have developed a physical-biogeochemical model for the Pacific Ocean. The lower trophic level ecosystem processes are linked with upper ocean carbon chemistry and embedded into a three-dimensional circulation model that is forced with observed the air-sea fluxes between 1952 and 2002. The improved physical-biogeochemical model produces a 50-year (1952-2002) retrospective analysis for the Pacific Ocean. The physical-biogeochemical model is capable of reproducing many observed features and their variability in

the Pacific Ocean. Analyses of the modeled results are focused on the North Pacific, a sink region for both natural and anthropogenic carbon. The abrupt shift in the North Pacific climate system that occurred during the mid 1970s, the modeled air-sea flux of CO_2 and the response of the upper ocean carbon cycle to this climate shift are discussed. Using the physical-biogeochemical model, we estimate how much anthropogenic CO_2 has entered into the North Pacific Ocean during the past several decades. The model estimated anthropogenic CO_2 uptake rate for various regions compare favorably with observational and other modeling estimates.

PICES XIII S8-2055 Oral
Carbonate Chemistry of the South China Sea

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In order to study the dissolved carbonate system in the South China Sea (SCS) and to understand the water mass exchange between the SCS and the West Philippine Sea (WPS), pH, total alkalinity and total CO_2 were measured aboard R/V *Ocean Researcher 1*. Because of the sill separating these two seas in the Luzon Strait with a maximum depth of 2200 m, the SCS Deep Water has the characteristics similar to the water at about 2200 m in the WPS. The minimum in pH and the maxima in normalized alkalinity and total CO_2 commonly found in the open oceans at mid-depth are also prominent in the WPS but are very weak in the SCS. Rivers, inflows of the Kuroshio Surface Water and Kuroshio Deep Water through the Luzon Strait as well as inflows through the Mindoro Strait transport carbon to the SCS year-round. On the other hand, the out-flowing Taiwan Strait water, as well as the SCS Surface and Intermediate Waters in the Luzon Strait transport carbon out of the SCS year-round. Carbon is transported into the SCS through the Sunda Shelf in the wet season but is transported out of the SCS in the dry season.

fCO_2 data and mass balance calculations indicate that the SCS is a weak CO_2 source in the wet season but an even weaker CO_2 sink in the dry season. Taken together, the SCS is a very weak CO_2 source. The anthropogenic CO_2 penetrates to about 1500 m deep in the SCS and the entire SCS contains $0.60 \pm 0.15 \times 10^{15}$ g excess carbon. Typical profiles of pH as well as the degrees of saturation of calcite and aragonite in 1850, 1990 and 2050 AD are presented. The maximum decrease in pH is estimated to be 0.16 pH unit in the surface layer with a doubling of CO_2. Aragonite in the upper continental slope may start to dissolve, thus neutralizing excess CO_2 around 2050 AD.

PICES XIII S8-2180 Poster
Spatial-temporal variations of pCO_2 and their driving forces in the western Arctic Ocean

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The 1st and 2nd Chinese National Arctic Research Expeditions were conducted in 1999 and 2003, respectively, in summer time to survey the Bering Sea and the western Arctic Ocean. The partial pressure of CO_2 in surface water (pCO_2) was continually measured using a Li-Cor 6262 CO_2/H_2O infrared analyzer onboard the icebreaker *Xuelong*. Distributions of pCO_2 show obvious geographic differences with lower values in continental shelf regions, increasing values in the slope regions and higher values in abyssal plains such as in the Canadian Basin. Major driving forces were analyzed and attributed to biological or physical processes. The Chukchi Sea appears to be a significant region for atmospheric CO_2 absorption through its characterized processes in summer time such as rapid sea ice melting, high primary production on the continental shelf and marginal ice zone (MIZ), and transformed water from the Bering Sea, *etc*. Analyzing spatial-temporal variations of pCO_2, this paper tried to distinguish different effects of driving forces to help understand the carbon cycle in the Arctic Ocean. Concentrations of pCO_2 show sharp fluctuations in the Chukchi continental shelf, which could be traced to inflows from the Bering Abyssal Plain and the Alaska coast current which bring higher pCO_2 water to the shelf. pCO_2 in the melted sea ice water zone is more stable and decreases towards the

ice edge, which is related to changes of temperature and salinity as well with the sea ice's melted state. Decreases can be found to reach the lowest in the ice edge then increase to more stable values in the pack ice zone. The temperature and salinity in surface sea water (SST and SSS) are almost steady in the pack ice zone. Therefore, biological production would play a major driving force for pCO_2 changes except for a gyre impact. For example, an abnormal increase of pCO_2 at 72.5°N along 169°W was observed where the Bering Sea water flows through. The temporal distribution of pCO_2 in the Chukchi Sea shows effects from sea ice melting, biological production and water masses transports. In the area adjacent to the Bering Strait (66-69°N), pCO_2 in mid-August is much lower than that in the end of July due to blooming of alga. In 68.5~69°N on 169°W, the pCO_2 and SST in August are much higher than in July, which could be attributed to a water mass transport from the Alaska coast current (ACC). In August in MIZ, pCO_2 and SST increased a little because SST is playing a major driving force during the sea ice melting, making the Pack ice zone recede.

PICES XIII S8-2008 Oral

Drivers of the seasonality in surface water pCO_2 in contrasting regimes in the subarctic North Pacific

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We evaluated the role of temperature, biological processes, air-sea exchange and the contribution from vertical mixing on the seasonality of surface water pCO_2 in the subarctic North Pacific during 2000. In addition to atmospheric pCO_2 and sea surface data of pCO_2 and nitrate, we used subsurface nitrate data and mixed layer depths from a new climatology and wind speed from the NCEP/NCAR Reanalysis for the evaluation. Data was divided into six domains extending from the Oyashio Current system (OY) to the Vancouver Island upwelling system including the Western subarctic Gyre (WSG) and the Alaska Gyre (AG). The magnitude of these processes showed large regional and temporal variability. In all areas, the major drivers for the monthly pCO_2 change were temperature and biological processes. The effect from air-sea exchange and vertical mixing played a minor role on the annual net pCO_2 change. However, our results also imply a difference between the controls of the pCO_2 in the WSG and the AG where vertical mixing in the WSG contributed to a pCO_2 change twice of the magnitude of the AG and showed less effect from temperature. This suggests that a change in the marine conditions (*e.g.* temperature and mixed layer depth) would have different consequences for the CO_2 system and the air-sea CO_2 flux in the AG and the WSG.

PICES XIII S8-2005 Oral

Modelling the impact of climate change on the carbon cycle: Redfield and non-Redfield models

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The biogeochemical cycles of carbon, nitrogen, phosphorus, and iron are tightly coupled in the upper ocean, and coupling of carbon cycle to other elemental cycles affects the net air-sea exchange of CO_2, "burial" of carbon in the meso- and bathypelagic ocean, and the relative importance of biotic and abiotic terms in the carbon cycle. While the Redfield Ratio remains one of the most robust and significant generalizations of ocean biogeochemistry, the assumption of fixed stoichiometry in biogeochemical ocean models is increasingly untenable. Model simulations at Station ALOHA (22˚45'N, 158˚W) show an enhancement of ocean carbon uptake in models where C/N/P ratios are permitted to vary. Several critical components of the biological pump, including primary production of organic matter and partitioning of export between dissolved and particulate organic carbon, are shown to be particularly sensitive to the variation of C/N/P ratios. In future climates, evolution of the phytoplankton community in response to climate variability may affect carbon fluxes in a number of ways that are unlikely to be adequately simulated by fixed-ratio models.

PICES XIII S8-1834 Oral
Attributing the causes of North Pacific oxygen changes

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We investigate the variability of dissolved oxygen in the upper water column of the North Pacific using a hind cast model simulation. The model applies the biogeochemical framework of the Ocean Carbon Model Intercomparison Project (OCMIP) to an isopycnal General Circulation Model (GCM) whose circulation is forced at the surface by historical atmospheric conditions. The resulting O_2 changes are similar in pattern and magnitude to those observed along repeat transects through the subtropical and subpolar gyres (Emerson *et al.* 2004). We perform a set of additional simulations designed to separate the contributions of changes in biology, ventilation, and circulation to O_2 variability. We find that the direct effect of circulation change is the dominant cause of O_2 changes over most of the North Pacific, and that model O_2 changes between the 1980's and 1990's are a transient response to circulation changes initiated in the 1970's. Variations in thermocline ventilation lead to significant O_2 decreases in the Subarctic Northwest Pacific, and changes in biological oxygen consumption are significant only in the upper thermocline.

PICES XIII S8-2151 Oral
Processes controlling air-sea exchange of carbon dioxide, Kaneohe Bay, Oahu, Hawaii

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In contrast to the open ocean, the coastal zone air-sea CO_2 exchange remains questionable because of the lack of data, particularly time series data. Kaneohe Bay, located on the windward side of Oahu, is a complex coastal region with a large barrier coral reef, numerous patch reefs, and several riverine inputs. Since September 2003 surface water has been collected bimonthly throughout the bay for total alkalinity (TA) and dissolved inorganic carbon (DIC) analysis. The partial pressure of carbon dioxide (pCO_2) is calculated using TA, DIC, and constants from Mehrbach et al. (1973), refit by Dickson and Millero (1987). For all data collected before December 2003, pCO_2^{sw} were above the atmospheric level (~375 μatm) for all sites (~400 – 1300 μatm). The highest values occurred at sites within Kaneohe Stream. The lowest values, still above atmospheric, occurred at sites outside the barrier reef, indicating that high surface water pCO_2^{sw} extend beyond the boundaries of the bay. A large storm occurred at the end of November 2003 that dramatically reduced pCO_2^{sw} to at or below the atmospheric partial pressure throughout the entire bay. This appears to be the result of increased river runoff adding additional nutrients to the bay that enhanced photosynthesis throughout the bay thereby drawing down surface water CO_2. Despite the significant effect of the storm, average pCO_2^{sw} for September 2003 through February 2004 are above the atmospheric level and indicate that Kaneohe Bay probably behaves as a net source of CO_2 throughout the year because of calcification and perhaps heterotrophy.

PICES XIII S8-1985 Oral
Decadal changes of CO_2 in the North Pacific Ocean

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The North Pacific Ocean plays an important role in controlling the long-term fate of CO_2 on Earth. Much of our understanding of the distribution of anthropogenic CO_2 in the North Pacific stems from intensive work conducted during the last two decades. Discrete high-quality dissolved inorganic carbon and total alkalinity data were acquired

as part of the WOCE/JGOFS Global CO_2 survey in the Pacific Ocean between 1991 and 1999 followed by repeat surveys in 2001 and 2004 as part of the Sub-arctic Gyre Experiment (SAGE) and Repeat Hydrography Program, respectively. The results of these research studies suggest an annual CO_2 uptake of 1.0-1.3 μmol kg^{-1} yr^{-1} in the mixed layer, based on direct observations and multiple linear regression approaches. Water column integrated uptake rates ranged from 0.25 to 1.3 mol m^{-2} yr^{-1}, depending on location and/or approach used. Deep ventilation within the Kuroshio Extension and the subsequent circulation in the subtropical gyre generates a strong east-west gradient in the anthropogenic CO_2 penetration depth. The combined effect of the tilted density surfaces and the younger waters with higher anthropogenic CO_2 concentrations leads to higher total column inventories in the western North Pacific. The gyre circulation and mixing works to smear out this anthropogenic signal. The integrated amount of anthropogenic CO_2 in the North Pacific is estimated to be 16.5 Pg C through 1994 north of the equator but not including the marginal seas. This estimate is approximately 16% of the amount of anthropogenic CO_2 taken by the global oceans.

PICES XIII S8-1817 Oral
Oxygen and Apparent Oxygen Utilization content variability in the upper North Pacific Ocean (1955 to 1998)

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Because of strong linkages, seasonal variations of oxygen, carbon, and nutrients can be used to estimate seasonal new production. However, over the past few decades a net decrease has occurred in the amount of atmospheric O_2/N_2 and oceanic O_2. In the ocean, these changes in oxygen concentration are generally larger than can be accounted for by thermal changes alone, suggesting that they are produced by biologically mediated O_2 production (marine production), vertical thermal stratification, or circulation variability. Here we use in situ data from CalCOFI, BATS, and the World Ocean Database to examine inter-annual to decadal variability in the inventories of dissolved oxygen, apparent oxygen utilization, and heat in the upper 1500 meters of the world ocean with emphasis on the North Pacific for the 1955 to 1998 time period. The water column inventories are generally characterized by relatively small linear trends superimposed on large decadal variability. Relatively lowest anomalies in the 1950s were followed by high anomalies in the mid 1980s and by low anomalies in the mid-1990s. Variability in the trends of these parameters is sensitive to the starting and ending time periods chosen to estimate any long-term trends. About half of the O_2 content variability can be explained based on gas solubility variability due to heat (temperature) content anomaly changes over the same time period. This suggests the interplay of additional forcing processes other than changes in O_2 solubility alone due to transient surface warming or cooling. The results suggest that the inventory of O_2 in the ocean is not in steady state as previously assumed.

PICES XIII S8-2031 Invited
Interannual to decadal variability in the carbon cycle and biogeochemistry of the North Pacific– Highlights from the NOAA/GCP/PICES synthesis and modeling workshop

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Evidence is accumulating that the cycling of carbon and of related biogeochemical elements varies significantly on time-scales from years to decades throughout the North Pacific (*e.g. Emerson et al.,* 2004). However, most of these studies were limited in time, space or number of parameters. What is lacking is a synthesis of North Pacific variability that may help us to understand better the possible mechanisms controlling the observed spatiotemporal patterns. We

will report results of a workshop convened this June that brought together experts to work toward eliminating this gap. The workshop focused on three central questions: How are air-sea CO_2 fluxes in the North Pacific affected by different modes of variability? How and why are the distribution of carbon, nutrients and oxygen in the water column changing with time? What are the requirements for detecting a climate change signal in the oceanic carbon cycle? Preliminary highlights that emerged from the workshop are: i) The occurence of substantial changes in the rate of surface ocean accumulation of CO_2 in the early to mid-1990s over the southern and central portions of the North Pacific, likely associated with a re-organization of the North Pacific climate state, ii) a changed perception of the observed interior ocean biogeochemical changes as reflecting decadal time variability rather than continuous linear trends, and iii) the emergence of the conclusion that most of the water column trends in oxygen are caused by physical rather than biological processes. Further analyses are under way, and we will report a more complete synthesis and a number of identified research needs at the meeting. (http://www.pmel.noaa.gov/co2/NP/)

PICES XIII S8-2147 Oral
Modelled carbon fluxes in the NE Pacific SERIES iron fertilization experiment

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The SERIES iron fertilization patch has been modelled as a physically homogeneous patch that expands and contracts in both the horizontal and the vertical entraining and losing fluid as prescribed by observations. Within the patch an ecological model, that follows carbon, nitrogen and silica independently, has been coupled to a mechanistic iron model. Chemical observations during the SERIES experiment are used to constrain the ecological/iron model. We use the model parameterization to experiment with the effect of nitrogen and silicic acid availability on carbon fluxes, focusing on carbon export.

PICES XIII S8-1876 Oral
Variations and distributions of pCO_2^{sw} in the western North Pacific during 1990 to 2003

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Measurements of the partial pressure of CO_2 (pCO_2^{sw}) have been made at least once a year in the western North Pacific (3-34˚N along 137˚E, Nemoto *et al.*, 2004) every winter since 1981. Over the 1990s, measurements of pCO_2^{sw} have been made frequently and extensively in the western North Pacific, which allow us to evaluate the seasonal, inter-annual, and long-term trends of pCO_2^{sw} in the subtropics of the western North Pacific. In order to evaluate temporal variations in pCO_2^{sw}, the curve fitting technique of Thoning *et al.* (1989) was applied to the observed data. This gave an average feature of seasonal variation in pCO_2^{sw}. During the winter season, the pCO_2^{sw} was low compared to the air (pCO_2^{air}) in latitudes slightly south of the Kuroshio ($\Delta pCO_2 = pCO_2^{sw} - pCO_2^{air} = -60\mu atm$), and it tended to increase toward south reaching levels slightly lower than pCO_2^{air} in the equatorial Pacific ($\Delta pCO_2 = -10\mu atm$). During the summer season the pCO_2^{sw} south of the Kuroshio increased to levels ($\Delta CO_2 = 20\text{-}30\mu atm$) higher than pCO_2^{air} in lower latitudes. In the area of the present work (3-35°N, 137°E), the pCO_2^{sw} showed an average growth rate of 1.6 µatm/yr (nearly equal to that of pCO_2^{air}) with large variability (±8.9 µatm/yr). Large growth rate of pCO_2^{sw} occurred in early 1998, which was probably associated with the 1997/98 ENSO phenomena. At the meeting, we will report variations in pCO_2^{sw} on time scale of months to years.

PICES XIII S8-1915 Poster

Decadal trend of the oceanic CO_2 in the western equatorial Pacific warm pool

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Decadal trends of CO_2 concentration (xCO_2) and total inorganic carbon (TCO_2) in the surface layer of the western equatorial Pacific were analyzed using data collected during 46 cruises conducted between 1990 and 2003. At 160°E (5°S–5°N), the apparent rate of CO_2 concentration increase in surface water (xCO_2^{sea}) was +5.0 ± 1.2 ppm yr^{-1} while the atmospheric (xCO_2^{air}) increase was +1.6 ppm yr^{-1}. Such a faster increase of xCO_2^{sea} relative to xCO_2^{air} is mainly ascribed to the tendency that the ENSO warm phase prevailed in the early 1990s. During the warm phase the warm pool, with lower xCO_2^{sea}, extended over the western Equatorial Pacific. In contrast, the ENSO cold phase, occurred in the period 1998-2001 when the western Equatorial Pacific was under the influence of equatorial divergence with high xCO_2^{sea}. We also analyzed the intrinsic trends of xCO_2^{sea} and TCO_2 in the warm pool observed between 150°E and 160°W by comparing the data with $21.5 < \sigma_t < 21.8$ to eliminate the influence of equatorial divergence and the influence of N_2 fixation that was often seen in a shallow mixed layer above a developed barrier layer. The increasing rate of xCO_2^{sea} in the warm pool was +1.2 ± 0.7 ppm yr^{-1} between 1992 and 2003, which is similar to the increasing rate of xCO_2^{air}. It is also consistent with the increasing rate of salinity-normalized TCO_2 of +1.0 ± 0.4 μmol kg^{-1} yr^{-1} in the warm pool during the same period.

PICES XIII S8-1918 Poster

Change in total inorganic carbon and dissolved oxygen along the 137°E meridian between 1994 and 2003

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Japan Meteorological Agency (JMA) has been making repeat observations including hydrography and partial pressure of CO_2 (pCO_2) measurements along the 137°E meridian (3°N - 34°N) in the western North Pacific. We made measurements of total inorganic carbon (TCO_2) as well as dissolved oxygen and nutrients in the water column along this line in July 1994 (WHP P9) and in November 2003, and determined the changes in these chemical parameters over the 9 years. On isopycnal surfaces sigma-theta = 25.1 - 25.4 kg/m^3, we found that salinity-normalized TCO_2 ($NTCO_2$) increased by 20.8 μmol/kg on average, which is about twice as large as that expected from the increase in pCO_2 in surface seawater, while AOU and nitrate increased by 5.1 μmol/kg and +0.98 μmol/kg, respectively. On the other hand, changes in $NTCO_2$, AOU and nitrate were +11.4 μmol/kg, +2.8 μmol/kg and +0.21 μmol/kg on sigma-theta 26.0 - 26.7 kg/m^3, and +3.1 μmol/kg, -5.7 μmol/kg and -0.99 μmol/kg on sigma-theta 26.7 - 27.0 kg/m^3 (all data are still preliminary). Data in January 1997 and in June 2000 are also to be presented and discussed.

PICES XIII S8-2047 Invited
Microbial biogeochemical Processes in the North Pacific Subtropical Gyre

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In October 1988, two transdisciplinary time-series stations were established in the open sea; one in the North Atlantic near Bermuda (BATS) and the other in the North Pacific near Hawaii (HOT). These two programs emerged from common planning to become open ocean twins with similar scientific objectives, research approaches, sampling frequencies, and methods of ecosystem interrogation. The primary objective is to observe and interpret time-dependent variations in microbial community structure and function, and the coupled changes in C-N-P cycling and energy flow through the microbial-based food web. Ideally, these repeat observations of key microbial and biogeochemical parameters would provide the data sets necessary for calibration and validation of existing ocean carbon cycle models – and, if necessary, to improve them. The repeat time-series would also provide data – largely for the first time – to define a mean state, or climatology, of oceanic microbes and processes from which a quantitative anomaly field could be derived. When our program began 15 years ago, we anticipated observing a time- and space-independent "climax" community of well known microbes. What we are finding is a complex, time-variable microbial assemblage, one that is phylogenetically diverse and metabolically versatile. For example, we have documented major shifts in community structure, induction of novel substrate processing pathways, and niche specialization/separation among otherwise closely related microorganisms, and much more. The causal mechanisms are not well understood, but appear to be consistent with ocean basin-scale climate variability. This sea of change keeps marine microbes in motion, and provides enormous opportunity for future research.

PICES XIII S8-2080 Oral
What controls the uptake of atmospheric CO_2 by the well-ventilated East/Japan Sea?

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Coastal and marginal seas account for only 7% of the surface of the world ocean. Nonetheless, they play an important role in the global carbon cycle by linking atmospheric, terrestrial, and oceanic carbon reservoirs. In particular, the East/Japan Sea could sequester a significant amount of CO_2 because it has a deep convection system, which vigorously brings surface water charged with anthropogenic CO_2 to the interior of the basin. During the period 1999-2000, a multi-national effort (USA, Russia, and Korea) led to a creation of comprehensive inorganic carbon and water mass tracer database for the East/Japan Sea. This paper presents comprehensive analysis of the basin-wide inventory of the anthropogenic CO_2 in the East/Japan Sea using high-quality inorganic carbon, alkalinity, nutrients, and chlorofluorocarbon, collected from the 1999-2000 survey. Anthropogenic CO_2 was separated from the large pool of dissolved inorganic carbon using an extended version of the ΔC^* method originally developed by Gruber et al. (1996). The extension of the method includes the use of an optimum multi-parameter analysis to determine the relative contributions from various source water types to the sample on an isopycnal surface. We attempt to find key mechanisms controlling the transfer CO_2 from the atmosphere to East/Japan Sea estimated anthropogenic CO_2 concentrations.

PICES XIII S8-2102 Oral
Age and AOU increases at the North Pacific subtropical-subpolar gyre boundary

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Changes in CFC-derived ventilation ages (pCFC-12 ages) and apparent oxygen utilization (AOU) are investigated in the eastern North Pacific, where a portion of a 1991 World Ocean Circulation Experiment (WOCE) cruise along 152ºW was repeated in 1997 and a portion of a 1985 WOCE cruise along 24ºN was repeated in 2000. Between 1991 and 1997, a large increase in pCFC-12 ages and AOU is observed at the subtropical-subpolar gyre boundary at 152ºW. pCFC-12 ages (including a correction for mixing biases) and AOU increased by as much as 4 years and 40 μmol kg^{-1}, respectively, which corresponds to an increase of 33-40%. These results are in agreement with previous studies suggesting a reduction of ventilation in the subpolar gyre. A proposed mechanism for this is a reduction or cessation of the outcropping of the core isopycnal of the age and AOU changes (σ_0 = 26.65 kg m^{-3}). Since mixing-bias corrected pCFC-12 ages and AOU at 152ºW changed in approximately equal proportions, oxygen utilization rates (OUR = AOU/age) remained roughly constant from 1991 to 1997. Hence, there is no evidence that changes in biology may be causing the differences in AOU observed at 152ºW. In contrast, OURs appear to have decreased off the coast of California in the 24ºN sections from 1985 to 2000 indicating that export production may have decreased in the fresh subpolar waters that form the eastern limb of the subtropical gyre. It is recognized, however, that the estimation of OURs is sensitive to assumptions about outcrop saturations.

PICES XIII S8-1895 Poster
Long-term trend and interannual variations of winter oceanic pCO_2 and air-sea CO_2 flux in the western North Pacific

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The Japan Meteorological Agency and Meteorological Research Institute have been conducting observations of CO_2 partial pressure in surface waters (pCO_2^{sea}) and overlying air (pCO_2^{air}) onboard the R/V *Ryofu Maru* from 3°N to 34°N along 137°E in the western North Pacific during nearly the same periods from late January to early February every winter, since 1981. We report the long-term trend and interannual variations of winter pCO_2^{sea} and air-sea CO_2 flux in the extensive area from subtropical to equatorial along 137°E based on two-decades of records. In the long term, the pCO_2^{sea} has increased at a similar growth rate (1.7-1.8 μatm yr^{-1}) to that of pCO_2^{air} (1.5-1.6 μatm yr^{-1}) over the whole region from 3°N to 34°N. These increases depend primarily on the increases in DIC concentration derived from the oceanic uptake of anthropogenic CO_2 from the atmosphere. The pCO_2^{sea} showed relatively large interannual variations (a standard deviation of yearly anomalies, Δ_{pCO_2}, 3.8-7.6 μatm), compared with pCO_2^{air} (Δ_{pCO_2}, 0.03-0.04 μatm). The air-sea CO_2 flux for January to February was estimated to be in the ranges from -0.64 ± 0.09 mol C m^{-2} at 25-28°N to 0.04 ± 0.05 mol C m^{-2} at 3-6°N and showed the insignificant secular trend with the confidence limit of 95% over the whole latitude ranges. These results suggest that the western subtropical North Pacific has acted persistently as a strong sink. The factors resulting in different interannual variations of winter pCO_2^{sea} and air-sea CO_2 flux at different latitudes will be discussed.

PICES XIII S8-2140 Oral

Interannual to decadal variability in Equatorial Pacific pCO_2 and surface CO_2 fluxes: An intermodel comparison

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An intermodel comparison of simulated sea surface pCO_2 and air-sea CO_2 fluxes for the Equatorial Pacific is presented. The models in this study include those from the University of Maine (NCOM), University of Wisconsin (MIT), MPI-Hamburg (MPI OM1-MAMMOC5), LODYC (ORCA2-PISCES), MPI Jena (ORCA2-PISCES-T), University of Maryland (ESSIC-BGCM), the Frontier Research Center for Global Change (COCO-NEMURO), and UCLA (UOM-FGM). Although the models differ in their resolution as well as their representation of the oceanic carbon cycle, they have all been forced with NCEP reanalysis fluxes over the period 1948-2002.

Model validation is performed against a wide range of oceanic CO_2 measurements spanning the last several decades. The models are first compared with the Takahashi *et al.* (surface delta-pCO_2 data product corresponding to 1995, as this provides a basin-scale dianostic of the surface delta-pCO_2 found in the models. The long-term trend as a function of latitude and longitude is also considered over the period 1960-1995 to identify the extent to which sea surface pCO_2 in the Equatorial Pacific is "tracking" the increase in atmospheric CO_2 associated with the anthropogenic transient (Feely *et al*., 1999).

We then consider variability on seasonal, interannual, and decadal timescales. The eastern, central, and western Equatorial Pacific regions are considered separately, as the processes responsible for variability in these regions are thought to be different. For the western and central Pacific, the analysis focuses on repeat cruises along 137ºE and 165ºE, as well as repeat measurements along on the equator. For the eastern equatorial Pacific, the analysis includes comparison with time series of sea surface pCO_2 constructed for 150ºW and 110ºW. Particular attention is paid to the changes associated with the transition between the mean El-Niño-like conditions which prevailed throughout the early- and mid-1990s, to the persistent La Nina conditions which followed the 1997/98 El Niño event.

PICES XIII S8-1988 Poster

The oceanic sink for anthropogenic CO_2

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Using inorganic carbon measurements from an international survey effort in the 1990s consisting of 9618 hydrographic stations collected on 95 cruises and a tracer based separation technique (ΔC*), we estimate a global oceanic anthropogenic CO_2 sink for the period from 1800 to 1994 of 118±19 PgC. Variations in surface concentrations of anthropogenic CO_2 are related to the length of time that the waters have been exposed to the atmosphere and to the buffer capacity, or Revelle Factor, for seawater. Currently, approximately 30% of the anthropogenic CO_2 is found shallower than 200 m and nearly 50% above 400 m depth. The global average depth of the 5 μmol kg^{-1} contour is 1000 m. About 60% of the inventory is found in the Southern Hemisphere. The oceanic sink accounts for ~48% of the total fossil fuel and cement manufacturing emissions between 1800 and 1994, implying that the terrestrial biosphere was a net source of CO_2 to the atmosphere of about 39±28 Pg C for the period. By contrast, over the last 20 years the net terrestrial biosphere is thought to be a sink for anthropogenic CO_2 of about 15±9 Pg C. Over the last 20 years, the percentage of anthropogenic emissions taken up by the oceans appears to be smaller than over the last 200 years. The current fraction of total anthropogenic CO_2 emissions stored in the ocean appears to be about one third of the long term potential.

PICES XIII S8-2069 Poster
CO_2 is HOT: Fifteen years quantifying carbon dioxide in the subtropical Pacific Ocean

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The Hawaii Ocean Time-series (HOT) program has continuously measured the oceanic carbon dioxide system for 15 years at Station ALOHA in the subtropical North Pacific Ocean near Hawaii. Samples are collected approximately monthly using a rosette system fitted with a SeaBird CTD. Dissolved inorganic carbon (DIC) and total alkalinity (TA) samples are returned to our shore-based laboratory and analyzed using semi-automated coulometry and open-cell titration techniques, respectively, following methods recommended by the Department of Energy (DOE). pH is determined spectrophotometrically at-sea also following DOE guidelines. The accuracy of these measurements is maintained using certified seawater reference materials. Precision for measurement of DIC is better than 1 μmol/kg and for TA it is better than 2 μmol/kg. Precision of pH measurements is 0.001 pH units with an estimated accuracy of 0.004 pH units. We are in the process of procuring a new underway pCO_2 system. HOT program data are accessible online using HOT-DOGS - the Hawaii Ocean Time-series Data Organization & Graphical System located at: http://hahana.soest.hawaii.edu/hot/hot-dogs/interface.html. A list of publications based on the HOT CO_2 time-series is accessible at: http://hahana.soest.hawaii.edu/hot/hotpub.html. Key findings include: The distributions of DIC, TA and pH are controlled by both physical and biogeochemical processes. A seasonal cycle of DIC in the surface water reveals the waters around Hawaii are a net sink for CO_2. An inventory shows the surface ocean accumulating DIC consistent with increasing atmospheric CO_2. The strength of the CO_2 sink is strongly influenced by regional changes in precipitation and evaporation due to climatic variability.

PICES XIII S8-1893 Oral
Seasonal change in surface pCO_2 distribution in the East China Sea

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Surface pCO_2, temperature, salinity, nutrients, and chlorophyll *a* were measured in the East China Sea (31~34 °N, 124~128 °E) from August 26 to September 2, 2003, and from April 28 to May 7, 2004. The high-salinity Tsushima Warm Current was observed in the eastern portion of the survey area in both years. Consequently, temperature and

salinity showed similar distributions in the summer of 2003 and the spring of 2004. By contrast, the surface pCO_2 changed dramatically from summer to spring across the shelf front, where the Tsushima Warm Current meets Yellow Sea water. High pCO_2 (> 380 μatm) in the east, and low pCO_2 (< 280 μatm) in the west, off China, were observed in the summer of 2003, and the pattern was reversed in the spring of 2004. Surface pCO_2 was positively correlated with temperature in the eastern portion of the shelf front in both summer and spring (r=0.82 and 0.74, respectively). Therefore, east of the front, temperature is thought to primarily control surface pCO_2, while west of the front it is controlled by many factors, such as fresh water discharge from Yangtze River in summer, water stability, primary productivity, and organic decomposition. The highly elevated pCO_2 west of the front in spring despite the low temperature and high chlorophyll concentration might be the result of surface water mixing with CO_2-rich bottom waters in spring or massive fresh water discharge from the Yangtze River in summer.

PICES XIII S8-1917 Poster
Variability in the degree of saturation for CFCs in the North Pacific Central Mode Water

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We made observations of chlorofluorocarbons (CFCs) in seawater along 165°E in the western North Pacific in spring. In the North Pacific Central Mode Water (NPCMW), as defined by the lower potential vorticity below the seasonal thermocline that is formed between the Kuroshio Bifurcation Front and Kuroshio Extension Front, CFC-12 have been significantly under-saturated (~96%) with respect to the atmospheric CFC-12, and the degree of under-saturation has changed year by year. Since the mode water is formed through deep vertical convection in the surface layer in winter and is considered not greatly influenced by mixing with ambient waters during the subsequent advection into the interior of the ocean, these results suggest that CFCs in the mixed layer in winter were already under-saturated with respect to the atmospheric CFCs. It is also found that the density of NPCMW is changing year by year, which suggests that the mixing ratio of subtropical water and subarctic water to form NPCMW is changing year by year. On the basis of these results, the relationship between the density and degree of CFCs under-saturation is also to be presented.

PICES XIII S8-2134 Poster
Temporal and spatial variation of dissolved inorganic carbon in the western North Pacific in recent years

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Temporal and spatial variations of dissolved inorganic carbon (DIC) in the western North Pacific were reassessed using the recent time-series data and cross-sectional data sets since the 1990s. DIC in the surface seawater have been determined by the Japanese ocean time series program at station KNOT (155°E, 44°N) from 1998 to 2004. The seasonal amplitude of DIC was more than 100 μmol/kg, which is larger than those of existing pelagic ocean time series sites. This large variation is mainly due to the biological production in spring to fall and strong vertical mixing in winter. Applying the equation of the Fourier sine expansion (Tanaka et al., 2003: GRL, 10.1029/2003GL018503), we estimated the increase rate of DIC in surface seawater at 1.0 μmol/kg/year. This value closely approximated the expected value under the equilibration between air and sea at KNOT. On the other hand, the increase rates of DIC were more variable in the intermediate and deep sea waters. We estimated the increase rates of DIC using the isopycnal data in 1992 and 2000 along the 165°E north-south transect. Increase rates of DIC were several times larger than the predicted values estimated only from the influence of anthropogenic carbon, especially in mid to high latitude areas. The distribution of DIC increase rates in the transect showed similar patterns with that of AOU. This suggests the possibility that the change of water circulation significantly influences the carbon cycle in the ocean.

PICES XIII S8-2174 Oral

Initial results of Russian-American Long-term Census of the Arctic (RUSALCA) Expedition: 2004

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In 2003, NOAA and the Russian Academy of Sciences signed a Memorandum of Understanding for World Ocean and Polar Regions Studies. The first project mentioned in the Memorandum, is a collaborative U.S – Russian Federation oceanographic expedition to the Arctic seas regions shared by both countries: the Bering and Chukchi Seas. In 2003, Russia and the United States requested proposals for sampling in U.S. and Russian territorial waters. The expedition during the summer of 2004 is the first activity under the Russian-American Long-term Census of the Arctic (RUSALCA), a joint project of NOAA and the Russian Academy of Science. The cruise objectives are to support the U.S. interagency Study of Environmental Arctic Change (SEARCH) Program [http://psc.apl.washington.edu/search/] and the NOAA Ocean Exploration Program.

These seas and the life within are thought to be particularly sensitive to global climate change because they are centers where steep thermohaline and nutrient gradients in the ocean coincide with steep thermal gradients in the atmosphere. Monitoring the flux of fresh and salt water passing through Bering Strait as well as establishing benchmark information about the distribution and migration patterns of the life in these seas are critical pieces of information needed prior to the emplacement of a climate-monitoring network in this region. During the expedition a mooring was deployed in western Bering Strait, more than 100 hydrographic stations, daily productivity measurements, microbial activity, zooplankton biomass, larval and adult fish abundance, benthic epifauna/infauna and rates of sediment processes were used to study the possible ramifications of climate change in this critical region where Pacific waters are transported into the Arctic.

PICES XIII S8-1882 Oral

Carbon change during SERIES (Sub-arctic Ecosystem Response Iron Enhancement Study)

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An iron enrichment, SERIES, was conducted July 9 to August 4, 2002 within an area of 50 km^2 near Ocean Station P (50ºN, 145ºW) in the sub-arctic Alaskan Gyre. The objective was to assess the CO_2 drawdown due to addition of iron as ferrous sulphate. Changes in CO_2 chemistry and inorganic and organic carbon budget and fluxes were observed inside the iron-enriched patch using hydrocasts and free-drifting sediment traps. Haptophytes, mainly the coccolithophorid of *Emiliania hyxleyi,* increased in the first 12 days with a maximum flux for day 11 and day 12, causing a change in pCO_2 due to the formation of biogenic calcium carbonate shell. There was another larger calcium carbonate flux from day 15 to day 19 with flux reaching the 125 m sediment trap. Diatom, which increased during the period of day 4 to day 13, remained high till day 19 after iron addition. pCO_2 drawdown was significantly large with a sudden increase in opal flux towards the end of the observational period, for day 21 to day 24, followed by high organic carbon flux in day 23. The study indicated different phases of biogenic fluxes of opal, calcium carbonate and organic carbon.

S9 CCCC Topic Session
The impacts of large-scale climate change on North Pacific marine ecosystems

Session Convenors: Harold P. Batchelder (U.S.A.), William R. Crawford (Canada), Michael J. Dagg (U.S.A.) and Suam Kim (Korea)

Although it is widely known from the fossil record of deep-sea cores that climate changes on the glacial-interglacial scale generate significant impacts on marine ecosystem productivity and structure, it is only in the last ten to fifteen years that marine scientists have begun to document evidence that basin- or large-scale climate changes might be significant forcing for decadal to millennium-scale changes in marine ecosystems. Tidbits of information led to the development of the Global Ocean Ecosystems Dynamics projects of many individual nations, and to several regional scale programs examining the influence of climate change. In 1994, PICES initiated the Climate Change and Carrying Capacity (CCCC) Program to provide an organizational framework for examining climate impacts on marine ecosystems in the North Pacific. During the past decade, the North Pacific experienced the strong 1997 El Niño and 1998 La Niña, as well, perhaps, as a regime shift in the late 1990s. The purpose of this session is to begin a general synthesis of these studies linking climate change to ecosystem productivity and structure in the North Pacific Ocean.

Many national programs examining climate – ecosystem linkages on a regional scale are nearing conclusion and will benefit by the grander scale, basin-wide, synthesis that will be initiated in this session. We believe that this session will bring together scientists from different regions of the Pacific to share their results, and will encourage collaborations for the broader synthesis that will be the topic of a PICES Symposium planned for April 2006.

Day 1 Wednesday, October 20, 2004 13:30-17:10

13:30-13:50 **Harold P. Batchelder**
U.S. GLOBEC: Significant findings of climate variability impacts on marine ecosystems in the Northeast Pacific (S9-1931)

13:50-14:10 **David Mackas and Ian Perry**
GLOBEC Canada: Results and follow-on activities (S9-2204)

14:10-14:30 **Vladimir I. Radchenko**
Russia in scientific collaboration in programs related to the GLOBEC International (S9-1842)

14:30-14:50 **Yoshioki Oozeki and Hiroaki Saito**
Progresses and achievements of GLOBEC research projects in Japan (S9-2076)

14:50-15:10 **Im Sang Oh**
Korea GLOBEC (S9-2186)

15:10-15:30 **Coffee break**

15:30-15:50 **Qisheng Tang**
The overview of Chinese National GLOBEC Program (S9-1880)

15:50-16:30 **Thomas Weingartner** (Invited)
Ecosystem structure and function on the Gulf of Alaska shelf (S9-2138)

16:30-16:50 **Julie A. Hall**
A new international research project: Integrated Marine Biogeochemical and Ecosystem Research (IMBER) (S9-2131)

16:50-17:10 **Enrique Curchitser, Dale Haidvogel, Albert Y. Hermann, Elizabeth Dobbins and Thomas Powell**
A numerical simulation of large-scale physical events in the North Pacific ocean during the 1997-2003 period (S9-1993)

Day 2 Thursday, October 21, 2004 8:30-16:30

08:30-08:50 **William R. Crawford**
The eastern Gulf of Alaska: A 36-year time series along Line-P and implications for biological impact (S9-2158)

08:50-09:10 **Adriana Huyer, P. Michael Kosro, Robert L. Smith and Patricia A. Wheeler**
Changing ocean conditions in the Northern California Current: 1997-2003 (S9-1871)

09:10-09:30 **John A. Barth, Brian A. Grantham, Francis Chan, Karina J. Nielsen, David S. Fox, Adriana Huyer, Jane Lubchenco, Bruce A. Menge, Anthony R. Kirincich, Burke Hales and Patricia A. Wheeler**
Upwelling-driven inner-shelf hypoxia and its connection to oceanographic changes in the Northeast Pacific (S9-1986)

09:30-09:50 **James Overland, Jennifer Boldt, Phyllis Stabeno, Anne Hollowed and George Hunt, Jr.**
Is the Bering Sea ecosystem stuck in a warm phase? (S9-1868)

09:50-10:10 **William Peterson and Rian Hooff**
The climate shift of 1998: Something old or something new? (S9-2081)

10:10-10:30 **Coffee break**

10:30-10:50 **Sanae Chiba, Hiroya Sugisaki and Toshiro Saino**
Decadal scale variation of copepod community structure in the Oyashio based on the Odate Collection (S9-1944)

10:50-11:10 **Kazuaki Tadokoro, Hiroya Sugisaki, Hiroaki Saito and Toshiro Saino**
Interannual variations in developmental timing of *Neocalanus* copepod populations in the Oyashio waters of western subarctic North Pacific (S9-1968)

11:10-11:30 **Jung-Hoon Kang, Woong-Seo Kim, Hae-Jin Jeong and Jae-Hoon Noh**
The latitudinal differences of mesozooplankton distribution in the Northeastern Equatorial Pacific under El Niño, La Niña and normal condition (S9-1894)

11:30-11:50 **Kenneth O. Coyle**
The Optimal Stability Window hypothesis and copepod concentrations on the Gulf of Alaska shelf during spring and summer, 1998 - 2002 (S9-1850)

11:50-12:10 **Andrei S. Krovnin and George P. Moury**
Climate variations and changes in the state of the main Northern Hemisphere fish stocks (S9-1987)

12:10-13:30 **Lunch**

13:30-13:50 **Kentaro Morita, Shoko H. Morita and Masaaki Fukuwaka**
Population dynamics of Japanese pink salmon: Does climate change explain the recent increasing trend? (S9-1789)

13:50-14:10 **Randall M. Peterman, Brigitte Dorner, Steven L. Haeseker and Brian J. Pyper**
The importance of regional-scale (< 700 km) environmental processes in driving temporal variation in recruits per spawner in Northeastern Pacific salmon (*Oncorhynchus*) populations (S9-2108)

14:10-14:30 **Lewis Haldorson, Jack Piccolo and Jennifer Boldt**
Effects of marine habitats on growth, condition and survival of juvenile pink salmon in the coastal Gulf of Alaska (S9-2035)

14:30-14:50 **Carrie A. Holt and Skip McKinnell**
Annual variability in condition factor of sockeye salmon (*Oncorhynchus nerka*) from 1915-1972 in British Columbia, Canada (S9-2032)

14:50-15:10 **Tim R. Baumgartner, Guillermo Auad, Hideaki Nakata and Arthur J. Miller**
Comparison of the effects of the 1976-77 North Pacific climate shift on the California and Japanese sardine habitats (S9-2014)

15:10-15:30 **Coffee break**

15:30-15:50 **Juergen Alheit and Andrew Bakun**
Comparison of synchronous ecological regime shifts in Humboldt and Kuroshio Currents (S9-1900)

15:50-16:10 **Shang Chen and Yoshiro Watanabe**
Did regime shift occur in the East China Sea? (S9-1807)

16:10-16:30 **Discussion**

Posters

Toby D. Auth and Richard D. Brodeur
Distribution and concentration of ichthyoplankton off the Oregon coast in 2000 and 2002 (S9-1856)

Rebecca E. Baldwin, Mary Bhuthimethee and Kym C. Jacobson
Comparing macroparasites of juvenile salmon and associated fish collected off the coast of Oregon and northern California (S9-1936)

Steven J. Bograd, William R. Crawford, Howard J. Freeland, Adriana Huyer, Jeffrey J. Polovina, Franklin B. Schwing and Robert L. Smith
On the origin and evolution of a "minty" water mass anomaly in the Northeast Pacific (S9-2084)

Richard D. Brodeur, Elizabeth A. Daly and Robert A. Schabetsberger
Interannual and interdecadal variability in juvenile salmon diets in relation to environmental changes in the Northern California Current (S9-1872)

Alexei I. Pinchuk and Kenneth O. Coyle
Interannual changes in abundance of dominant euphausiids in the northern Gulf of Alaska (S9-1859)

Svetlana V. Davidova
Dynamics of the mass pelagic fishes of the Japan/East Sea during the second part of the 20th century and factors responsible for the variation (S9-1907)

Svetlana Yu. Glebova
Reorganizations of atmosphere regime over the Far Eastern Seas occurred in 2000-2003 (S9-1804)

Albert J. Hermann, Enrique N. Curchitser, Dale B. Haidvogel and Elizabeth L. Dobbins
A comparison of remote versus local influence of El Niño on the coastal circulation of the Northeast Pacific (S9-2040)

Kym C. Jacobson and Edmundo Casillas
Varying climate-driven ocean conditions and the growth of juvenile salmonids in the California Current system (S9-1902)

Julie E. Keister and William T. Peterson
Biological patterns in years of contrasting upwelling-favorable winds (S9-2075)

Thomas C. Kline, Jr.
Spatial and temporal variability patterns in the nitrogen and carbon stable isotope composition of sub-arctic Pacific biota during the GLOBEC long-term observational program: Implications for interpreting long-term records (S9-1855)

Toru Kobari, Kazuaki Tadokoro, Sanae Chiba, Takashige Sugimoto, Kazuki Kuroda and Naoki Nagai
Interannual variations in diatom abundance during winter and summer in western tropical to subtropical Pacific (S9-2030)

Lydia B. Ladah
A coastal ocean monitoring program along the Baja California coastline: Climate change, internal waves and the kelp forest ecosystem (S9-1881)

Chung Il Lee, Kyu Dae Cho and Kwang Ho Choi
The effects of El Niño events on sea water temperature variation and squid catch in the Korean coastal and off-shore waters (S9-1949)

Jae Bong Lee, Chang Ik Zhang, Karen Hyun, Suam Kim and Dong Woo Lee
Spatio-temporal distributions of small pelagics around Korean waters using a neural network pattern recognition approach (S9-2052)

Vadim V. Navrotsky
Climate, ocean ecosystems, and sustainable fisheries (S9-1971)

Akira Nihira and Masakazu Takahashi
Decadal variations of demersal fish populations in relation to climate/oceanic regime shifts in the waters off the northeast coast of Japan (S9-2142)

Thomas C. Royer, Chester E. Grosch, Thomas J. Weingartner and Seth Danielson
A warmer and fresher Northern Gulf of Alaska? (S9-2072)

Amy R. Childers, Terry E. Whitledge and Dean A. Stockwell
Seasonal and interannual variability in the distribution and dynamics of nutrients and chlorophyll across the Gulf of Alaska shelf: 1998-2000 (S9-2175)

PICES XIII S9-1900 Oral

Comparison of synchronous ecological regime shifts in the Humboldt and Kuroshio Currents

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The low frequency dynamics of the Humboldt Current ecosystem are controlled by shifts between alternating sardine and anchovy regimes that involve restructuring of the entire ecosystem. These regime shifts are related to lasting periods of warm or cold water anomalies resulting from the approach or retreat of warm subtropical oceanic waters to the coasts of Peru and Chile. Phases with mainly negative temperature anomalies parallel anchovy regimes (1950s-1970; 1985-up to now) and the rather warm period from 1970-1985 was characterised by sardine dominance. The transition periods (turning points) from one regime to the other were 1968-1970 and 1984-1986. Similarly, the Kuroshio ecosystem (including adjacent waters east of Japan) is characterized by alternating periods of dominance of sardines or anchovies, with transition periods that have been strikingly synchronous to those of their Humboldt congeners. Japanese anchovy catches started to go down in the late 1960s/early 1970s and sardine catches began their increase in 1971 after a period of extremely low catches since 1958. Dynamics of both species reversed again in the second half of the 1980s. In contrast to the Humboldt populations, Japanese sardines thrived during cold and anchovies during warm periods. Interestingly, the mixed layer depth of the Kuroshio extension shifted in the late 1960s from shallow to deep and in 1985 from deep to shallow, almost exactly at the time of the regime shifts in the Humboldt Current. This contribution will describe the ecological regime shifts in the two Pacific ecosystems and discuss commonalities, differences and possible teleconnection patterns.

PICES XIII S9-1856 Poster

Distribution and concentration of ichthyoplankton off the Oregon coast in 2000 and 2002

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The species composition, distribution, and concentration of ichthyoplankton off the central Oregon coast in the Northeast Pacific Ocean were examined in 2000 and 2002 to investigate annual, seasonal, vertical, and cross-shelf variability. Larval concentrations were also analyzed in relation to water temperature and salinity. The 281 samples collected between April and September of the two study years yielded 4944 fish larvae comprising 72 taxa in 30 families. The most abundant taxa collected were: *Sebastes spp.*, *Stenobrachius leucopsarus*, *Engraulis mordax*, *Lyopsetta exilis*, and *Tarletonbeania crenularis*. Total larval density increased from 49.3/1000 m^3 in 2000 to 72.0/1000 m^3 in 2002, with seasonal concentrations highest in August 2000 (90.3/1000 m^3) and April 2002 (151.2/1000 m^3). Relatively few larvae were found at depths >100 m, while highest larval densities generally occurred from 10-50 m. However, *E. mordax* larvae were most often found in the upper 10 m of the water column, while *L. exilis* concentrations were highest from 50-100 m. Larval diversity and concentration were higher offshore (40-72 km) than onshore (8-24 km). Highest concentrations were normally found at an intermediate station 56 km off the coast. Species designated as either on or offshore species by previous studies where predominantly found in their respective coastal regions, except for *Clupea pallasi* larvae (an onshore species) which were taken exclusively at offshore stations. With the exception of *L. exilis*, larval densities were positively correlated with temperature and negatively correlated with salinity ($P<0.0001$).

PICES XIII S9-1936 Poster

Comparing macroparasites of juvenile salmon and associated fish collected off the coast of Oregon and northern California

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Macroparasites indicate a history of host diet due to the complex life cycles of the parasites and their relatively long life within vertebrate hosts. We examined macroparasites to better understand the trophic interactions between juvenile salmon, their prey and other pelagic nekton in the California Current System. Coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha*), jackmackerel (*Trachurus symmetricus*), Pacific herring (*Clupea pallasii*), Pacific sardine (*Sardinops sagax*), surf smelt (*Hypomeses pretiosus*), and whitebait smelt (*Allosmerus elongates*) were the dominant fish sampled by surface trawls offshore of Oregon and northern California in June and August of 2000 and 2002. Salmon had the highest macroparasite species richness (12 in 2000, and 17 in 2002). For the other fish species, macroparasite species richness ranged from 1 to 4 in both years suggesting higher prey selectivity than salmon. Two nematode species were found in all fish species and an acanthocephalan species was shared between three fish species (jackmackerel, coho salmon and chinook salmon). Trematodes may be more host specific, than nematodes or acanthocephalans, since they were only found in one host species or in phylogenetically related hosts. Seven macroparasite species were common in all sampling periods and 8 were rare. The prevalences of common macroparasites indicated varying abundances of prey and definitive hosts (*e.g.* marine birds and mammals), or a combination thereof. These observations suggest seasonal and interannual differences in ocean conditions such as temperature or upwelling events.

PICES XIII S9-1986 Oral

Upwelling-driven inner-shelf hypoxia and its connection to oceanographic changes in the Northeast Pacific

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In summer 2002, we observed the unprecedented development of severe inner-shelf (<70 m) hypoxia and resultant mass die-offs of fish and invertebrates within the northern California Current System. Severe inner-shelf hypoxia was detected during coastal oceanographic cruises along the 44.00ºN to 44.65ºN portion of the California Current System. Between July and September 2002, bottom dissolved-oxygen concentrations of 0.21–1.57 ml l^{-1} were found to extend from the shelf break to nearshore stations (700 m offshore). At the observed height of hypoxia, dissolved-oxygen-deficient bottom waters occupied up to 40 m of the water column and covered at least 820 km^2 of shelf area inshore of the 70-m isobath. In 2002, water upwelled into the euphotic zone over the shelf from a depth of ~100 m offshore was 1ºC colder and nitrate concentrations were elevated by 11.6 µM (or 64%) over past years. As a result, standing stocks of phytoplankton were two to three times higher than those observed in the four preceding years. So although source waters for the near-bottom water over the shelf were low in oxygen (1.27–1.67 ml l^{-1}) during 2002, further depletion of oxygen occurred as a result of respiration of downward fluxed carbon. Data on sea-surface height, drifter tracks and mid-shelf currents suggest an anomalous invasion of nutrient-rich, subarctic water into the California Current, forced by large-scale wind stress anomalies over the northeast Pacific. Data from 2001 and 2003-2004 suggest that summertime hypoxic bottom waters were present during more than just one year.

PICES XIII S9-1931 Oral

U.S. GLOBEC: Significant findings of climate variability impacts on marine ecosystems in the Northeast Pacific

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The U.S. GLOBEC program in the Northeast Pacific (NEP) began in 1997 with initial modeling, retrospective and long-term observation programs (LTOPs) of the Coastal Gulf of Alaska (CGOA) and northern California Current (CCS) regions. Subsequently, each region has been studied intensively, using multiple survey, process and trawling vessels, in each of two years: 2000 and 2002 for the CCS and 2001 and 2003 for the CGOA. LTOPs in the two regions have continued with sampling 5-7 times per year for 6-7 years. The GLOBEC NEP research program is structured to address three core scientific hypotheses: (1) Production regimes in the CGOA and CCS covary, and are coupled through atmospheric and ocean forcing, (2) Spatial and temporal variability in mesoscale circulation constitutes the dominant physical forcing on zooplankton biomass, production, distribution, species interactions, and retention and loss in coastal regions, and (3) Ocean survival of salmon is primarily determined by survival of the juveniles in coastal regions, and is affected by interannual and interdecadal changes in physical forcing and by changes in ecosystem food web dynamics. The GLOBEC NEP program was fortunate to sample during a period of strong signals in the ocean and atmosphere, including a 1997-98 El Niño, a 1999 La Niña, and a more persistent (regime?) shift to a different climate and ecosystem. A few results from the GLOBEC NEP program that address these hypotheses will be presented, specifically highlighting the large-scale atmospheric forcing of 2001-2002, that had significant impacts on local ecosystems in the CCS, flow-topography interactions that impact productivity and trophic patterning, and the role of mesoscale eddies in structuring coastal marine ecosystems. The legacy of the NEP program will be four-fold: (1) improved knowledge of climate variability impacts on marine ecosystems, (2) better coupled biophysical models, (3) extensive data sets that will provide a basis for future research and guidance to future monitoring programs, and (4) an improved basis for resource management.

PICES XIII S9-2014 Oral

Comparison of the effects of the 1976-77 North Pacific climate shift on the California and Japanese sardine habitats

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We compare the effects of the 1976-77 climate shift on the regional dynamics of the Kuroshio-Oyashio system and the California Current system that led to increased reproductive success for both the Japanese (*Sardinops melanostictus*) and the California sardine (*Sardinops sagax caeruleus)*. Spawning grounds of the Japanese sardine expanded eastward in the late 1970s and 1980s, from coastal waters around Japan, into the oceanic waters of the Kuroshio Current. Favorable spawning conditions for the California sardine expanded northward from more coastal waters south of 34°N latitude and shifted offshore off central and northern California. Important differences were the rapid build-up of the Japanese population compared to the slower recovery off California, and the dramatic decline of the Japanese sardine in the late 1980s and early 1990s during which the California sardine continued to maintain its increased population size. We use an ocean circulation model (OPYC) to investigate simultaneous regional changes in the eastern and western North Pacific through equilibrium runs in which the atmospheric forcing included differences in basin-wide wind stress, wind stress curl, surface heat flux, and turbulent kinetic energy averaged over the 6-year periods prior to and after the 1976-77 shift. The model results reveal fundamental changes in regional circulation that provide important insights into the relationship between the changes in ocean conditions and reproductive success of the two populations. These changes created increased seasonal availability of favorable spawning habitat as well as improved conditions for adult feeding and enhancement of survival of recruits.

PICES XIII S9-2084 Poster
On the origin and evolution of a "minty" water mass anomaly in the Northeast Pacific

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A highly unusual water mass characterized by cool, fresh ("minty") anomalies was observed at several locations within the California Current System in summer 2002. This feature was also characterized by elevated nutrient levels which supported higher primary production, but which also led to increased water column and benthic respiration and ultimately to a severe hypoxic event on the Oregon continental shelf. We use satellite and in situ measurements to describe the conditions and processes that led to the development of this anomalous water mass, and to report on its evolution and current status from a basin- and climate-scale perspective. A large-scale shift in upper-ocean conditions and circulation, away from a positive-PDO phase, occurred following the 1997-98 El Niño event. Broad changes in the gyre-scale circulation in the Northeast Pacific appear to have led to an increased flux of subarctic waters into the California Current as well as an increased equatorward transport within the California Current. We examine the historical observational record to identify periods with similar forcing conditions and/or water mass anomalies. If this minty water mass results from an ongoing process within a new climate regime, the prospects of a more productive California Current ecosystem will continue, as will the possibility of further hypoxic events.

PICES XIII S9-1872 Poster
Interannual and interdecadal variability in juvenile salmon diets in relation to environmental changes in the Northern California Current

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The feeding habits of juvenile coho (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*) were examined based upon sampling during two different time periods (1980-1985 and 1998-2003) of highly contrasting oceanographic conditions in order to determine environmental effects on interannual or interdecadal changes in taxonomic composition of prey, feeding intensity, or prey size spectra. Fish prey dominated coho and chinook diets by weight during most years, but this was more pronounced during the earlier sampling period. In terms of numerical composition, the diets were more variable on an interannual basis but decapod larvae were important prey most years for coho salmon and either decapods or fishes were important for chinook salmon. Pteropods and copepods were important prey during weak upwelling or El Niño years whereas euphausiids were important during strong upwelling or otherwise highly productive years. Hyperiid amphipods comprised a substantial proportion of the diets of both species only in 2000. Both an index of feeding intensity and prey/predator size ratios for fish prey were highly variable by year but larger than average fish prey were consumed during 1998, leading to the highest feeding intensity observed. These results will be discussed relative to trends in prey availability and early ocean survival of these two species. The highly opportunistic feeding mode of juvenile salmon allows them to be potential indicators of long-term ocean variability.

PICES XIII S9-1807 Oral
Did regime shift occur in the East China Sea?

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Since the 1990s, the regime shift of marine ecosystem has become one of the hot spots in fisheries oceanography. Most studies have focused on subarctic and temperate waters such as the Bering Sea, Oyashio, California and Kuroshio currents in the North Pacific. The regime shifts have been proved to exist in these areas. We ask the question, "Do regime shifts occur in subtropical waters such as the East China Sea (ECS)?" We have investigated the long-term change in the ECS in terms of climatic, hydrological, biological, and fisheries factors and found that regime shifts did occur in the ECS. Sea surface temperature (SST) in the ECS appears to have shifted twice: from warm to cool regime in 1940 and from cool to warm regime in 1992. Japanese sardine (*Sardinops melanostictus*) and Japanese anchovy (*Engraulis japonicus*) have had completely opposite biomass trends since 1960. Sardine shifted from low to high biomass in 1978 and back to a low level in 1998. Anchovy shifted from high to low level in 1978 then shifted to high level in 1998. Jack mackerel (*Trachurus japonicus*) and Japanese anchovy shared the same pattern of biomass trends however mackerel seem to have responded to the regime shift earlier than anchovy. Regime shift of the three fishes are strongly affected by East Asian Summer Monsoon and Pacific Decadal Oscillation. Moreover sardine is closely related to Aleutian Low Pressure Index (ALPI), Siberian-Alaskan Index and North Pacific Index too. Anchovy is closely related to ALPI and extratropical-based North Oscillation Index.

PICES XIII S9-1944 Oral
Decadal scale variation of copepod community structure in the Oyashio based on the Odate Collection

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Based on the 50 yr archival zooplankton collection, the Odate Collection, we investigated seasonal and interannual variation of copepod community structure in the Oyashio. Multivariate analysis methods revealed a distinctive decadal scale variation pattern, and major shift of the community structure roughly coincided with the North Pacific regime shift in 1976/77 and 1988. Major copepod species were classified into 3 groups depending on difference in the timing when the numerical abundance reached its maximum: Spring group, Early-summer group and Summer group, peak abundance of which was observed in April to May, May to June and June to July, respectively. In the 1970s, seasonal variation of copepod abundance was small with relatively high abundance from early spring to summer more or less for all the groups. In the 1980s, abundance in early spring as well as in mid-summer declined especially in the Spring and Early-summer groups, suggesting a short reproductive season compared to the previous decade. In the1990s, on the other hand, abundance in spring months markedly declined while mid-summer abundance increased in the Early-summer and Summer groups. These results suggested that climatic change in the late 1970s might mainly alter upper water environment from winter to spring, and subsequently affect springtime lower trophic level production, while that in the late 1980s might influence springtime to summertime condition. This study presented an implication that different climatic forcing might work between winter and summer. Possible mechanisms of the community structure change observed will be discussed in the presentation.

PICES XIII S9-1850 Oral

The Optimal Stability Window hypothesis and copepod concentrations on the Gulf of Alaska shelf during spring and summer, 1998 - 2002

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The Optimal Stability Window hypothesis (OSW) posits that year class strength of salmon is determined largely by water-column stability. In the northern Gulf of Alaska (GOA) enhanced stability is thought to improve salmon survival by elevating primary production and consequently, zooplankton forage on the GOA shelf. Stability on the GOA shelf is hypothesized to result from lower surface salinity due to elevated precipitation and runoff during periods of a strong Aleutian Low. Although seasonal abundance of the dominant copepod taxa during spring and summer, 1998-2002, was negatively correlated to salinity, correlations between abundance and the stability coefficient were weak or absent. An intense thermocline was observed in July and August across the entire shelf, during years of high and low copepod abundance. Little or no correlation was observed between copepod abundance and mixed-layer temperatures. Lowest copepod abundance was observed when cross-shelf salinity profiles revealed intrusion of oceanic water onto the inner shelf, confining lower-salinity shelf waters to a narrow region along the coast. While data support the contention that greater volumes of freshwater runoff elevates the abundance of zooplankton forage on the shelf, the data are inconsistent with the OSW hypothesis. Rather, the data are more consistent with the hypothesis that mixing of iron-poor, high-nutrient oceanic water with iron-rich waters from coastal runoff elevates phytoplankton production, thus optimizing conditions for growth and reproduction of zooplankton forage when conditions promote expansion of mixed water across the shelf.

PICES XIII S9-1859 Poster

Interannual changes in abundance of dominant euphausiids in the northern Gulf of Alaska

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The 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 as a part of U.S. GLOBEC LTOP during the production season from 1998 to 2002. *Thysanoessa inermis* and *T. longipes*, which inhabit the Alaska Coastal Current, showed a significant increase in abundance from 1998 to 2002. In contrast, the abundance of *T. spinifera* and *E. pacifica*, which were common on the outer shelf, did not changed. The spawning of *T. inermis* and *T. longipes* occurred in April-May, while that of *T. spinifera* and *E. pacifica* extended from April through October, and from July through October, respectively. The spawning of *T. inermis, T. longipes* and *T. spinifera* appeared to be closely related to the spring diatom bloom on the inner shelf, while the spawning of *E. pacifica* occurred later in season, when the temperature of the mixed layer increased. A strong association of the extended colder phase in the North Pacific, as reflected by PDO index, with the increase in abundance of *T. inermis* and *T. longipes*, indicated that progressive cooling on the inner shelf in 1998-2002 may have resulted in greater reproductive success of early spawning *T. inermis* and *T. longipes* on the inner shelf.

PICES XIII S9-2158 Oral

The eastern Gulf of Alaska: A 36-year time series along Line-P and implications for biological impact

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Regular observations of ocean properties have been made along Line-P for the past half-century. This line runs about 1400 km from the western end of Juan de Fuca Strait to Ocean Station Papa at 50ºN, 145ºW. Bottle samples and CTD casts by research vessels provide most observations, supplemented by XBT profiles from ships of opportunity. The time series in the upper 400 m is almost continuous since 1968. Temperature anomalies in several

depth ranges are computed for summer and winter. These provide one of the longest-running time series of sub-surface temperatures in the northeast Pacific Ocean. Temperature anomalies in the upper 200 metres in both summer and winter show remarkable correspondence to Los Niños and to the Pacific Decadal Oscillation (PDO). Ocean Surface temperatures (0 to 50 m depth) responded to these events within a single season. Temperature anomalies at 100 to 150 m depth responded more slowly to La Niña events, with cool subsurface anomalies persisting for up to several years following the end of La Niña. Much of the warming of waters midway along Line-P was attributed to mesoscale eddies. Closer to shore the warming and cooling might be due to anomalously warm or cool waters forced by persistent winds of Los Niños, or of longer-period PDO regimes. Many of the biological impacts of these changes in water mass temperatures will be discussed.

PICES XIII S9-1993 Oral

A numerical simluation of large-scale physical events in the North Pacific ocean during the 1997-2003 period

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We present results of a numerical simulation of the circulation in the North Pacific ocean for the period of 1997-2003. This simulation has been carried out in the context of the GLOBEC Northeast Pacific program and overlaps with its field seasons (2000-2003). The North Pacific simulation serves a dual purpose: 1. To generate initial and boundary conditions for high-resolution regional simulations in the observational domains (California Coastal Current and the Coastal Gulf of Alaska) and 2. Investigate the large-scale physical events with potential implications to the biological systems in the Northeast Pacific. We will present results evaluating the model skill in simulating the 1997/1998 El Niño and quantify the influence of this event on the circulation in the Gulf of Alaska. We also show look at the 2002 Northeast Pacific cold anomaly, and comment on the possible regime shift back to pre-1977 conditions. The model used for this simulation is the Regional Ocean Modeling System (ROMS), forced with NCEP daily fluxes and winds. The model domain extends from 30S to 65N, and from 100E to 70W at a resolution of 0.4 degrees.

PICES XIII S9-1907 Poster

Dynamics of the mass pelagic fishes of the Japan/East Sea during the second part of the 20th century and factors responsible for the variation

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Biological parameters of the main subtropical fishes of the Japan/East Sea (sardine *Sardinops melanostictus*, saury *Cololabis saira*, mackerel *Scomber japonicus*, anchovy *Engraulis japonicus*), and environments condition influenced the fish stocks fluctuations are considered. As application of the hypothesis of match/mismatch of terms of planktonivorous fishes spawn with periods of high abundance of zooplankton, mechanisms and consequences of this link for certain species in dependence on their ecology are discussed and explained for last decades. Materials have been collected for all parts of the Japan/East Sea. These data have been used to analyze the entire life cycle of fishes (early ontogeny, prespawn and reproduction period, feeding migration) in connection with environmental factors. Environmental parameters (SST anomalies for spring-winter and summer-autumn periods, EOF1 for summer and winter in the south part, atmospheric processes, development of thermal structures, and dynamics of zooplankton in the southern and northern parts of the Japan/East Sea) at the end of 20th century and the beginning of 21st century were responsible for the decreasing sardine population. Conversely, the environment was favorable for anchovy, saury and mackerel.

PICES XIII S9-1804 Poster
Reorganizations of atmosphere regime over the Far Eastern Seas occurred in 2000-2003

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Charts of sea-level atmospheric pressure, averaged for winter, spring, summer and autumn seasons, were used for the analysis of synoptic conditions over the Far Eastern Seas. The condition of the atmosphere action centers and wind circulation over each of the seas (Japan, Okhotsk and Bering) were considered. To estimate quantitatively the intensity and direction of wind transfer, Katz meridional and zonal indices were calculated. Long-term fluctuations of the atmosphere regime over the Far East region were explained as changes of types atmospheric processes (using the author's classification developed for the Japan, Okhotsk and Bering Seas separately).

The Siberian High and Aleutian Low weakened gradually in the cold seasons in 2000-2003, and the Aleutian Low shifted southwestward from its climatic position. As a result, the winter monsoon became weaker and climate in all Far Eastern Seas warmed, and this led to a decrease of ice cover. The greatest warming was in the Bering Sea in 2003. Simultaneously, gradual amplification of the summer monsoon was noted over the Far Eastern Seas in spring and summer.

The analysis of repeatability of the types of atmospheric processes for the period of 1980-2003 has shown periodic variability, with substantial variation at 8-10-year periodicities. In 2000-2003 there was an appreciable reduction of repeatability of the "cold" winter types, while the frequency of the "warm" winter and "monsoon" summer types increased.

The weak winter and strong summer monsoons caused a regional "warming". The last such regional warming event occurred in the mid-1990s. Maximum warming in the current cycle is expected in 2003-2005, and then the atmospheric regime should shift to a cooling phase.

PICES XIII S9-2035 Oral
Effects of marine habitats on growth, condition and survival of juvenile pink salmon in the coastal Gulf of Alaska

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Juvenile pink salmon are produced from four hatcheries in Prince William Sound (PWS). During their first summer at sea they occur in PWS, the Alaska Coastal Current (ACC) and in shelf water seaward of the ACC front. In July, fish are in PWS and in ACC water, but rarely in shelf water. By August, they also occur in shelf water. In August, fish size differed among habitats. In 2002 and 2003 fish in shelf water were larger than those in the ACC or PWS; whereas in 2001 fish in shelf water were smaller than in ACC or PWS. Habitat-related size differences were usually found in all hatchery cohorts. Fish condition varied in a similar way. Fish in shelf water were in better condition than ACC fish in 2002 and 2003, but were in poorer condition in 2001. Habitat use, size and condition patterns may have been related to feeding and zooplankton availability. The habitat differences we observed in fish size and condition may have important implications for marine survival. There are indications that juvenile salmon reaching a critical size by the start of their first winter at sea have higher over-winter survival. If the critical size hypothesis holds for pink salmon, larger individuals in August may be more likely to return as adults in the following summer. Our observations are consistent with this hypothesis - hatchery fish that were released in 2001 had very low survival, whereas those released in 2002 had exceptionally high survival. These observations suggest that conditions in shelf water during late summer affect overall survival of juvenile pink salmon.

PICES XIII S9-2131 Oral

A new international research project: Integrated Marine Biogeochemical and Ecosystem Research (IMBER)

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The need to understand and prepare for the impacts that global change will have on the Earth System has lead to the development of a new multidisciplinary, global scale research programme called IMBER. Jointly developed and sponsored by IGBP and the SCOR, IMBER will focus on marine biogeochemical ecosystems and their interactions. IMBER will investigate the impacts changing environmental conditions, forced by natural and anthropogenic factors will have on the worlds oceans, and what effect a changing ocean will have on other components of the Earth System. IMBER will focus in 4 domains, the euphotic and mesopelagic layers of the ocean, the continental margins, and high-latitude and polar oceans. IMBER will also identify key feedbacks from marine biogeochemical cycles and ecosystems to other components of the Earth System. The goal of the IMBER project is: *'To understand how interactions between marine biogeochemical cycles and ecosystems respond to and force global change'.*

To address this goal, four scientific themes, have been identified:

1. What are the key marine biogeochemical cycles, ecosystem processes, and their interactions, that will be impacted by global change?

2. Sensitivity to Global Change: How will key marine biogeochemical cycles, ecosystems and their interactions, respond to global change?

3. Interactions with the Earth System: What is the role of the ocean biogeochemistry and ecosystems in regulating climate?

4. Responses of Society: What are the relationships between marine biogeochemical cycles, ecosystems, and the human system?

PICES XIII S9-2040 Poster

A comparison of remote versus local influence of El Niño on the coastal circulation of the Northeast Pacific

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A set of nested circulation models has been used to explore the remote and local influence of the 1997-1998 El Niño on the circulation and temperature fields of the Northeast Pacific. Our nested set includes a basin-scale model of the North Pacific at ~40 km resolution (NPac), and a regional model of the Northeast Pacific at ~10 km resolution (NEP). The NEP model spans an area from Baja California through the Bering Sea, from the coast to ~2000 km offshore. In this context, "remote influence" refers to effects driven by changes in ocean velocity and temperature outside of the NEP domain; "local influence" refers to direct forcing by winds and runoff within the NEP domain. We have performed a series of sensitivity runs with the NEP model, which analyze the effects of: 1) hindcast winds (from NCEP reanalysis) and coastal runoff, as compared to monthly climatologies; and 2) hindcast boundary conditions (from the NPac model), as compared to monthly climatologies. Results indicate penetration of SSH and associated upwelling/downwelling anomalies from the basin-scale model into the NEP domain (*e.g.* "remote influence"), with propagation as Coastal Trapped Waves from Baja up through British Columbia. Most of the SSH anomaly off Alaska in El Niño years appears due to direct forcing by winds ("local influence"). We quantify such

effects, including the penetration of anomalous temperatures through the southern boundary of the NEP domain, and suggest how they might impact patterns of primary production.

PICES XIII S9-2032 Oral

Annual variability in condition factor of sockeye salmon (*Oncorhynchus nerka*) from 1915-1972 in British Columbia, Canada

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Studies of sockeye salmon (*Oncorhynchus nerka*) life history characteristics typically consider interannual variability in salmon mass and length at maturity separately, ignoring the strong positive correlation between them. However, interannual variability in the relation between mass and length may have important fitness consequences. For example, larger mass at a given length (*i.e.* higher condition factor) may confer reproductive and survival advantages. The paucity of individual length and mass data has previously been an obstacle in examining temporal and spatial variability in condition factors in Pacific salmon. We used a unique long-term data set of individual masses and lengths to examine intra- and inter-annual variability in condition factor in two sockeye salmon stocks, Rivers Inlet and Nass River, British Columbia, Canada from 1915 to 1972. We also considered the spatial scale of covariation and proposed potential environmental drivers. Notably, the temporal variability in condition factor was dominated by interannual variability instead of long-term multi-year trends that have been identified in North Pacific salmon catch records. Furthermore, interannual variability was similar between stocks, for certain age-classes. For fish that spend the same number of years in fresh water, we found strong positive correlations between stocks and among age-classes, but this was not the case for fish spending different numbers of years in fresh water. These results suggest differences in ocean distribution or migration rates among age-classes of different stocks. In addition to inter-annual variability, we found some evidence for intra-annual patterns in condition factor from the strong positive correlations in condition factor among fish sampled in consecutive weeks.

PICES XIII S9-1902 Poster

Varying climate-driven ocean conditions and the growth of juvenile salmonids in the California Current system

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Climatic-driven ocean conditions have been linked to the survival of coho salmon (*Oncorhynchus kisutch*). Growth of juvenile salmon during their initial months at sea is believed to be a major factor influencing marine survival. Marine growth is influenced by food availability, fish health, and many other factors. As part of a comprehensive research program we have begun to identify which factors predominate each year, and how marine growth of juvenile salmonids affects survival. We collected juvenile coho salmon, yearling and subyearling chinook salmon (*O. tshawytscha*) off Oregon and Washington in June and September from 1998-2002. This period included a variety of climatic and ocean conditions including, the 1997-1998 El Niño, the 1999-2000 La Niña, the 2001 drought, and a cold subarctic water intrusion in 2002. Based on the assumption that size differences reflect differences in growth rates in addition to differences in size-specific survival, we observed interannual differences in growth between species and life history types. Subyearling chinook salmon were largest in September 2001 and smallest in September 2000. In contrast, juvenile coho salmon were smallest in September 2001. Yearling chinook salmon were small in September 1999 and 2001. High marine growth of juvenile coho salmon was observed in 1998 and 2002. Yearling chinook salmon also appeared to grow best in 2002, during persistent low sea surface temperatures and high zooplankton abundance. The observed variation in salmon growth seems to be climate driven. Mechanisms remain to be defined.

PICES XIII S9-1894 Oral

The latitudinal differences of mesozooplankton distribution in the Northeastern Equatorial Pacific under El Niño, La Niña and normal condition

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To investigate the effects of physical structures induced by climate change on the mesozooplankton distribution, we measured water temperature, salinity, concentrations of nitrate and chlorophyll-*a* (chl-*a*), and abundance of the mesozooplankton above 200 m depth along the meridian line (5°N-12°N, 131.5°W) in the summer of 1998, 1999, and 2003.

Regions of upwelling and downwelling shifted in association with climate change, and this affected the spatio-temporal variation of mesozooplankton latitudinal distribution by changing the concentration of nitrate and chl-*a* as well as the physical conditions. Abundance of mesozooplankton in 1999 (La Niña year) was higher than that in 1998 (El Niño year) and 2003 (normal year), and it increased as going to the north, whereas decreased in 1998 and 2003. At the study area, the locations of convergence and divergence zones and the magnitude of upwelling and downwelling differed in 1998, 1999 and 2003. A strong upwelling in the divergence zone in 1999 (from 10.5°N to 11°N) might have increased the chl-*a* concentration and in turn the abundances of the calanoid-, cyclopoid copepods, chaetognaths, ostracods and radiolarians. Upwelling was not clearly detected at the study area in 1998, which might be responsible for the low concentrations of nitrate, chl-*a*, and mesozooplankton. Upwelling was observed in 2003, but was located at lower latitude (9°N) than that in 1999, and was weaker. Concentrations of nitrate, chl-*a*, and mesozooplankton in 2003 were lower than in 1999, but higher than those in 1998.

This evidence suggests that the intra- and interannual heterogeneity of mesozooplankton latitudinal distribution was related to the shift of divergence and convergence zones, which might be affected by the scales and positions of South Equatorial Current (SEC), North Equatorial Current (NEC) and North Equatorial Countercurrent (NECC) in relation to the climate change during the study period.

PICES XIII S9-2075 Poster

Biological patterns in years of contrasting upwelling-favorable winds

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Global warming, through increased wind-forcing, is hypothesized to lead to increased upwelling along the west coast of the United States. Increased upwelling may enhance productivity through supply of nutrient-rich deep water, but upwelling increases mixing and advection, so therefore could negatively impact the retention of organisms in productive nearshore areas.

Wind-forcing of the northern California Current system contrasted in summers 2000 and 2002. Winds became predominantly upwelling-favorable earlier in 2002 and were stronger and more persistent over much of the summer compared to 2000. Due to anomalously strong basin-scale winds and equatorward transport the preceding winter/spring, the California Current in summer 2002 was characterized by unusually low temperatures, low sea level height, and high equatorward transport. During cruises conducted as part of the U.S. GLOBEC Northeast Pacific program, we found that nutrient and phytoplankton concentrations were 1.5-2 times higher throughout the study area (41.8 – 44.8°N) in August 2002 compared to August 2000. However, copepod biomass was nearly 2X lower in 2002 than 2000. Data from bi-weekly sampling at a nearshore station off Oregon (44.6°N) suggest that copepod biomass followed the typical seasonal cycle in 2000; in contrast, biomass peaked very early (mid-May) in 2002 and had declined by August compared to the long-term average. We hypothesize that the atypical seasonal pattern of copepod biomass seen in 2002 was a result of the anomalously strong winds and advection during that

year. Contrasts in the biological responses between years of contrasting winds may aid understanding of potential effects of global-warming on upwelling ecosystems.

PICES XIII S9-1855 Poster

Spatial and temporal variability patterns in the nitrogen and carbon stable isotope composition of sub-arctic Pacific biota during the GLOBEC long-term observational program: Implications for interpreting long-term records

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Natural abundance of the stable isotopes of carbon and nitrogen may reflect change in ecosystems because their variability, which is driven by primary producers, is transferred in a predictable manner to higher trophic levels. A multi-decade stable isotope time-series measured in whale baleen has recently been suggested to reflect change in Bering Sea productivity. The data, however, are open to multiple interpretations due to the lack of supporting lower trophic level data. An immediate goal was thus to establish spatial and temporal patterns, especially inter-annual isotopic variation, across multiple trophic levels. There were both meso-scale spatial gradients and inter-annual isotopic variations measured in primary consumer level zooplankton. Inter-annual variations varied among fish taxa suggesting differential higher trophic level utilization of carbon resources across the continental shelf. Inter-annual variability measured in the long-term record was similar to that observed here in zooplankton. Nevertheless, shifts in feeding area could also explain trends. More value would be ascertained if an observation time-series comprised several trophic levels or sample types that underwent parallel shifts. The inter-annual isotopic patterns observed in zooplankton may reflect recent climatic shifts of recent years, which appeared to have more than one mode. The planned integration of the stable isotope results with the gamut of other GLOBEC observations, including physics, chemistry, biology, and modeling, may lead to a better understanding of their meaning. It may be possible to relate isotopic shifts with concordant shifts in these parameters with the goal to understand processes associated with climatic shifts.

PICES XIII S9-2030 Poster

Interannual variations in diatom abundance during winter and summer in western tropical to subtropical Pacific

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There has been accumulating evidence that lower trophic levels in the marine ecosystem responds to climate impacts in different regions of the Pacific. However, we have little information on long-term changes in phyto- and zooplankton in western subtropical to tropical Pacific. Thus, interannual variations in diatom abundance were investigated on a time-series collected at stations along 137˚E during winter and summer from 1972 to 1992 by R/V *Ryofu Maru* of the Japan Meteorological Agency. The stations extended to 5 sub-areas including Coastal Kuroshio Region (CKR), Kuroshio Region (KR), Subtropical Counter Current Region (SCCR), North Equatorial Current Region (NECR), and North Equatorial Counter Current Region (NECCR). 116 species were identified throughout the study period. Diatom cell numbers showed a mid-latitude minimum around the SCCR and the latitudinal pattern was correlated with surface phosphate concentrations. The yearly fluctuations of diatom abundance in winter and summer revealed quasi-decadal oscillation patterns, which were high during the late 1970s and 1980s and low during the early 1980s. The oscillation signals were similar in the KR, SCCR, and NECR, and diminished in the northernmost (CKR) and southernmost subareas (NECCR). According to Spearman rank correlation coefficients, significantly positive correlation was observed for 3-year running means of diatom abundance and N* during both winter and summer in the SCCR and NECR. However, other environmental parameters (SST, nitrate, phosphate,

Southern Oscillation Index) were of minor importance for the interannual variations in diatom abundance. From these results, a possible mechanism of the interannual variations in diatom abundance will be discussed.

PICES XIII S9-1987 Oral
Climate variations and changes in the state of the main Northern Hemisphere fish stocks

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To isolate objectively the most important factors of common variability in the 100 physical and biological time series in the North Pacific and North Atlantic for the 1970-2003 period, the principal component analysis (PCA) was used. The first three PC account for about 43% of the total variance. Despite, the first principal component (PC1) being associated with the North Atlantic Oscillation (r=-0.74), the temporal variations of some Far East fish stocks are highly correlated with PC1 scores. The PC1 was mostly positive until 1982 and strongly negative beginning from 1983. High loadings (r>|0.4|) on PC1 occur for 37 of the time series. In particular, PC1 shows the in-phase fluctuations of some haddock and saithe stocks in the Northeast Atlantic and Kamchatka sockeye salmon stocks. The PC2, related to the Pacific Decadal Oscillation (r=-0.80), shows three regimes, with abrupt shifts in 1977 and 1989, but it is interesting that high loadings on this component occur for some herring and saithe stocks in the North Atlantic. The PC3 is characterized by four distinct regimes, with abrupt transitions in 1974, 1983, and 1991. This component reveals coherent variations of Northwest Atlantic haddock and cod stocks. The results of PCA show a good correspondence between shifts in the state of climatic characteristics and biological parameters of most North Pacific and North Atlantic fish stocks on decadal and interdecadal time scales. However, the correlations between the basin-scale or regional atmospheric and oceanic indices and survival indices on the interannual time scale in most cases are weak, especially for moderate conditions of survival. As to the extreme cases of favorable or unfavorable survival conditions sometimes it is possible to distinguish a large-scale factor which may influence the formation of the year-class strength. But even in this situation the sign of relationship may be opposite to that observed on decadal time scale.

PICES XIII S9-1881 Poster
A coastal ocean monitoring program along the Baja California coastline: Climate change, internal waves and the kelp forest ecosystem

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The kelp forest ecosystem is an excellent indicator of climate change in the coastal ocean as it integrates changes from the benthos through the water column, and incorporates primary producers to top feeding predators. This ecosystem is highly dependant on ocean temperature and the inversely correlated nutrients in the coastal zone. In this contribution, monitoring of both biological and physical parameters in this ecosystem along the Baja California coastline over the past ten years will be presented. The time series will be discussed with specific attention to oceanographic regime shifts, ENSO events, and global climate change. Because the Baja California coastline exists within a strong biogeographic transition zone between temperate and subtropical conditions, and because of the kelp ecosystem's integrative nature, the monitoring of this ecosystem along this coast may be particularly important in elucidating the complicated effects of climate change along temperate coasts.

PICES XIII S9-1949 Poster

The effects of El Niño events on sea water temperature variation and squid catch in the Korean coastal and off-shore waters

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It has been widely accepted that there is a strong link between El Niño events and the changes of oceanic and fisheries environments. In order to understand key processes related to the relationship in the coastal waters of Korea, Southern Oscillation Index for El Niño events and sea water temperature as well as fishery data were analyzed. SOI data from 1900 to 2000 were collected from National Oceanographic and Atmospheric Administration. Temperature data from 1961 to 2000 and fishery data from 1980 to 2000 were also collected from Korean Oceanographic Data Center and Japan Meteorological Agency. It was found that two periods of about 4 to 8 years and 16 years were dominant in temperature variations. These periodic temperature variations were highly correlated with El Niño events whose dominant periods were about 4 to 8 years and 16 years. The time lag between temperature variations and El Niño events of about 4.8 and 16.3 years were 1.3 and 4.5 years, respectively. In particular, period of about 16 years observed both in temperature and El Niño events showed very good relationship with temperature variations, especially from 1980 to 2000. It was also found that these temperature variations from 1980 to 2000 possibly resulted in the different pattern of squid catchments in the East Sea and West Sea of Korea. In case of West Sea (East Sea) of Korea, squid catchments increased (decreased) in the 1980s, but decreased (increased) in the 1990s. This phenomenon suggested the possibility of decrease or increase in squid catchments due to longer period of temperature variations rather than decadal period. This can be explained by gradual temperature increase (decrease) in the West Sea (East Sea) of Korea.

PICES XIII S9-2052 Poster

Spatio-temporal distributions of small pelagics around Korean waters using a neural network pattern recognition approach

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Shifts in the habitats of small pelagic fishes were triggered by climatic events, such as ENSO and climatic regime shifts (CRS) around Korean waters (Zhang et al., 2004). In the post-1988 CRS, the distribution area of jack mackerel expanded and shifted southward to 27°N, while the confidence region for the habitat of chub mackerel moved to west of 128°E. As a result, the joint confidence regions of jack and chub mackerels became more narrow. These shifts in the habitats of chub and jack mackerels resulted in Pacific sardine occupying a habitat area separate from the shared mackerel distributions. We examined the role of spatio-temporal oceanographic variability on the distribution patterns of small pelagics around Korean waters. A neural network pattern recognition technique, called a self-organizing map (SOM) was applied in this study to seek clusters in the data using this unsupervised learning methodology over a twenty-year time series of CPUE distribution data of major small pelagics for the Korean large purse seine fishery. A two-step process of training SOM was used: first crude initial patterns were formed, following by a refinement, constructing monthly and annual frequency maps. Frequency maps have the dimensions of the SOM output array and show the frequency of occurrence of each pattern in the data set.

PICES XIII S9-1789 Oral
Population dynamics of Japanese pink salmon: Does climate change explain the recent increasing trend?

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Understanding the mechanisms that regulate fish production is a central issue in fisheries science. We examined the joint effects of density dependence, climatic variation, and hatchery release on the population dynamics of the pink salmon *Oncorhynchus gorbuscha* around Hokkaido Island, Japan, from 1969 to 2002. The number of fry released by hatcheries, winter temperatures, and abundance of pink salmon increased significantly during this period. For the analysis of population dynamics, we used the stochastic Ricker population model considering climatic effects. The results indicated that density dependence and climatic variation, but not hatchery release, are important for understanding the population dynamics of pink salmon. The patterns of covariation between climatic variables and population growth were consistent with previous hypotheses: the population growth rate was enhanced by mild winters, high rainfall during fall seasons, and an intensified Aleutian Low. The Monte-Carlo simulation showed that recent increases in pink salmon catch are explained by climate change alone without necessarily involving increased hatchery release. Although it has been believed that Japanese salmon increased as a result of intensified hatchery programs, our findings are inconsistent with this legend.

PICES XIII S9-1971 Poster
Climate, ocean ecosystem, and sustainable fisheries

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Variations and changes of the Earth biosphere are generally related to climate variations, which can be forced by extraterrestrial (mainly of solar origin) and intraterrestrial factors, such as electromagnetic, magnetic and gravitation fields.

Direct influence of these factors on the Earth living matter is well known, but till now interrelations between climate, ecosystems and external and internal factors are not clearly understood. A scheme of such interrelations is constructed, that takes into account the following processes: 1) atmosphere and its characteristics perturbations caused by solar activity fluctuations; 2) changes of heat content of oceanic waters due to solar radiation and atmospheric characteristics fluctuations; 3) ocean-atmosphere interactions displaying themselves in a very wide range of space-time scales; 4) large-scale ocean currents, transporting heat content anomalies from tropics to middle and high latitudes and thus affecting atmosphere circulation over the globe; 5) direct influence of electromagnetic and magnetic field fluctuations on biota and spreading their effects up trophic chains and inside populations; 6) feed-back of biota anomalies on the ocean and atmosphere physical properties.

Analysis of the above named processes using existing models and observations shows that influence of forcing factors on ecosystem changes can be realized by two ways: 1) globally in different parts of trophic chains; 2) locally with delays corresponding to times of climatic anomalies transport a) by currents from tropics to the local areas, b) trophic chains up and inside populations. As a result, some ecosystem changes may follow climate changes, but some of them may precede climate changes and be used to forecast them. In any case, large stochastic variations are inherent for climate as well as for biota systems, leading to rather quick transitions between different mean conditions in both systems. Such transitions, generally named as *regime shifts,* and random fluctuations of environment and biota parameters, give new properties to interrelations between contradicting demands of stability and effectiveness of fisheries, which are explored in the paper.

The most prominent changes in biota will arise in key regions and in key periods of time when there is resonance between external forcing and internal cycles. Using existing models for ocean circulation, comparisons of observed recurrence in some important fish populations with several known forcing cycles are made.

PICES XIII S9-2142 Poster
Decadal variations of demersal fish populations in relation to climate/oceanic regime shifts in the waters off the northeast coast of Japan

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Many demersal fish populations in the waters off the northeast coast of Japan were examined for the period 1976-2001. They decreased in the 1970s, remained low during the 1980s and rapidly increased in the 1990s. The increase of demersal fish populations in the 1990s was dramatic for species living in the continental shelf area, shallower than 200 m depth. However, species living on the slope, at 200 m to 800 m depth, did not increase in the 1990s, but started to increase after 2000. Many strong year classes of flounders appeared after 1994. Species that increased in the 1990s spawned in winter to spring. The most southern position of Oyashio intrusions into this area in spring shifted to the south in 1972/1973, and shifted to the north in 1986/1987. Zooplankton biomass also increased in the 1990s. Relations between water temperatures, zooplankton biomass and the recruitment of willowy flounders were examined. Zooplankton biomass was related to the survival of the pelagic stage of flounders and water temperatures were related to the survival of the metamorphosis stage flounders. Why did the appearance of dominant year-classes of flounders and the increasing of the zooplankton biomass late for the Oyashio intrusion shift of 1986/1987? Japanese sardine recruitment failed after 1988, but adult sardines were still abundant in the early 1990s and aggregated in this area from winter to spring, where they consumed large quantities of zooplankton. After sardine adult biomass declined in the mid 1990s, the flounder larvae experienced greater zooplankton prey, and higher survival.

PICES XIII S9-2186 Oral
Korea GLOBEC

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In 1998, a Korea GLOBEC committee was jointly established by the Korean Society of Fisheries Resources and the Korean Society of Oceanography, and was chaired by Prof. Suam Kim of Pukyong National University. The first phase of Korea GLOBEC started with a project entitled "Investigation on the relationship between climate change and fisheries resources in the Japan/East Sea" supported by the Ministry of Maritime Affairs and Fisheries from 2001 to 2003. Prof. Suam Kim was a principal investigator of the project. The research focused mainly on retrospective analyses of historical data in Korea. In August 2000, we organized the first Korea-Japan Joint GLOBEC Symposium on "Long-term variations in the northwestern Pacific ecosystem" at Busan, Korea. Selected papers from the symposium were published in a special session of Fisheries Oceanography. In December 2002, we organized the first China-Japan-Korea Joint GLOBEC Symposium on "Processes and dynamics in the northwestern Pacific ecosystem" at Ansan, Korea. Selected papers from that symposium will be published in the Journal of Oceanography.

A second phase of Korea GLOBEC began in January 2004. A new chairperson, Prof. Im Sang Oh of Seoul National University was elected. For this second phase of Korea GLOBEC, a new 9-year project titled, "Long-term change of the biogeochemical cycling and biological processes in the East China Sea: Observation and Prediction" was initiated. The project is supported by the Ministry of Science and Technology. Recently, the Korea GLOBEC committee decided to encourage young scientists by supporting their travel expenses to relevant scientific meetings. This program will continue for 10 years.

PICES XIII S9-2076 Oral
Progresses and achievements of GLOBEC research projects in Japan

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Serial GLOBEC research projects started in 1989, with the grant-in-aid of the Japanese Ministry of Agriculture, Forestry and Fisheries. The projects have steadily unveiled the linkage between climate changes and small pelagic fish population dynamics in relation to plankton communities. As the first step, BIO-COSMOS project was conducted from 1989 to 1999 with the aim of understanding the recruitment processes of the Japanese sardine. Two major findings were obtained: 1) a positive correlation between the decadal SST change and the mortality of pre-recruitment sardine and 2) a positive feedback loop as a mechanism of the interdecadal fluctuation of the sardine abundance. Accordingly, the next project, VENFISH program (1997 - 2001), targeted bottom-up control processes from the phytoplankton production to the recruitment of Pacific saury (*Cololabis saira*) and walleye pollock (*Theragra chalcogramma*). As the output of this project, the NEMURO.FISH model was developed based on the lower trophic marine ecosystem model NEMURO constructed by the PICES MODEL Task Team. Concurrently, the FRECS program aimed to understand the survival mechanism of jack mackerel (*Trachurus japonicus*) and Japanese common squid (*Todarodes pacificus*) during the transportation from the spawning grounds in the East China Sea to Japanese coastal areas. At the termination of VENFISH project, DEEP project was launched in 2002 as the five years research project, focusing on meso-pelagic micronekton species. The other GLOBEC-like research projects, to understand the climate impacts on fisheries, have also been started for improving the accuracy of forecasts of small pelagic fish population.

PICES XIII S9-1868 Oral
Is the Bering Sea ecosystem stuck in a warm phase?

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The southeastern Bering Sea was subject to a change in the physical environment and an ecosystem reorganization after 1976 associated with the Pacific Decadal Oscillation (PDO), a minor influence from shifts in Arctic atmospheric circulation in the early 1990s, and persistent warm and ice-free conditions over the previous 4 years. Weather and tree-ring proxy data suggest that the Bering Sea was generally cool for at least 170 years before 1977, with sufficient time for slow growing, long-lived, cold-adapted Arctic species to adjust. Thus the last few decades appear to be a major transition period for the Bering Sea from an ice-dominated Arctic system to a sub-Arctic ecosystem. Fisheries surveys and model calculations show a shift in the importance of pollock to the ecosystem, to over 50% of the energy flow at mid-trophic levels in the 1980/90s from near 10% in the 1950/1960s, although biological information for the earlier period is limited. There was an accompanying reduction in recruitment of Greenland turbot and yellowfin sole and a northward shift in the Pacific walrus population. Although ecological conditions appear mostly stable over the last decade, the warmest water column temperatures on the southeast Bering Sea shelf have occurred in 2001-2003 (6 deg summer mean temperature relative to 4 deg summer mean temperature in 1995-1997), despite considerable year-to-year variability in the Arctic Oscillation and PDO. We hypothesize that the overall climate change occurring in the Arctic, as indicated by warmer atmospheric and oceanic temperatures and loss of 15 % of sea ice and tundra area over the previous two decades, is making the Bering Sea less sensitive to intrinsic climate variability of the North Pacific. Thus we project that the Bering Sea will more likely continue on its current warm trajectory, with biomass transitioning northward allowing pollock a larger productive domain at the expense of cold and ice-adapted species, rather than transitioning back to a cold regime. Bering Sea indicators should be closely watched over the next five years to confirm or reject this hypothesis.

PICES XIII S9-2204 Oral
GLOBEC Canada: Results and follow-on activities

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The Canadian national GLOBEC program ran from 1996 through early 2001, funded by Fisheries and Oceans Canada (DFO) and the Canadian Natural Sciences and Engineering Research Council Research (NSERC) Partnerships program. GLOBEC Canada brought together a large number of marine scientists (45) and students/PDFs (35) affiliated with both universities (7) and DFO laboratories (5), and included work in both the NE Pacific and the NW Atlantic. The key motive for GLOBEC Canada was a growing perception (since become a firm knowledge) that biological productivity covaries strongly and for prolonged periods with the physical state of the ocean. To better recognize where, when, and why present and future changes will occur, we designed the program to include:

- Collaboration between biologists and physicists
- Interaction and feedback between:
  retrospective analysis of long time series,
  focussed process studies, and
  numerical modelling.
- Comparisons among different species and regions.

Research activities spanned time and space scales ranging from interdecadal changes affecting the full North Pacific and North Atlantic to process studies of local interactions between topography, currents, and plankton and fish distributions. What did we learn?

Retrospective and ongoing time series documented important decadal changes. In the NE Pacific, the surface layer of the Alaska Gyre became more stratified, leading to reduced annual re-supply of nutrients by winter mixing and to a zone of summer nutrient depletion along the eastern margin. The seasonal cycle also changed: surface layer warming and restratification, and the annual peak of zooplankton biomass moved earlier in the calendar year. A recalibration of zooplankton nets improved the reliability of the Stn P time series. El Niño events became more frequent and prolonged, and included a major and well observed El Niño/La Niña in 1997-1999. Along the British Columbia continental margin, there were low-frequency changes in zooplankton community composition, with a 1990s trend toward a more southerly zooplankton fauna that reversed abruptly in 1999. Stocks of all five BC salmon species initially increased, but declined steeply in the 1990s due in large part to decreased marine survival rate and poor growth. Seabird colonies in southern BC showed similar trends. There were large 1990s changes in hake abundance and distribution, and a major resurgence of sardine in Canadian waters.

Process studies showed how zooplankton and fish are aggregated and retained by flow patterns at the shelf break, in submarine canyons, and around mid-shelf banks. Hotspots in primary productivity and phytoplankton biomass were related to nutrient supply rates and mechanisms. Isotopic and biochemical tracers helped discriminate feeding history, especially for taxa that move between shelf and offshore. Effects of 10-50 km scale topography on continental margin winds and currents were measured and modeled.

Other *numerical modeling* studies included development of basin-scale coupled models to map the response of plankton productivity to seasonal and "regime" changes in circulation and vertical mixing, neural network methods for forecasting ENSO events, and a high resolution continental shelf circulation model to follow the movement of passive and active "tracers".

Most participants felt that GLOBEC Canada ended too soon, but many have continued with "GLOBEC-like" research in smaller groups and from other funding sources. Present examples include the ongoing west coast time series, intensive field and modeling studies of the Strait of Georgia, of *Pseudo-nitzschia* (HAB) blooms off southern Vancouver Island, and of zooplankton aggregation near abrupt topographic edges.

PICES XIII S9-2108 Oral

The importance of regional-scale (< 700 km) environmental processes in driving temporal variation in recruits per spawner in Northeastern Pacific salmon (*Oncorhynchus*) populations

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Substantial evidence has been gathering over the last six years that regional-scale environmental processes (those that are coherent across less than about 700 km) are more important drivers of temporal variation in recruits per spawner for salmon (*Oncorhynchus spp.*) populations than more-frequently-referred-to large, ocean-basin-scale processes. We report new results here that further substantiate this relative importance of regional-scale mechanisms in the dynamics of over 100 stocks of pink (*O. gorbuscha*), chum (*O. keta*), and sockeye (*O. nerka*) salmon in the Northeastern Pacific. We used both within- and between-species comparisons across stocks. For each salmon stock, we used time series of abundances of spawners and resulting adult recruits as input to a Ricker stock-recruitment model that we cast in the context of a Kalman filter. We previously demonstrated that this filter is effective at estimating underlying systematic changes over time in the Ricker *a* parameter (the signal) amid random variation (noise) that is independent of that trend. The resulting reconstructed time series of productivities (Ricker *a* parameters) were highly correlated among stocks that have ocean entry points within several hundred km of one another. Across-species comparisons for pink and chum stocks showed very similar regional scales of positive covariation in their reconstructed time series of productivities. These results suggest that to better understand mechanisms causing temporal variation in productivity of salmon stocks, scientists should emphasize more research on regional scales than in the past. Better management may also result from this shift in perspective.

PICES XIII S9-2081 Oral

The climate shift of 1998: Something old or something new?

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Peterson and Schwing (Geophys. Res. Letters, 2003, 30,17) suggested that a climate shift was initiated in the northeast Pacific in August 1998, and that this new climate state might resemble the previous "cool regime" observed between the years 1947-1977. Six years have elapsed since the 1998 climate shift, and thus far a variety of physical and ecological data sets confound our ability to definitively categorize currently observed ocean climate conditions. In this paper, we ask, "Are we in a cool regime?". If so, how closely does this regime compare to the cool regime observed before 1977? Key differences include the following: (1) this particular regime seems better related to the second mode of the PDO rather than the first mode, corresponding to what is being called the "Victoria Pattern"; (2) wind direction is more westerly than northerly, leading to (3) stronger eastward transport in the Transition Zone. Increased eastward transport may in turn explain our observations that (4) copepod biodiversity has increased dramatically since the 1998 regime shift, to values higher than observed during the two massive El Niño "events of the century" (1983 and 1997/98). Lastly, (5) fish stocks are responding differently as compared to the pre-1977 period: salmon stocks in both the Gulf of Alaska and the California are productive, and both anchovy and sardine stocks continue to do well in the northern California Current. Based on these observations we conclude that current conditions are dissimilar from the pre-1977 "cool regime".

PICES XIII S9-1842 Oral
Russia in scientific collaboration in programs related to the GLOBEC International

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In the post-socialist epoch, the involvement of Russia in the international collaboration in studies of structure, functioning, and response to physical forcing of the global ocean ecosystem occurred in several ways. Russian Academy of Sciences has contributed to IGBP projects: PAGES, SOLAS, and biodiversity conservation in tropical latitudes together with GLOBEC Ukraine. There are two regional GLOBEC programs in the Pacific region: the PICES-GLOBEC CCCC, and ESSAS – at its strategic planning stage. Fishery science leads among Russian institutes in this activity. In recent years, TINRO-Center created contemporary managed database on nekton and zooplankton of Far-Eastern seas. First results occur in publication of the "Atlas of quantitative distribution of nekton species in the Okhotsk Sea", which is the first book in a planned series. The following conclusions (Shuntov *et al.*, 2003) were recently made: 1) the interannual and long-term dynamics of marine ecosystems is primarily controlled by climate-oceanological processes, in spite of the increasing anthropogenic influence. Despite the importance of greenhouse effect on the Earth climate, the ocean regime in the northwestern Pacific since 1997 has been relatively cold; 2) moving factors of the differently directed dynamics of common fishery stocks and decrease in total biological and fish-productivity of the ecosystems of far-eastern seas should be searched for in the natural processes. Pelagic fish under-utilized the food supply formed by crustacean zooplankton. Zoobenthos biomasses have grown against the background of demersal fish biomass reduction. Besides, the specialists of Russian fishery science participate in ACIA, BASIS, and NPRB scientific plan elaboration.

PICES XIII S9-2072 Poster
A warmer and fresher Northern Gulf of Alaska?

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The 33-year time series of temperature and salinity versus depth to 250 m at the mouth of Resurrection Bay, Alaska (60 N, 149 W) (GAK 1) is used to establish the climatic conditions for the Northeast Pacific GLOBEC Long Term Observation Program (LTOP) and to determine the hydrographic conditions during the GLOBEC sampling (October 1997-2004).

The water temperature and salinity are forced by solar heating, freshwater discharge, winds and El Niño-Southern Oscillation (ENSO) events. The amplitude and phases of the hydrographic responses to the recent ENSO events of 1997 and 2002 are compared with earlier events. These hydrographic responses are also compared with indices of North Pacific atmospheric forcing such as SOI (Southern Oscillation Index), PDO (Pacific Decadal Oscillation, NOI_x (Northern Oscillation Index), Nino3, North Pacific Index (NPI) and the Arctic Oscillation (AO). The seasonal variations of the water temperature and salinity are compared with the seasonal solar heating, coastal freshwater discharge, and winds to investigate the possibility of significant changes in their seasonal amplitude and phase during the GLOBEC LTOP period. The hydrographic data and the coastal air temperature and precipitation for Southcoast Alaska will be investigated for summer-winter climate change differences. It appears that the record low temperatures observed in the early 1970s were a winter phenomenon. Are there other influences that are confined to either the summer or winter alone?

PICES XIII S9-1968 Oral

Interannual variations in developmental timing of *Neocalanus* copepod populations in the Oyashio waters of western subarctic North Pacific

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In order to clarify the interannual variations in biomass and production of *Neocalanus* copepod in the Oyashio waters, we analyzed mesozooplankton samples (the Odate Collection) collected in offshore waters of northeast Japan from 1970 to 2000. The interannual variation in the developmental timing was determined by the date when copepodite stage 5 made up 50% of the copepodite abundance (Mackas *et al*. 1998). The developmental timing of *N. flemingeri* populations showed decadal scale oscillation which was late in the mid-1970s, mid-1980s, and mid 1990s. On the other hand, the developmental timing in *N. plumchrus* and *N. cristatus* populations showed bidecadal scale oscillations which were very late in the late 1970s and late 1990s. Differences in the patterns suggested that mechanisms of the interannual variations in *N. flemingeri* populations developmental timing are different from that of *N. plumchrus* and *N. cristatus.* We will discuss the possible causes of the interannual variations in the developmental timing of *Neocalanus* copepod populations in the Oyashio waters including physical environmental variations and abundance of mesozooplankton predator as Japanese sardine.

PICES XIII S9-1880 Oral

The overview of Chinese National GLOBEC Program

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Chinese GLOBEC studies carry through the national science program from 1997, which is titled "Ecosystem Dynamics and Sustainable Utilization of Living Marine Resources in China Coastal Seas". It is regarded as a contribution providing a regional study of coastal ecosystems and its living resources dynamics. The scientific objectives of the program is to

- ◊ determine impacts of key physical processes on biological production
- ◊ determine cycling and regeneration mechanisms of biogenicelemen
- ◊ determine basic production processes and zooplankton role in the ecosystem
- ◊ determine food web trophodynamics and shift in dominant species.

There are 6 key scientific questions establish by Chinese GLOBEC. They are

1. energy flow and conversion of key species
2. dynamics of key zooplankton population
3. cycling and regeneration of biogenicelement
4. ecological effect of key physic processes
5. pelagic and benthic coupling
6. microbial loops contribution to main food web.

Chinese GLOBEC studies in the East China Sea and the Yellow Sea are examples of regional contributions to GLOBEC studies of shelf ecosystems. In the past five years studies have focused on anchovy spawning ground and recruitment mechanism, *Calanus sinicus* dynamics and its over-summering strategy, mechanisms that determine the over-wintering ground of anchovy, biogenic element cycling, and decadal change of the East China Sea and the Yellow Sea ecosystems. 18 multidisciplinary surveys, totaling about 340 days at sea were completed from 1999-2004 to investigate these key dynamic processes. The major progress and results achieved by Chinese GLOBEC are:

1. Anchovy spawning ground surveys
    - Anchovy larvae are mainly distributed in inshore tidal front zones, in the upper 10 m layer; no distinct vertical migration was found.

- No clear distributional relationship was found between anchovy larvae and its prey.
- The percentage of dead eggs was very high rate with the mean of 83% and maximum of 97%.
- New insights obtained on prey and predator relationship.
- Regions of dense anchovy larvae are more related to physical effects than trophic (biological) effects.

2. Over-summering strategy of *Calanus sinicus*
    - *C. sinicus* spawn around the whole year, but concentrated mainly in spring and summer.
    - C. *sinicus* has marked spawning rhythm; its fecundity and hatch rate was not significantly affected by temperature, but hatching duration was affected.
    - Adult copepods collected in field spawn and hatch in the laboratory
    - Feeding activity is with high digestive enzyme and metabolism activity at low temperature.
    - Activity of digestive enzyme decreases 3-4 times and respiration rate halved at high temperature.
3. Ecological efficiency of high trophic level
    - Basic framework model of food web simplified for the spawning ground off Qingdao was developed.
    - Data on daily consumption, feeding periodicity, ecological conversion efficiency of some key species was obtained.
    - Experiment for bioenergetics studies on pelagic species (Spanish mackerel, chub mackerel, red-nose anchovy, dotted gizzard shad, sand lance) was devised.
    - Bioenergetics parameters have been estimated for about 20 fish and invertebrate species, and are quite dynamic and variable among species.

PICES XIII S9-2138 Invited
Ecosystem structure and function on the Gulf of Alaska shelf

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This talk provides an overview of the Coastal Gulf of Alaska GLOBEC Program by drawing upon results of the monitoring, process, mesoscale, and retrospective components.

The seasonally-varying Aleutian Low induces large annual cycles in air-sea heat flux, runoff, and winds, which with complex shelf bathymetry and coastal orography, form the physical basis of this environment. These effects establish substantial cross- and along-shelf circulation and hydrographic gradients reflected in stratification, nutrient transport pathways, and the production, distribution, and community composition of phytoplankton, zooplankton, and fish. Cross-shelf variability in phytoplankton and zooplankton appear linked to freshwater dispersal processes and along- and cross-shelf transports. Nutrient ratios, phytoplankton size distributions, and the greater abundance of *Neocalanus* in low-salinity waters, possibly reflect bottom-up control. Pink salmon distribution and size also depend upon salinity, with greater fish abundance in low salinity, nearshore waters, but larger size juveniles in saltier, offshore waters. Both bottom-up and top-down controls appear to influence fish recruitment.

Interannual and longer-term physical variability is manifested in fall-winter heat fluxes and runoff associated with the position and strength of the Aleutian Low. These influence biological production through variability in the onset of springtime stratification, transports, and possibly through iron availability via runoff. Interannual variability in the summertime frequency of wind-mixing and/or weak upwelling affects nutrient replenishment in the surface layers and summer productivity. The talk concludes with speculations on how a warmer and wetter winter environment, as envisioned under global warming scenarios, might affect this ecosystem.

PICES XIII S9-1871 Oral
Changing ocean conditions in the Northern California Current: 1997-2003

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GLOBEC sampled the northern California Current (42N to 45N) seasonally from July 1997 to November 2003, experiencing a rich variety of ocean conditions: strong El Niño (1997-8), moderate La Niña (1998-2001), weak El Niño (2002-3) and an invasion of Subarctic water (2002). Meanwhile coho salmon survival recovered from record low rates of <1% of smolts released during 1992-7 to >3% for smolts released since 2000. In 1999, the North Pacific atmospheric pressure pattern changed from the positive PDO pattern that characterized the region since 1976-7; we compare recent conditions to those during 1961-72. El Niño in 1997-8 was the strongest of the century. The effects of the following La Niña and El Niño were subtler. The unusual invasion of Subarctic Pacific water into the northern California Current in summer 2002 produced dramatic results: water in the halocline, which supplies much of the upwelling along the Oregon coast, was unusually cold and enriched in nutrients; southward flow was unusually strong; chlorophyll concentrations were exceptionally high. Colder water and high integrated chlorophyll were again present in summer 2003. In the halocline, the competition between the warming influence of El Niño in 2002-3 and the cooling influence from the Subarctic was won by the Subarctic during summers 2002 and 2003. However, effects of El Niño became apparent at depth by fall 2002 and in the upper 100 m during winter and spring. Whether the increased influence of the Subarctic will continue is a matter of conjecture at this time.

PICES XIII S9-2175 Poster
Seasonal and interannual variability in the distribution and dynamics of nutrients and chlorophyll across the Gulf of Alaska shelf: 1998-2000

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The northern Gulf of Alaska shelf is a productive coastal region that supports several commercially important fisheries such as salmon, halibut, and pollock. The mechanisms supporting such high levels of productivity over this shelf however are not understood since it is a downwelling-dominated shelf. In an effort to understand the mechanisms driving such high biological productivity, the cross-shelf nutrient distributions were sampled 18 times throughout 1998, 1999, and 2000. Nitrate, silicate, and phosphate were positively correlated with salinity indicating an offshore nutrient source. Throughout the summer months, the upper 10-20 m across shelf was depleted of nitrate, silicate, and phosphate over the inner and middle shelves and depleted of nitrate and phosphate over the shelf break and slope; however, just below this nutrient- poor layer the water column was nutrient-replete. During each summer, there was an onshore flux of dense nutrient-rich bottom water onto the shelf when the downwelling relaxed. This seasonal flux created a nutrient reservoir near the bottom of the inner and middle shelves. The reservoir was eventually mixed throughout the water column during the winter months. There was a large degree of interannual variability among the three years, which included El Niño (1998) and La Niña (1999) years. Nutrient concentrations and phytoplankton biomass were generally highest in 2000, except in May 1999, when a large eddy traveling along the continental slope greatly enhanced phytoplankton biomass. Daily new production estimates based on nitrate disappearance averaged over the spring-summer season ranged from 2.5-7.0 mmol nitrate m^{-2} day^{-1}.

S10 CCCC/MODEL Topic Session
Modeling approaches that integrate multiple spatial scales and trophic levels between shelf and open oceans

Session Convenors: Shin-ichi Ito (Japan), Michio J. Kishi (Japan), Bernard A. Megrey (U.S.A.) and Francisco E. Werner (U.S.A.)

Marine ecosystems are characterized by complex trophic interactions that occur on disparate time and space scales. Modulation by physical and biogeochemical properties further complicates these interactions. To date, most studies of marine ecosystems consider shelf and open ocean regions separately. However, through active migration and/or advective processes, shelf and oceanic populations are coupled. In this session, we welcome modeling contributions that consider shelf, open ocean and coupled shelf-ocean domains that integrate across multiple spatial scales, temporal scales and trophic levels. From these studies we seek to develop a better understanding of how open ocean and shelf ecosystems are linked.

Wednesday, October 20, 2004 8:30-11:50

08:30-09:00 **Xinyu Guo, Yasumasa Miyazawa and Toshio Yamagata** (Invited)
Intrusion of Kuroshio water onto the continental shelf in the East China Sea and its influences on the ecosystem (S10-1919)

09:00-09:20 **Jian Su and Lai-Ah Wong**
A three-dimensional numerical study of the spirals and water exchange near the shelf front in the northern South China Sea in winter (S10-1796)

09:20-09:40 **Tian Tian, Hao Wei, Jian Su and Chang-Soo Chung**
Simulations of annual cycle of phytoplankton production and the utilization of nitrogen in the Yellow Sea (S10-1798)

09:40-10:00 **Maki N. Aita, Yasuhiro Yamanaka and Michio J. Kishi**
Interdecadal variation of lower trophic ecosystems in the Northern Pacific between 1948 and 2002, using a 3-D physical-NEMURO coupled model (S10-1960)

10:00-10:30 **Coffee break**

10:30-10:50 **Shin-Ichi Ito, Miciho J. Kishi, Daiki Mukai, Yutaka Kurita, Yasuhiro Ueno, Yasuhiro Yamanaka, Bernard A. Megrey and Francisco E. Werner**
A study for interannual variability of Pacific saury using a simple 3-box model of NEMURO.FISH (S10-2120)

10:50-11:10 **Albert J. Hermann, Sarah Hinckley, Elizabeth L. Dobbins and Dale B. Haidvogel**
Quantifying cross-shelf and vertical nutrient flux in the Gulf of Alaska with a spatially nested, coupled biophysical model (S10-2041)

11:10-11:30 **Carolina Parada and Sarah Hinckley**
A biophysical model for walleye pollock in the Gulf of Alaska to study recruitment variability: A coupled modelling approach (S10-2112)

11:30-11:50 **Andrew W. Leising**
The effects of seasonal variability on copepod overwintering and population success: The match-mismatch of zooplankton and phytoplankton (S10-2062)

Posters

Irina V. Ishmukova
Assessing the quality of marine ecosystem models (S10-1920)

Daiki Mukai, Fei Chai and Michio J. Kishi
Modeling interannual and decadal variability of Pacific saury (S10-2083)

Annette Samuelsen and James J. O'Brien
Influence of energetic meso-scale eddies on the lower trophic levels of the ecosystem in the northeastern tropical Pacific (S10-1978)

PICES XIII S10-1960 Oral

Interdecadal variation of lower trophic ecosystems in the Northern Pacific between 1948 and 2002, using a 3-D physical-NEMURO coupled model

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Regime shifts, consisting of decadal-scale oscillation in atmosphere-ocean systems, have recently been the focus of many marine ecosystem studies. These "regime shifts" affect the sea surface temperature and Mixed Layer Depth (MLD), as well as overall changes the environment of marine ecosystems. We simulated changes in lower trophic marine ecosystems caused by interdecadal climate variability, using data from 1948 to 2002 using a global three-dimensional physical-biological "3D-NEMURO" coupled model.

The results were consistent with observations. Comparing before and after the late 1970s regime shift, primary production and biomass of phytoplankton increased in the North Central Pacific region but decreased in the sub tropical zone in the Western and Eastern Northern Pacific after the regime shift. This corresponds to the Pacific Decadal Oscillation index (PDO) that indicates interdecadal climate variability in the sub-tropical and tropical Pacific. The biomass in the North Central Pacific correlates positively with PDO, while that in the East and West North Pacific correlates negatively with PDO.

PICES XIII S10-1919 Invited

Intrusion of Kuroshio water onto the continental shelf in the East China Sea and its influences on the ecosystem

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A 1/18-degree nested ocean model is used to determine the location, the volume transport, and the temporal variation of Kuroshio onshore flux across the shelf break (KOF) of the East China Sea (ECS). The KOF shows a strong seasonal variation: maximum (~3 Sv) in autumn and minimum (< 0.5 Sv) in summer. The short-term (~17 day) variation due to Kuroshio meanders induces large fluctuations of the onshore fluxes but its temporal average over one year almost vanishes. The KOF has two major sources, the Kuroshio intrusion northeast of Taiwan and the Kuroshio separation southwest of Kyushu; with the former providing larger onshore flux than the latter. In addition to the KOF, the water from the Taiwan Strait is also a major source of water into the ECS. The role of the Taiwan Strait water and the KOF on material transport in the ECS is examined with passive tracer experiments. In the summer, about half of the tracer in the Tsushima Strait, the major exit of the water over the continental shelf of the ECS, originates in the Taiwan Strait, while the other half comes from the Kuroshio region. From summer to winter, the ratio changes dramatically: the contribution from the Taiwan Strait decreases to 20% and that from the Kuroshio increases to 80%. The tracer distribution shows the Kuroshio water dominates the bottom layer of the continental shelf of the ECS throughout the year. This implies that the oceanic nutrient supply from the Kuroshio region plays an important role in the ecosystem of the ECS.

PICES XIII S10-2041 Oral
Quantifying cross-shelf and vertical nutrient flux in the Gulf of Alaska with a spatially nested, coupled biophysical model

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The Coastal Gulf of Alaska (CGOA) is strongly productive, yet is subject to downwelling favorable winds over most of the year. Sources of nutrients to feed primary production in this topographically complex region are poorly known. As part of US-GLOBEC, we are utilizing a spatially nested, coupled biophysical model of the CGOA and the deep basin offshore, to explore when and where cross-shelf and vertical nutrient fluxes are most intense. The circulation model is based on the Regional Ocean Modeling System, implemented for this area with spatial nesting and one-way coupling of velocity and scalar fields. Our embedded NPZ model contains 11 state variables, chosen to simultaneously represent both coastal and oceanic ecosystems. Nutrient limitation terms include both nitrogen (which is believed to be more limiting on the shelf) and iron (which is believed to be more limiting in the open ocean). Our nested model results indicate significant "rivers" of cross-shelf nitrogen flux due to horizontal advection, as well as "fountains" of vertical transport over shallow banks due to tidal mixing. Using this output, we construct a provisional budget of nutrient transport among subregions of the Gulf of Alaska.

PICES XIII S10-1920 Poster
Assessing the quality of marine ecosystem models

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Aquatic ecosystem studies are of special interest to experts in marine biology. Basically, biologists express the knowledge about ecosystems as informal models. These models contain various numbers of trophic blocks and coupling between them as well as average values of the mass or energy flows for certain periods of time. For verification of the informal models the mathematical models are implemented and their properties studied. Well-known methods for representation of the dynamic processes in trophic chains have been used for the formal description of metabolism. Implementation of mathematical models based on known biological descriptions of ecosystems includes the following stages: a choice of the mathematical relations describing exchange processes; a definition of the concrete trophic functions and functions of mortality; and identification of parameters. It is necessary to note that usually not all values of the parameters are known. Thus, models are determined only to within several parameters. Therefore, it is required to carry out calculations under various assumptions about the unknown values.

An approach for assessing the quality of marine ecosystem models was developed and applied to an informal model of the Okhotsk Sea ecosystem. The aggregated three-block system was implemented and analyzed theoretically. Then it was decomposed into six-block and eleven-block models and the properties of these expanded models were numerically investigated. The dynamic processes that evolved by the deviation of equilibrium points were considered. The results obtained are an indirect confirmation that the informal representation of the Okhotsk Sea ecosystem requires detailed elaboration.

PICES XIII S10-2120 Oral

A study for interannual variability of Pacific saury using a simple 3-box model of NEMURO.FISH

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A simple 3-box model of NEMURO.FISH (saury version: Ito *et al.* 2004) was forced by observed sea surface temperature (SST) from 1950 to 2002. In the model, fish wet weight is calculated according to a fish bioenergetics equation. The observed condition factor of Pacific saury showed quite large decadal variability with relatively large year-to-year variability. In the model, wet weight of Pacific saury also showed decadal and year-to-year variability, however the amplitude of decadal variability was much smaller than the observed. It may be due to the absence of a multi-species fish formulation in the model. Fishes like sardine which have large biomass and fluctuation, have the potential to affect to the zooplankton density in the saury migration region. We also investigate differences of interannual growth variability between spawning seasons. Since Pacific saury spawns from autumn to the folllowing spring, we set three seasonal (autumn, winter and spring) spawned cohorts in the model. The amplitude of growth variability is largest for the autumn spawned cohort and smallest in the spring spawned cohort. This difference is caused by the difference of life history of each spawned cohort. The spring spawned cohort spawns only once in the life, however other cohorts spawn twice in their life. The second spawning timing changed year-to-year and it caused relatively large interannual variability in the autumn and winter spawned cohorts.

PICES XIII S10-2062 Oral

The effects of seasonal variability on copepod overwintering and population success: The match-mismatch of zooplankton and phytoplankton

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In temperate and high-latitude regions, large-bodied copepods typically enter a dormant state and descend to depth during the winter, re-ascending to the surface in the late winter/early spring in order to reproduce and take advantage of the spring bloom. Interannual variability may lead to mismatches between the timing of copepod reemergence, which is partly determined by conditions encountered by the copepods during the previous season, and the spring phytoplankton bloom. In turn, such mismatches can lead to further mismatches between copepod productivity and their availability as prey to higher trophic levels, such as small pelagic fish and first-feeding juveniles of certain species. Using an individual-based model (IBM), the effects of changing the timing of physical and biological seasonal cycles on the diapause entry and exit timing, and subsequent reproductive success of the common coastal copepod *Calanus pacificus* were investigated. The variable seasonal cycles examined included temperature, and spring bloom amplitude, timing, and magnitude. Because each individual copepod within an IBM can be "tagged" and their history recorded over their entire life, it was also possible to examine the effects of spring bloom variability on the reproductive success of the 2nd yearly generation of copepods, which are produced by females in the early spring which had just finished overwintering. Thus the ramifications of early spring copepod-phytoplankton matches or mismatches on subsequent generations were examined. The results of this model, as well as the possible implications for predators which rely on copepod blooms, will be discussed.

PICES XIII S10-2083 Poster
Modeling iterannual and decadal variability of Pacific saury

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Pacific saury, *Cololabis saira*, is mainly located in Northwest Pacific, and it is one of important commercial fisheries in Japan. Saury migrates widely in Northwest Pacific. Saury growth and stock vary widely from year to year, but the cause for these fluctuations is unclear due to paucity of data. A modeling approach is useful to investigate physical and biological processes responsible for variation of saury biomass and growth rate. This study focuses on interannual and decadal variability of physical and biological processes regulating Pacific saury growth. The saury model is linked with a 3-D lower trophic biological model consisting of multiple phytoplankton and zooplankton. The results show that the saury growth rate is higher during El Niño years, but lower in La Niña years. This is mainly due to the modeled interannual variability of zooplankton biomass in the mixed water region (Kuroshio-Oyashio interfrontal zone) and Oyashio regions where both young and adult saury feed. Also, the growth rate tends to be higher after the 1976/77 Pacific climate shift due to the modeled zooplankton biomass increase after the 1976/77 climate shift, which correlate well with the Pacific Decadal Oscillation (PDO). During the positive PDO phase, the mixed water region tends to be colder with deeper mixing during the winter and early spring. Therefore spring phytoplankton productivity is higher, which results in higher zooplankton biomass. The results show potential linkages between the physical variability and plankton dynamics with the Pacific saury growth and migration patterns.

PICES XIII S10-2112 Oral
A biophysical model for walleye pollock in the Gulf of Alaska to study recruitment variability: A coupled modelling approach

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An individual-based model for young pollock in the Gulf of Alaska coupled to an hydrodynamic model output (*i.e.* salinity and u,v,w components of velocity) and a 3D NPZ (Nitrogen-Phytoplankton-Zooplankton) model that accounted for the food of the early stages of pollock up to juveniles was run. The NPZ model was used to describe the population dynamics of two zooplankton species, *Neocalanus spp*., the biomass-dominant copepod in the western coastal Gulf of Alaska and Shelikof Strait, and *Pseudocalanus spp*. Ten years of simulations of the coupled models estimating a pre-recruitment index (*i.e.* proportion of juveniles remaining from the total eggs released which reached the nursery area inshore of the Shumagin islands) were performed to examine variation in recruitment featuring years 1993-2003. To assess alternative recruitment hypotheses several factors were varied such the pre-recruitment index definition, nursery areas, spawning areas and dates of spawning.

PICES XIII S10-1978 Poster
Influence of energetic meso-scale eddies on the lower trophic levels of the ecosystem in the northeastern tropical Pacific

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A sub-domain of the global Navy Coastal Ocean Model is coupled to a medium complexity ecosystem model in order to simulate biogeophysical interactions in the northeast tropical Pacific. The model domain encompasses the Costa Rica Dome and the coast of Central America. The ecosystem model includes two size-classes of

phytoplankton and two size-classes of zooplankton. The physical model is run with real-time forcing and data assimilation from 1999 to 2002, and the results of the coupled model are validated with ocean color data from SeaWiFS. The emphasis of the study is on interactions between the coast and the offshore regions through upwelling and advection by eddies. Patterns of modeled upper-layer chlorophyll concentration correspond well with those observed by SeaWiFS, although the magnitude differs somewhat. Model runs without horizontal advection do not reproduce these patterns, indicating that a one-dimensional model would have been inadequate in this area. Horizontal advection by eddies provides a strong and perhaps unique link between the productive coastal areas and open ocean. As the eddies propagate offshore, they develop a characteristic signature, with elevated chlorophyll concentration along the rim of the eddy and lower concentration in the center. This signature can be detected more than 1000 km from the coast. Whether this phenomenon is purely advective or is associated with local upwelling in the eddy has yet to be determined.

PICES XIII S10-1796 Oral

A three-dimensional numerical study of the spirals and water exchange near the shelf front in the northern South China Sea in winter

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In recent years, the Pearl River and adjacent continental shelf areas in the northern South China Sea have become eutrophic. These regions have also seen the highest frequency of occurrence of Harmful Algal Blooms (HAB) in the coastal China Seas. The Princeton Ocean Model (POM) is used to study the water exchange of the eutrophic coastal water and oligotrophic open sea in the shelf front area. To simulate the front well, an orthogonal curvilinear grid is used in the horizontal (the grid near the front is about 2km×2km) and 15 sigma levels in the vertical. The open boundaries, including tidal elevation, temperature and salinity, are obtained from a large SCS ocean model. Surface conditions are obtained from a realistic MM5 meteorological model. First, the tidal results are validated in this paper. Next we compare the temperature, salinity and current results with *in situ* survey data in January 2004. The characters of the SST distribution agree well with the data from space imagery. Therefore, we conclude that the model can successfully reproduce the main hydrodynamic process of the front area in winter, such as front dynamics, water exchange, and some frontal instability phenomena associated with atmospheric variations. The formation of the vortex in February 2001 is also simulated in this paper. The mechanism of the eddy formation is related to inertial instability and the meso-scale climatic fluctuation.

PICES XIII S10-1798 Oral

Simulations of annual cycle of phytoplankton production and the utilization of nitrogen in the Yellow Sea

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A nutrient dynamics model coupled with a 3D physical model has been developed to study the annual cycle of phytoplankton production in the Yellow Sea. The biological model involves interactions between the inorganic nitrogen (nitrate, ammonium), phosphate and phytoplankton biomass. The model successfully reproduces the main features of phytoplankton-nutrient variation and the production dynamics. 1. The well-mixed coastal water is characterized by high primary production, as well as high new production. 2. In summer, the convergence of the tidal front is an important hydrodynamic process, which contributes to the high biomass at the frontal area. 3. The evolution of phytoplankton blooms and thermocline in the central region demonstrate that mixing is a dominant factor to the production in the Yellow Sea. In this simulation, the nitrate- and ammonium-based productions are estimated regionally and temporally. The study also reveals that phosphate is the major nutrient, limiting the

phytoplankton growth throughout the year and can be an indicator to predict the bloom magnitude. The North Yellow Sea ranks among the major regions in fixing carbon and nitrogen. The annual averaged *f*-ratio of 0.37 indicates that regenerated production prevails over the Yellow Sea. Finally, the relative roles of external nutrient sources have been evaluated, and benthic fluxes might play a significant role in compensating 54.6% of new nitrogen for the new production consumption.

S11 TCODE E-Poster Session
Data visualization of open ocean processes in the North Pacific

Session Convenors: Mark Merrifield (U.S.A.), Thomas C. Royer (U.S.A.) and Igor Shevchenko (Russia)

In keeping with the PICES XIII theme of open ocean processes, this session will provide an opportunity to present technigues that animate remotely sensed data such as TOPEX/Poseidon/Jason altimetry, SeaWiFS and MODIS ocean color, and sea surface temperature measurements. Integration of remotely sensed physical, biological and chemical data are solicited especially with regard to oceanic "hot spots" of biological activity. Electronic posters on techniques of data retrieval and archiving are also welcome.

Wednesday, October 20, 2004 17:30-19:30

Tatyana V. Belonenko and Alexey V. Koldunov
Research of the interrelation of sea level deviations and water temperature fluctuations in the northwest part of the Pacific on the satellite information basis (S11-1806)

Peter Etnoyer (Invited)
Visualizing pelagic habitat in the Northeast Pacific (S11-2171)

Andrew V. Golik and Vitaly K. Fischenko
The technologies of integration of the oceanographic data, tools of their visualization and analysis in internet-based GIS (S11-1849)

Albert J. Hermann, Enrique N. Curchitser, Dale B. Haidvogel, Elizabeth L. Dobbins, Sarah Hinckley and Christopher W. Moore
Immersive visualization of the circulation and biology of the Northeast Pacific using spatially nested model output (S11-2042)

Dmitry D. Kaplunenko, Young J. Ro , Vyacheslav B. Lobanov and Eung Kim
Development of web-based technology for composing comprehensive oceanographic data sets of the East/Japan Sea (S11-1975)

Abigail L. McCarthy, Selina S. Heppell, Scott S. Heppell, Molly E. Lutcavage and Thomas Dellinger
A characterization of pelagic habitat of loggerhead (*Caretta caretta*) turtles in the North Atlantic Ocean (S11-1935)

Vladimir I. Rostov, Natalia I. Rudykh, Elena V. Dmitrieva and Igor D. Rostov
Atlas of hydrophysical characteristics of the northeastern part of Kamchatka Peninsula (S11-1788)

Igor Shevchenko, Georgy Moiseenko and Olga Vasik
Using Marine Biology ontology for metadata exchange (S11-1943)

Mukti Zainuddin, Katsuya Saitoh and Sei-ichi Saitoh
Spatio-temporal dynamics of albacore fishing ground and environmental conditions detected by remotely sensed satellite data (S11-1941)

PICES XIII S11-1806 E-poster

Research of the interrelation of a sea level deviations and water temperature fluctuations in the northwest part of the Pacific on the satellite information basis

Tatyana V. **Belonenko** and Alexey V. Koldunov

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The statistical research between the various characteristics of oceanic fields is carried out for 80 stations. For the statistical analysis we used information from October, 1992 to February, 2002. Data on water temperature were obtained from NOAA, JPL and DAAC, while the sea level data were obtained from TOPEX/POSEIDON, ERS-1 and ERS-2.

The maximum correlation (0.85) is observed in the area farthest removed from the Kuril islands with another high correlation (0.75) found over shallow areas near to islands of Kunashir and islands of the Small Kuril ridge. The appropriate temporal shifts in the southeast part of area are insignificant and do not exceed 20 days while temporal shifts are much higher near Kunashir and Shikotan and reach 80 days.

The water temperature spectral frequency has a maximum at the annual period, while the sea levels have the annual period plus additional spectal peaks at periods of 50, 90 and 185 days. The seasonal component dominates the water temperature signal whereas the sea level signal has other components that are determined by other physical laws (for example, the contribution of the steric components, and the contributions determined by dynamic processes).

The analysis carried out on the basis of satellite measurements supports the expressed interrelation between surface water temperature and sea level. Changes of temperature precede changes of a level, proving the presence of the essential contributions of steric processes in the variability of sea level.

PICES XIII S11-2171 Invited

Visualizing pelagic habitat in the Northeast Pacific

Peter **Etnoyer**

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I present spatial analyses that define pelagic habitat in the Northeast Pacific based upon the density of steep temperature gradients, or fronts, and we quantify their spatial and temporal persistence over a single ENSO cycle (1996-1999) to benefit marine conservation and marine management strategies. I run a moving window over a grid surface of sea surface temperature to calculate slope, and I define a threshold for the steepest slopes in order to isolate temperature fronts. Adjacent steep grid values are transformed to line features, and another moving window calculates the density of frontal features in km/km^2. A second threshold delimits "high concentrations". The final grid is a monthly binary grid of high concentration, and low concentration. Using map algebra, monthly grids are summed for annual values of persistence between 1 and 12. We find less that than <1% of the Northeast Pacific ocean exhibits a persistent (> 8 mo/yr) concentration of temperature fronts (> .2 km/km^2) within and between years. The Baja California Frontal System (BCFS) is the largest concentration within federal waters, between 20 km and 300 km east of Baja California Sur. Multi-specific habitat functions are associated with the BCFS, including Blue Whales (*Balaenoptera musculus*), Swordfish (*Xiphias Gladius*), Striped Marlin (*Tetrapturus audax*), and Red crabs (*Pleuroncodes planipes*).

PICES XIII S11-1849 E-poster

The technologies of integration of the oceanographic data, tools of their visualization and analysis in internet-based GIS

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The technologies for the integration of the oceanographic data, tools of their visualization and analysis, realized in corporate GIS of the Far Eastern Branch of the Russian Academy of Sciences (FEB RAS) in the northwestern Pacific, are considered. GIS is based on Internet technologies according to architecture "client – server". Clients are the computers of scientists connected to a high-speed corporate network of scientific institutes of the FEB RAS. The server is the high-efficiency computer processing queries of clients. All GIS data can be divided into three groups: 1 - the data stored in primary database of a GIS-server; 2 - the data on information datastores, located in a corporate network of FEB RAS; 3 - the oceanographic data accessible on the Internet. The GIS-server uses specially developed protocols for interaction with each group of the data, thus the user interface remains common. The GIS-server provides cartographical visualization of the data. It accepts requests from users, translates them into queries to databases, makes spatial transformations, and builds cartographical projections of the data as raster images displayed on a computer of the user. Analytical data processing in GIS is provided at three levels. First, users can access data as files which then can be processed by programs of scientific calculations (Matlab, Scilab, *etc.*). Second, some processing procedures are realized directly on a server-side. Third, the technology of embedding of programs is realized in GIS and such processing executed directly on a computer of the user. Some information and analytical resources are accessible also to Internet users.

PICES XIII S11-2042 E-poster

Immersive visualization of the circulation and biology of the Northeast Pacific using spatially nested model output

Albert J. **Hermann**[1], Enrique N. Curchitser[2], Dale B. Haidvogel[3], Elizabeth L. Dobbins[1], Sarah Hinckley[4] and Christopher W. Moore[1]

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Immersive visualization techniques are employed to illustrate the 3-D structure of output from a set of spatially nested physical and biological models based on the Regional Ocean Modeling System. This nested set is being used to explore the remote and local influence of the 1997-1998 El Niño on the circulation and temperature fields of the Northeast Pacific, and the lower trophic level dynamics of the Coastal Gulf of Alaska. Elements of this set include a basin-scale model of the North Pacific at ~40 km resolution, a regional model of the Northeast Pacific at ~10 km resolution, and a local model of the Coastal Gulf of Alaska (with embedded NPZ dynamics) at ~3 km resolution. The regional model spans an area from Baja California through the Bering Sea. We have performed a series of sensitivity runs with the regional model, which analyze the effects of 1) hindcast winds as compared to monthly climatological winds (both from the NCEP reanalysis), and 2) hindcast boundary conditions as compared to monthly climatological boundary conditions (both from a hindcast run of the basin-scale model). Results indicate penetration of velocity and scalar anomalies from the basin-scale model into the regional model. Immersive techniques are found to be especially powerful in revealing the structure of spatially patchy fields, which include: 1) physical anomaly fields from our sensitivity experiments; and 2) biological scalars, such as phytoplankton, in the local model.

PICES XIII S11-1975 E-poster

Development of web-based technology for composing comprehensive oceanographic data sets of the East/Japan Sea

Dmitry D. **Kaplunenko**[1,2], Young J. Ro[2], Vyacheslav B. Lobanov[1] and Eung Kim[2]

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Continuing interest of society in the global and regional climatic changes concerned with the East/Japan Sea and growing monitoring activities result in a large number of archived and real-time oceanographic data sources distributed over different countries and agencies. One of the key issues of GOOS and regional monitoring programs is the combining of various available data into particular data sets for specific research, operational and forecasting purposes. In this case the technology of Virtual Database (VDB) might be useful for making quick selections of data samples from the different databases. This requires development of the software (technology) that allows combining necessary data samples in a real time mode by simultaneous queries to different sources.

In this work, the oceanographic data provided by NEAR-GOOS data bases, Korean Oceanographic Data Center (KODC) and other available Korean and Russian sources have been used. Merging and blending of these data has been obtained by the VDB technology and Optimal Interpolation using the GMT tools and Virtual IDL Machine as two different approaches. The user's interface was designed as a web-site by the joint efforts of the Chungnam National University and Pacific Oceanological Institute (http://vdb-eastsea.poi.dvo.ru/). Such approach to the data processing allow to obtain quickly online comprehensive datasets from different locations and may be used as a helpful tool for analysis of data obtained by the GOOS project.

PICES XIII S11-1935 E-poster

A characterization of pelagic habitat of loggerhead (*Caretta caretta*) turtles in the North Atlantic Ocean

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For many species of marine turtle, the characteristics that define pelagic habitat have yet to be fully identified. A better understanding of these habitat characteristics is critical to reduce high seas fisheries interactions with turtles, especially since the status of many turtle populations has placed them on the threatened or endangered species list. To gain a more thorough understanding of pelagic loggerhead habitat, we analyzed sea surface temperature, sea surface height anomaly and chlorophyll a values for sites where loggerhead turtles were caught during scientific longline cruises in the Central North Atlantic. The cruises were conducted during the months of May, June, July and August of 2001 and 2002, in an area of the central North Atlantic that is rarely fished. We analyzed the same oceanographic data for satellite- tracked loggerhead turtles from the Eastern North Atlantic, and compared habitat definitions derived by the two different data-collection methods. The analyses indicated that both satellite tracked and incidentally caught turtles were located near oceanographic features such as fronts, possibly due to the high concentrations of prey items at those features. This work showed that satellite tracking and fisheries data can be successfully integrated to identify important pelagic habitats for marine turtles, an approach which can be applied to populations in the Pacific Ocean as well as the Atlantic.

PICES XIII S11-1788 E-poster
Atlas of hydrophysical characteristics of the northeastern part of Kamchatka Peninsula

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The new electronic atlas contains a summary of many major aspects of the north eastern part of Kamchatka Peninsula regional oceanography and hydrophysics presented as tables, pictures and textual materials. The CD-ROM contains a brief annotated description of information on the main physical-geographical characteristics, peculiarities of hydrological regime, water masses, tidal phenomena and water circulation of the region as well as modern experimental research and modelling results. The atlas contains vast graphic material characterizing the large-scale background peculiarities of distribution and inter-annual variability of the sea water temperature, salinity, sound velocity, Brunt-Vaisala frequency, some hydrochemical elements, tides and internal waves parameters (calculated) and currents. The CD-ROM contains an integrated oceanographic data base, moored current meter data set and software for processing of oceanographic station data. The system provides fast access to selected data stored on CD-ROM, as well as to the other operative or generalized reference information scattered among various sources, and hence,available for wide use. A copy of full version of the CD-ROM is available through the Internet <http://www.pacificinfo.ru>.

PICES XIII S11-1943 E-poster
Using Marine Biology ontology for metadata exchange

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Collected marine biology data are usually treated as proprietary and no direct access for the information retrieval is available. Metadata bases provide data about data that allow one to understand if some data are of interest for a particular purpose. However, it is practically impossible to keep the metadata up-to-date without use of automated procedures.

We propose an architecture and implementation of a prototype of the system for the publication of metadata on the Web with use of a draft of the Marine Biology ontology. The approach allows us to integrate distributed metadata repositories by providing the semantic foundations for translations among different languages and representations.

PICES XIII S11-1941 E-poster
Spatio-temporal dynamics of albacore fishing ground and environmental conditions detected by remotely sensed satellite data

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Synoptic measurements of satellite sea surface temperature (SST) derived from TRMM/TMI, sea surface chlorophyll (SSC) concentration estimated from SeaWiFS and sea surface height anomaly obtained from AVISO combined with catch data are used to demonstrate spatio-temporal dynamics of potential albacore fishing grounds relative to their environments during winter (November-March) 1998-2000. Results showed that the high CPUEs were obtained in the preferred environmental conditions, SST (18.5-21.5°C) and SSC (0.2-0.35 mg m^{-3}), particularly in November. These ranges reflected predicted area where fronts are likely to occur. Altimetry data coincide with high CPUEs concentrated in areas with both cyclonic and anti-cyclonic eddy fields. The predicted areas and eddy fields were defined as "an oceanic hot spots", where biological productivity might be enhanced. In November 1998, the most successful fishing grounds occurred between 34 and 38°N, and between 165 and 170°E, contained an anti-

cyclonic eddy field and then moved into a frontal area and subsequently tended to move toward the cyclonic eddy field. During November 1999 albacore were taken in substantial numbers in areas from 35 to 38°N and from 162 to 172°E with a wider longitudinal band of frontal area and with an eddy field that was less developed. In contrast, in November 2000 the productive fishing grounds tended to be localized in the area of an anti-cyclonic eddy and frontal structures that were less well formed. The center of fishing ground in this period was located near 36°N and 165°E. We have visualized the space-time dynamics of these oceanographic features on the potential albacore fishing ground.

BIO Paper Session

Session Convenor: Vladimir I. Radchenko (Russia)

Papers on all aspects of biological oceanography in the North Pacific and its marginal seas are invited.

Thursday, October 21, 2004 8:30-12:00

08:30-08:50 **Sean Toczko, J. Nishikawa and N. Nishida**
Structure and trophic ecology of the micronektonic crustacean assemblage in the subarctic Pacific and Bering Sea (BIO_P-2128)

08:50-09:10 **Kaoru Nakata, Hiroshi Itoh, Kiyo Kurita and Hiroshi Kiyosawa**
Seasonality in the oncaeid copepods in the epipelagic layers of the subtropical water off Kuroshio (BIO_P-1840)

09:10-09:30 **Hye Seon Kim, Ho Young Soh, Yang Ho Yoon, Doojin Hwang and Sang Duk Choi**
Molecular population structure of the euphausiid *Pseudeuphausia sinica* from the Northeastern Asia (BIO_P-2064)

09:30-09:50 **Chuan-Lin Huo, Geng-Chen Han, Ju-Ying Wang and Dao-Ming Guan**
Monitoring biological effects of contamination in fat greenling *Hexagrammos otakii* along the Dalian coast by measurement of EROD activity (BIO_P-1778)

09:50-10:10 **Coffee break**

10:10-10:30 **Vitali Dudarev and Vadim Savinikh**
On the fluctuations of sardine-iwashi abundance (BIO_P-1812)

10:30-10:50 **Alexey A. Baytalyuk and Vadim F. Savinykh**
Abundance dynamics of pacific saury (*Cololabis saira*) in the northwestern Pacific Ocean (BIO_P-2078)

10:50-11:10 **Felipe Amezcua, Ivan Martínez-Tovar and Yanira Green**
Use of otoliths to determine the age and growth of two subtropical flatfishes, *Cyclopsetta querna*, and *Cyclopsetta panamensis* (Pleuronectiformes: Paralichthyidae), off the southeast coast of the Gulf of California, Mexico (BIO_P-1835)

11:10-11:30 **Robert Suryan, David Irons, Evelyn Brown, Patrick Jodice and Daniel Roby**
Site-specific factors affecting productivity of an upper trophic level marine predator: Bottom-up, top-down, and mismatch effects on reproduction in a colonial seabird (BIO_P-2059)

11:30-11:50 **Discussion, recommendations for BIO Committee**

Posters

Tatyana A. Belan, Elena V. Oleynik, Valentina D. Budaeva, Luisa N. Propp, Marina S. Selina, Vyacheslav G. Makarov and Ludmila S. Belan
Productivity of pelagic communities and distribution patterns of benthos on the continental shelf and slope of the Okhotsk Sea along NE Sakhalin Island (BIO_P-1781)

Eun Seob Cho
PCR-based assays for detecting ichthyotoxic *Cochlodinium polykrikoides* (Gymnodiniales, Dinophyceae) in the South Sea of Korea (BIO_P-1980)

Hung-Yen Hsieh, Wen-Tseng Lo, Don-Chung Liu and Wei-Cheng Su
Spatial distribution of fish larvae in relation to hydrographic conditions in the waters around Taiwan (BIO_P-1912)

Morio Ichihara, Kazushi Miyashita, Hiroto Murase, Hikaru Watanabe and Shigeyuki Kawahara
Acoustic visualization of the relationship between ocean structure and the vertical distribution of biota in the Kuroshio-Oyashio Transition Zone (KOTZ) (BIO_P-2101)

Tsutomu Ikeda, Fumikazu Sano and Atsushi Yamaguchi
Metabolic characteristics of meso- and bathypelagic copepods in the Oyashio region, western North Pacific Ocean (BIO_P-1888)

Sam Geon Lee and Seung Heo
The distribution of modern dinoflagellate cysts in the Yellow Sea (BIO_P-1958)

Vladimir I. Dulepov and Natalia N. Lelyukh
Study of macrobenthos communities in Peter the Great Bay using an underwater vehicle (BIO_P-1965)

Akihiro Shiomoto, Kosei Sasaoka, Mitsuhiro Toratani and Shinji Hashimoto
Relatively high chlorophyll *a* spots in the offshore subarctic North Pacific in summer (BIO_P-1844)

Tao Zuo and Rong Wang
Community structure of zooplankton in the East China Sea and the Yellow Sea (BIO_P-1770)

PICES XIII BIO_P-1835 Oral

Use of otoliths to determine the age and growth of two subtropical flatfishes, *Cyclopsetta querna* and *Cyclopsetta panamensis* (Pleuronectiformes: Paralichthyidae), off the southeast coast of the Gulf of California, México

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Sagittal otoliths were used to determine the age and growth of *Cyclopsetta querna* and *Cyclopsetta panamensis* caught off the southeast coast of the Gulf of California with commercial trawls. In total, 245 individuals of *C. querna* and 172 individuals of *C. panamensis* were examined. For both species, the marginal growth increments indicated that the bands were formed yearly, the hyaline bands were formed during the summer and the opaque bands were formed during the winter. Four hyaline bands and three opaque bands were recognized, representing ages from 0.5 to 4.5 years. The von Bertalanffy growth parameters for the entire population were $L\infty$=66.171cm; k=0.214/yr; t_0=0.404 yr for *C. querna*, and $L\infty$=60.024cm; k=0.177/yr; t_0=0.26 yr, for *C. panamensis*. No significant differences in length-at-age were found between sexes for any species. The life span of these species is short, about 5 years. The use of otoliths to determine the age and growth of these species is an adequate method, notwithstanding the usual paradigm that determining the age of species of warmer climates is difficult because there are no clear annual rings in the otoliths.

PICES XIII BIO_P-1781 Poster

Productivity of pelagic communities and distribution patterns of benthos on the continental shelf and slope of the Okhotsk Sea along NE Sakhalin Island

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An expedition in August of 2003 on the continental shelf and slope of the Okhotsk Sea along NE Sakhalin Island obtained new data on productivity of pelagic communities and abundance and distribution patterns of benthos. Water and sediment samples were taken at 20 stations along 5 transects between 52°and 54°N ata depth from 20 to 1500 m.

Concentrations of Chl *a* in in the photic layer varied from 0.13 to 11.79 mg/m^3 (mean = 1.76 mg/m^3). Primary production varied from 0 to 7.30 mgC/m^3 day (mean = 1.40 mgC/m^3 day). As a rule, the highest Chl *a* concentration and primary productivity was observed at layer of 10-20 m near the shore. The diatom microalgae community with the highest abundance, Chl *a* concentration and productivity level was observed in the coastal waters. Areas of high productivity of pelagic communities in 2003 were concentrated in zones of local cyclonic eddies.

The benthos abundance pattern in 2003 corresponded to data obtained in the 1990s, indicating that the highest biomass (>1000 g/m^2) and densities (>16,000 ind/m^2) were observed at the depth range 30-100 m due to strong aggregations of suspension-feeders: sea urchins, amphipods and cumaceans. This zone encompasses the area of coastal upwelling. Maximum species abundance was registered at the depth range 100-200 m.

PICES XIII BIO_P-1980 Poster
PCR-based assays for detecting ichthyotoxic *Cochlodinium polykrikoides* (Gymnodiniales, Dinophyceae) in the South Sea of Korea

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Rapid detection of the harmful dinoflagellate *Cochlodinium polykrikoides* is necessary for effective monitoring in Korean coastal waters. Recently, the DNA ITS (Internal Transcribed Spacers) region has been identified as a suitable means for the identification of *C. polykrikoides*. This study is the first to design specific DNA primers and to evaluate their specificity and sensitivity in a PCR assay on cultures. Oligonucleotide primers Cocho 1F and Cocho 5R were designed to amplify an approximately 500 base pair fragment, comprising sections of the rDNA ITS of *C. polykrikoides*. PCR products of predicted size were produced for 4 isolates from Narodo and Daebyeon, Korea, and from the Yatsushiro Sea of Kumarr and Inokushi Bay, Japan. No PCR products were amplified when the primers were tested against *Heterosigma akashiwo*, *Gymnodinium impudicum*, *Alexandrium tamarense*, *Prorocentrum micans*, *Akashiwo sanguineum*, *Chaetoceros affinis*, *Scrippsiella trochoidea*, and *Chlamydomonas* sp. In cultures of *C. polykrikoides*, the limit of detection was 10 cells l^{-1}. This PCR assay directly detected *C. polykrikoides* in the ocean at Dolsan (St. 1) in June, where it existed at approximately 10 cells l^{-1} (determined by light microscope). However, neither PCR-positive products nor detection by light microscope was seen during March, April, May, or June in any locations, except for Dolsan on June. During the period of study, fluctuations in environmental conditions, nutrients, and the ratio of DIN/DIP were similar regardless of sampling sites. The cause of the outbreak of *C. polykrikoides* at Dolsan did not appear to be associated with environmental characteristics. These specific primers will be a useful tool in simple, rapid, and accurate assessment of *C. polykrikoides* in natural samples.

PICES XIII BIO_P-1812 Oral
On the fluctuations of sardine-iwashi abundance

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The sardine-iwashi (*Sardinops melanosticta*) has shown prominent periodic fluctuations in its abundance, similar to other species of the genus *Sardinops*. Both the stock of this species and value of the catch change in a hundred-fold or more times in 25-30 years. This fluctuation is among the highest of any fish population in the North Pacific. After 30-years of depressed abundances, a sardine generation with high abundance appeared in 1972, and in 1976 an active seine fishery began in the Japan Sea, with a value reaching 370,000 MT in Russian EEZ alone in 1982. The total biomass of sardines in the Northwest Pacific was about 20 MMT in that period. The fishery was unlimited and the total catch of sardines by all Asian-Pacific countries was 4.5 MMT – higher than the catch of Alaska walleye pollock. We hypothesize that changes in solar activity are the primary factor behind climate changes and large-scale reconstructions of marine ecosystems, including the fluctuations of sardine abundance. Regional climate-oceanographic environments provide the starting conditions for sardine stock growth, but when it reaches a high value, mechanisms of population density regulation are switched on, and environmental control terminates. Independent of environmental factors, density factors can lead the population to an inevitable depression.

PICES XIII BIO_P-1912 Poster
Spatial distribution of fish larvae in relation to hydrographic conditions in the waters around Taiwan

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The purpose of this study is to investigate the species composition and distribution of fish larvae in relation to hydrographic conditions in the waters around Taiwan collected during a R/V FRI cruise in February 2003. Samples

were collected from 28 stations by oblique tows from 200 m depth (or 10 m from bottom at stations with shallower depth) to the surface using an ORI net, with 1.6 m mouth diameter and 330μm mesh. Two hundred and twenty-nine taxa of fish larvae belonging to 126 genera and 70 families were recognized. Of these, 96 taxa were identified to family or genus level, and the rest to species. The ten most dominant taxa were *Engraulis japonicus*, *Auxis rochei*, *Diaphus* spp., *Benthosema pterotum*, *Carangoides ferdau*, *Embolichthys mitsukurii*, *Maurolicus* sp., *Gonostoma gracile*, Myctophidae gen.sp. and *Trichiurus lepturus*; together they constituted 68% of the total fish larvae. The winter hydrographic conditions in the waters around Taiwan were mainly influenced by the China Coastal Waters (CCW) and the Kuroshio Current (KC). The distribution of fish larvae showed apparent association with water masses. Higher abundance was observed in the northwestern Taiwan where CCW was located and lower in KC, but the reverse was true for species number and diversity. Based on the results of cluster analysis, three seasonal groups were distinguished and are discussed.

PICES XIII BIO_P-1778 Oral

Monitoring biological effects of contamination in fat greenling *Hexagrammos otakii* along the Dalian coast by measurement of EROD activity

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There have been many efforts to find suitable biological parameters for pollution monitoring programmes in the past 20 to 30 years. The monooxygenase (MO)-activity of fish has been shown to be useful as an 'early warning' system for environmental contamination caused by polycyclic aromatic hydrocarbons (PAH), polychlorinated dibenzodioxins (PCDD) and certain PCB (polychlorobiphenyl). Ethoxyresorufin-O-deethylase (EROD) is one of the model reactions of the cytochrome P-450-1A1 mediated monooxygenase system. In this study, EROD activity, measured by kinetics fluorescence spectrophotometry, was selected as an indicator of PAH and PCB effects in benthic fishes. EROD induction in fish liver exposed to organic contamination demonstrated the ability of this technique to be an available and efficient marker of exposure to specific pollutants. After it was determined that there existed a dose/effect relationship between EROD activities and specific pollutant concentrations, an initial assessment of biological effects on fat greenling *Hexagrammos otakii* was carried out in well-chosen stations of the coasts along Dalian. It was proved to be feasible that EROD activity can be used to assess specific contamination through combination with other analysis of PCB data. It should be noted that multiple factors may have an effect on EROD activities in organisms. Therefore, a regular biological effects monitoring had been carried out for three years along Changhai area of Dalian by measurement of EROD activities in fish, to determine the feasibility of studying such parameters in the field and thehe optimal conditions for analysis of EROD activity are discussed. Moreover, a much faster and simpler method for measuring hepatic EROD activities of fish, using a fluorescence plate-reader, was introduced and discussed.

PICES XIII BIO_P-2101 Poster

Acoustic visualization of the relationship between ocean structure and the vertical distribution of biota in the Kuroshio-Oyashio Transition Zone (KOTZ)

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The Kuroshio-Oyashio Transition Zone (KOTZ) is well known as a region where a complex ecosystem forms because of the mixing of warm and cold water. Especially in the spring, remarkable biological production is observed because of the increase of primary productivity and the resulting phytoplankton bloom. It is important to examine how the environmental conditions in the KOTZ affect the horizontal and vertical distribution pattern of

marine organisms. Acoustic methods are an effective way to examine vertical distribution patterns of biota. The aim of this study is to clarify the relationship between oceanographic conditions and the horizontal and vertical distribution pattern of biota in the KOTZ using a quantitative echosounder system. Acoustic, net sampling and oceanographic data were obtained during a survey of prey preference of baleen whales conducted in April 2003 off the Pacific coast of northeastern Japan. Acoustic backscattering from Japanese anchovy (*Engraulis japonicus*) was frequently seen in the surface layer of the warm water region and from zooplankton such as euphausiids and copepods in the cold water region. Two kinds of water mass structure occurred in Sendai Bay, which was located in the mixed water region, and the distribution of marine organisms was divided according to the water layers. These results suggest that the acoustic method can visualize how strongly biota of the complex region are distributed according to ocean structure.

PICES XIII BIO_P-1888 Poster
Metabolic characteristics of meso- and bathypelagic copepods in the Oyashio region, western North Pacific Ocean

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Copepods living in the 500-1000, 1000-2000, and 2000-3000m depth strata in the Oyashio region were retrieved by vertical hauls with closing nets, and their oxygen consumption rates were determined on board ship at near *in situ* oxygen concentrations (2-3.5 $mlO_2\ l^{-1}$) and temperatures (1.5-3^oC) by using a sealed-chamber method. Oxygen consumption rates thus obtained on a total of 64 copepod species were standardized to body nitrogen to examine the effect of body size (nitrogen), temperature, depth of occurrence, and ambient oxygen concentration. Stepwise-multiple regression analyses on these data, combined with information on epipelagic copepods inhabiting similar thermal regimes in the Arctic and Antarctic, revealed that, in addition to body size and temperature, the depth of occurrence is a factor affecting the oxygen consumption rates of deep-sea copepods. Typically, the oxygen consumption rates of bathypelagic copepods were 1/3-1/4 of the rates of epipelagic ones. Possible artifacts caused by the sampling process are unlikely as simultaneous determinations of ETS-activities of these copepods exhibited the same depth effect (F. Sano *et al.*, unpublished data). Thus, our results do not support the standing view that the metabolic activity of pelagic copepods is not affected by the depth of their occurrence in the ocean.

PICES XIII BIO_P-2064 Oral
Molecular population structure of the euphausiid *Pseudeuphausia sinica* from the Northeastern Asia

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The euphausiid *Pseudeuphausia sinica* (Crustacea, Euphausiacea), is abundant in the coastal regions of the South and East China Sea all the year round, and was first reported from the southwestern coastal region in Korean waters in November 1989. However, it has recently also been found in Gwangyang Bay in the southern region of Korea. DNA sequences for a 610bp region of mitochondrial cytochrome oxidase I (mtCOI) were determined to examine the relationships of 23 specimens from three coastal regions of Korea and China (southwestern coastal region of Korea; Gwangyang Bay, southern Korea; and the mouth of the Changjiang (Yangtze) River, China). Alleles from the three sample regions formed paraphyletic groups. In Gwangyang Bay more than 91% of specimens collected in October were classified into the same clade as the China population, while the other specimen and one collected on July formed an independent clade. Specimens collected from the southwestern coastal region of Korea and the mouth of the Changjiang of China in May and July were classified into three clades: Southwestern and southern Korean populations and a Chinese one. Beardsely *et al.* (1992) showed that in summer the southern coastal waters of Korea could be affected by Changjiang River water ca. two months after discharge. This suggests that the Chinese

population of *P. sinica* predominating in the coastal regions of China below 34°N could be continuously transported to Korean waters.

PICES XIII BIO_P-1958 Poster
The distribution of modern dinoflagellate cysts in the Yellow Sea

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Approximately 30 species of modern dinoflagellate cysts were identified in surface sediments in the Yellow Sea with a total abundance of 100~12,830 cysts/g. The predominant order was Gonyaulacales, accounted for 87% to total modern dinoflagellate cysts and followed by Peridiniales (9%) and Gymnodiniales (4%). The dominant species of Gonyaulacales were *Alexandrium tamarense, Gonyaulax scrippsae, G. spinifera*, and *G. verior*; those of Peridiniales were *Diplopsalis lenticula* and *Protoperidinium conicum*; and those of Gymnodiniales were *Pheopolykrikos hartmanii* and *Gynodinium catenatum*. The overall distributional patterns of modern flagellate cysts showed high densities in the central part of the Yellow Sea where Gonyaulacales was 30~400 cysts/g and Peridiniales with 10~1,500 cysts/g and showed decreasing densities in the coastal areas of Korea and China. In the coastal areas, it was relatively higher in Korea than in China except for Gymnodiniales which showed higher abundances of 20~850 cysts/g in waters near China side than near Korea. *Alexandrium tamarense* and *Gynodinium catenatum*, well-known toxic dinoflagellate species, were dominant taxa collected with densities of 10~8,000 cysts/g and 5~170 cysts/g, respectively.

PICES XIII BIO_P-1965 Poster
Study of macrobenthos communities in Peter the Great Bay using an underwater vehicle

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Underwater vehicles are being increasingly used to monitor aquatic ecosystems. The underwater vehicle created for this study is equipped with a system of sensors for video recording of benthic communities. To test this technology, video recordings of benthic communities in Peter the Great Bay have been compared to data simultaneously collected by a diving method in October, 2000. One hundred and twenty eight pictures taken from the underwater vehicle and 40 pictures from divers were analyzed. The density of aquatic organisms was determined for the 9 most abundant species in pictures: 1. *Aphelasterias japonic*a; 2. *Asterias amurensis*; 3. *Patiria pectinifera*; 4. *Strongylocentrotus intermedius*; 5. *Strongylocentrotus nudus*; 6. *Stichopus japonicus*; 7. *Glycymeris yessoensis*; 8. *Crenomytilus grayanus*; 9. *Halocynthia roretzi*. From these, the most common species (2, 3, 5, 8) in this area are chosen for improvement of techniques of quantitative analysis. The average density of each of these species was determined from the 128 pictures: 5.03 ± 0.47; 0.039 ± 0.002; 0.25 ± 0.04; 0.64 ± 0.07 individuals m^{-2}. Comparison of these results from the underwater vehicle with data from the diving method indicates the underwater vehicle can be reliably used to monitor aquatic systems.

PICES XIII BIO_P-1840 Oral
Seasonality in the oncaeid copepods in the epipelagic layers of the subtropical water off Kuroshio

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Seasonality in the biomass, distribution and production of oncaeid copepods, one of the main food organisms for pelagic fish larvae, was investigated in the epipelagic layer of the subtropical water off Kuroshio. Oncaeids occupied about 15% of

the total copepod biomass through the four seasons. More than 30 species of oncaeid copepods appeared in the upper 200m, and showed vertical zonation. Although the mean depth of distribution for each species was shallower in the stratified seasons than in the mixing season, the orders of the species in the zonation were similar during both seasons. The egg productivities of the surface dominated oncaeids were high in the surface layers as compared with chlorophyll maximum layers, and were positively related with the biomass of the microbial food web members such as bacteria and HNF. On the other hand, the egg productivities of the species whose peak biomass occurred in the chlorophyll maximum layers were positively related with the phytoplankton biomass. The vertical zonation, productivity and composition of the oncaeid copepods seemed to be largely affected by the biomass and the composition of phytoplankton and the microbial group members.

PICES XIII BIO_P-2078 Oral
Abundance dynamics of pacific saury (*Cololabis saira*) in the northwestern Pacific Ocean

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Pacific saury is one of the common commercial epipelagic fishes in the northwestern Pacific. Numbers and biomass of saury were estimated based on data from trawl surveys of the northwestern Pacific that have been conducted since the 1980s.

Pacific saury biomass in the Transition region outside of the Russian EEZ over last twenty years fluctuated between 328,000 and 846,000 tons, with the minimal indices during 1980s. Some increase of saury abundance in this region was observed after 1990. According to our estimation, in summer of 2002 the saury was the second most abundant species by biomass within the nekton community of the epipelagic layer. In contrast, abundance and biomass of species that are usually dominant, Japanese sardine, Pacific mackerel and Japanese anchovy, were low at this time. According to the available data, biomass of Pacific saury near the Kuril Islands fluctuated from less than a few tons to 450,000 tons, with the minimal level seen during the 1990s. Since 2000 the saury, salmon and myctophids have made up the basis of the fish community in the upper epipelagic layer in this region.

The distribution of the fishing ground of Pacific saury is closely related to oceanographic processes such as the thermal regime of waters and the course and velocities of the main currents. The increase of saury biomass after 2000 may be connected with changes of migration routes in these years.

PICES XIII BIO_P-1844 Poster
Relatively high chlorophyll *a* spots in the offshore subarctic North Pacific in summer

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High-Nutrient and Low-Chlorophyll (HNLC) conditions occupy the majority of the offshore North Pacific. Chlorophyll *a* (chl *a*) concentration in the HNLC regime is generally accepted as being less than 1 mg m^{-3}. However, SeaWiFS chl *a* images of mesoscale features often show zones of 1 mg m^{-3} or greater in the offshore subarctic North Pacific.

Chl *a* concentration was investigated between 165°E and 145°W along 48°N from late August through early September 2000, by ship and satellite observation. Mesoscale, relatively high chl a zones of 1 mg m^{-3} and greater were observed in the upper 30 m near 165°E, between 178°W and 170°W, and between 168°W and 157°W. Inflow of near-shore water was inferred to play an important part in the formation of these high chl *a* zones. Large sized phytoplankton (> 10 μm) as well as small sized phytoplankton (< 2 μm or 2-10 μm) contributed to the high chl *a* zones in cases of strong influence by near-shore water. In addition, high chl *a* zones were considered to be a

summertime phenomenon in the offshore subarctic North Pacific, based on the SeaWiFS chl *a* images from 1998-2001.

PICES XIII BIO_P-2059 Oral

Site-specific factors affecting productivity of an upper trophic level marine predator: Bottom-up, top-down, and mismatch effects on reproduction in a colonial seabird

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We report on a broad-scale, integrated study of a piscivorous, colonial-nesting seabird, the black-legged kittiwake *Rissa tridactyla,* and its prey in Prince William Sound, Alaska. Our study spanned five breeding seasons (1995 – 1999) and focused on three primary colonies that differed in size (~ 250 to over 7,000 breeding pairs) and proximity to a variety of marine habitats. The diversity of marine habitats and physical and biological coupling between the Gulf of Alaska and Prince William Sound created a complex foraging environment for breeding kittiwakes. The abundance of three primary prey species for kittiwakes (Pacific herring *Clupea pallasi,* Pacific sand lance *Ammodytes hexapterus,* and capelin *Mallotus villosus*) varied both annually and regionally, with little uniformity among years or regions. We found that bottom-up, top-down, timing mismatch, and colony-specific effects were all important to kittiwake nesting success. Although bottom-up effects appeared to be strongest, they were not evident in some cases until other factors were accounted for. Important factors influencing kittiwake reproductive success were not only total prey abundance and the rate at which energy was provisioned to nestlings, but also species, age-class, and chronology of prey occurrence (match/mismatch of timing with critical brood-rearing periods). All of these effects varied among colonies and years. Top-down effects from egg and nest predators (independent of prey abundance) confounded seabird-forage fish relationships. Ultimately, when confounding factors were controlled for, non-linear relationships were identified between kittiwakes and their prey, with the asymptotic threshold of effects on kittiwake nesting success at a fish school surface area density of ~ 5 m^2/km^2.

PICES XIII BIO_P-2128 Oral

Structure and trophic ecology of the micronektonic crustacean assemblage in the subarctic Pacific and Bering Sea

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The vertical distribution, assemblage structure, and diet of dominant micronektonic crustacea (pelagic decapods and mysiids) in the subarctic North Pacific and Bering Sea were examined at four stations: the western subarctic Pacific (WSA), central subarctic Pacific (CSA), eastern subarctic Pacific (ESA), and the Bering Sea (BS). Results were compared to literature reports for euphausiid diet and mesozooplankton biomass concurrently sampled with the micronekton. Diel distribution patterns were highly variable ranging from strong vertical migration in the epipelagic zone to absence of any migration for species residing in the mesopelagic zone. The biomass and abundance of the epipelagic zone was dominated by euphausiids, while mysiids dominated the biomass and abundance of the mesopelagic zone. Decapods were a significant, but smaller fraction of the mesopelagic biomass and abundance than mysiids. Decapods were the most diverse taxa (17 sp.), followed by euphausiids (13 sp.), and mysiids (5 sp.). Dominance within each taxon was represented by 3 species (both in abundance and biomass) across the study area. Daily ration estimates for the micronektonic crustacea and their impact on mesozooplankton production in the subarctic Pacific and Bering Sea are presented, and implications for their trophic positioning in the subarctic Pacific food web are discussed.

PICES XIII BIO_P-1770 Poster

Community structure of zooplankton in the East China Sea and the Yellow Sea

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Community structure and indicator species of zooplankton in the East China Sea and the Yellow Sea were examined using multivariate methods. Seasonal variations in zooplankton were described in detail with respect to abundance, biomass and species composition, and vertical distribution in the southern part of the Yellow Sea. Zooplankton indicators of Yellow Sea Warm Current (YSWC), the main hydrographic phenomena in winter in this region, were also analyzed.

Zooplankton showed higher diversity in the lower latitudes and thermophilic species occurred mainly south of 31°N. Five communities were distinguished based on results of TWINSPAN with the following species composition and environmental characteristics: Yellow Sea neritic community (F) with indicator species of *Labidocera euchaeta* in autumn and *Centropages mcmurrichi* in spring; Yellow Sea central community (HC) with indicator species of *Themisto gracilipes*, *Calanus sinicus* and *Euphausia pacifica*, the latter two species only in spring; East China Sea continental shelf mixed water community (K) with indicator species of *Rhincalanus cornutus* and *Pterosagitta draco* which were limited in waters with high temperature and salinity; Yellow Sea and East China Sea mixed water community (HE) and East China Sea inshore mixed water community (M), both of which were made of species belonging to diverse ecotypes, but temperate species showed more preference in HE while wide-distributed warm species occurred more in M. From multiple –regression analyses, temperature and salinity in surface water were the most important environmental factors related to zooplankton distribution and communities divisions. In the southern part of the Yellow Sea, zooplankton showed decadal changes with the abundance, biomass and diversity of zooplankton, and the ratio of abundance of *Calanus sinicus* to that of *Sagitta crassa* all increasing compared to corresponding data from 1959. The distribution patterns of warm water species clearly showed that the YSWC flows beneath the surface northwards into the Yellow Sea along the Yellow Sea Trough. The northern limit to where the YSWC can penetrate was about 35-36°N and the intrusion of the warm water took place mainly in the middle layer. Temperature was the main determinative factor for zooplankton vertical distribution according to Canonical Correlation Analysis (CCA). The seasonal variations in vertical distribution of *C. sinicus* and *T. gracilipes*, provided evidence that Yellow Sea Bottom Cold Water served as an over-summering site by some temperate species which generally live in waters with relative low temperature.

FIS Paper Session

Session Convenor: Yukimasa Ishida (Japan)

Papers on all aspects of fishery oceanography in the North Pacific and its marginal seas are invited.

Thursday, October 21, 2004 13:00-16:20

13:00-13:15 **Chiyuki Sassa and Yoshinobu Konishi**
Recruitment process of the Japanese jack mackerel in the East China Sea (ECS) - Spawning ground and larval transport into fishing grounds (FIS_P-1823)

13:15-13:30 **Motomitsu Takahashi, Yoshiro Watanabe, Hiroshi Nishida and Akihiko Yatsu**
Interannual variation in growth of larval and early juvenile Japanese anchovy in the Kuroshio-Oyashio transition region (FIS_P-1857)

13:30-13:45 **Ivan Martinez Tovar, Felipe Amezcua Martinez and Juan Madrid Vera**
Analysis of fish bycatch from the commercial shrimp fleet in the Southeast Gulf of California (FIS_P-1924)

13:45-14:00 **Ling Tong and Qisheng Tang**
Impacts of global change on fisheries resources of a coastal ecosystem (FIS_P-1813)

14:00-14:15 **Hiroshige Tanaka, Akinori Takasuka, Ichiro Aoki, Seiji Ohshimo and Yozo Wada**
Geographical variations in carbon and nitrogen stable isotope ratios of Japanese anchovy *Engraulis japonicus* (FIS_P-1957)

14:15-14:30 **Michael J. Schirripa, Jim J. Colbert and Omar Rodriguez**
Interannual changes in Pacific hake (*Merluccius productus*) growth in response to oceanographic conditions (FIS_P-1995)

14:30-14:45 **Mikhail A. Stepanenko**
Environmental differentiation of pollock reproduction in the Bering Sea (FIS_P-1809)

14:45-15:00 **Oleg A. Bulatov**
Pollock fishery and total allowable catch in the Bering Sea (FIS_P-1976)

15:00-15:20 **Coffee break**

15:20-15:35 **Tetsuichiro Funamoto, Keizo Yabuki and Satoshi Honda**
Temperature-dependent stock-recruitment model for walleye pollock around Hokkaido, Japan (FIS_P-1822)

15:35-15:50 **Jennifer P. Stahl and Gordon H. Kruse**
Maturation of walleye pollock, *Theragra chalcogramma*, in the eastern Bering Sea in relation to temporal and spatial factors (FIS_P-1873)

15:50-16:05 **Yong-Woo Lee, Bernard A. Megrey and S. Allen Macklin**
Predictability of future recruitment by parametric and non-parametric models: Case study of Gulf of Alaska walleye pollock (FIS_P-1937)

16:05-16:20 **Andre Buchheister and Matthew T. Wilson**
Differential food habits as a mechanism for seasonal and geographic variation in juvenile walleye pollock condition in the western Gulf of Alaska (FIS_P-2107)

Posters

Alexander I. Abakumov, Lev N. Bocharov and Evgeny P. Karedin
Modeling analysis for multispecies fisheries (FIS_P-1814)

Felipe Amezcua, Juan Madrid and Hugo Aguirre
Effect of the artisanal shrimp fishery on the ichthyofauna in a subtropical coastal lagoon in the Gulf of California (FIS_P-1820)

Alexander V. Buslov and Oleg B. Tepnin
New data on walleye pollock spawning in waters of the Commander's Islands Preserve (FIS_P-1776)

Yaqu Chen, Zhaoli Xu, Yong Ni and Yuanquan Chen
Study on dynamic of fisheries resources and protection countermeasures in adjacent waters of Jiuduansha (FIS_P-2190)

Vladimir B. Darnitsky, Vladimir A. Belyaev, Nikolay P. Pahorukov and Svetlana P. Bomko
Composition and changeability of the fish community of the central seamounts of the Kyushu-Palau Ridge and some oceanographic features (Part II) (FIS_P-1800)

Elena Dulepova
Trophic relations of chum (*Oncorhynchus keta*) and pink salmon (*O. gorbuscha*) in the western Bering Sea (FIS_P-2170)

Yukimasa Ishida, Tomonori Azumaya, Masaaki Fukuwaka and Toru Nagasawa
Estimation of catch efficiency of salmon gillnets, distance traveled by salmon, and salmon density in the Bering Sea (FIS_P-1922)

Nozomi Ishiko, Hidetada Kiyofuji and Sei-Ichi Saitoh
Prediction of Pacific saury fishing grounds based on physical variability derived from daily satellite remote sensing data (FIS_P-2025)

Vladimir I. Karpenko and O.A. Rassadnikov
Status of Far Eastern Pacific salmon stocks during recent years (1971-2002) (FIS_P-2152)

Eun Jung Kim, Suam Kim, Dae-Yeon Moon and Jeong-Rack Koh
The variations in distribution, catch, and biology of skipjack tuna (*Katsuwonus pelamis*) induced by climate variability (FIS_P-2021)

Hee-Yong Kim, Atsushi Kaneda, Taisuke Inai, Xinyu Guo and Hidetaka Takeoka
Effect of the Kuroshio frontal eddy on the recruitment of jack mackerel larvae and juveniles in the Bungo Channel, Shikoku, Japan (FIS_P-1896)

Sergey G. Korostelev and P.M. Vasilets
Changes in the composition of demersal fish communities on the western Kamchatka shelf under the influence of fishing (FIS_P-1836)

V.V. Kuznetsov and E.N. Kuznetsova
The stock assessment and fishery of walleye pollock in the Sea of Okhotsk off West Kamchatka (FIS_P-2103)

Sergey V. Loboda and Pavel V. Vorobyov
Influence of commercial fishing on the stock conditions of Pacific herring from the northern part of the Okhotsk Sea (FIS_P-2013)

Ole A. Mathisen and Lowell Fair
Density dependent growth of sockeye salmon in the ocean (FIS_P-1950)

Alexander Nikolaev and Michail Kuznetsov
Acoustic methods for monitoring and ecosystem studies in the Bering and Okhotsk Seas (FIS_P-1879)

Todd Sandell, Kym Jacobson, David Teel and Edmundo Casillas
The distribution and prevalence of Bacterial Kidney Disease (*Renibacterium salmoninarum*) in juvenile chinook and coho salmon in the Northeast Pacific Ocean (FIS_P-1853)

Anatoly V. Smirnov
Environmental impact of interannual variability of Okhotsk Sea pollock abundance (FIS_P-1805)

Gennady V. Avdeev, Anatoly V. Smirnov, Evgeny E. Ovsyannikov and Svetlana L. Ovsyannikova
Variability in sex ratio of the northern Okhotsk Sea walleye pollock spawning stock in 1997-2002 (FIS_P-1953)

Katsuya Suzuki, Tsutomu Takagi, Shinsuke Torisawa and Kazushi Miyashita
Video analysis of the schooling behavior of Japanese surfsmelt (*Hypomesus japonicus*) under light and dark conditions using a mathematical model (FIS_P-1959)

Andrey V. Vinnikov, Dmitry A. Terentiev, Alexei M. Tokranov and Boris A. Sheiko
The preliminary estimation of abundance of some fishes in adjacent waters of the Commander Islands by results of bottom long-line catching in 1995-1997 (FIS_P-2088)

Songguang Xie and Yoshiro Watanabe
Hatch-date dependent difference in growth and development of jack mackerel *Trachurus japonicus* during early life stages recorded in otolith microstructure (FIS_P-1830)

Songguang Xie, Yoshiro Watanabe, Toshiro Saruwatari, Reiji Masuda, Yoh Yamashita, Chiyuki Sassa and Yoshinobu Konishi
Growth and morphological development of sagittal otolith of jack mackerel *Trachurus japonicus* in larval and early juvenile stages (FIS_P-1831)

Chang Ik Zhang, Jae Bong Lee and In-Ja Yeon
Current status of ecosystem-based fisheries management in Korea (FIS_P-2051)

PICES XIII FIS_P-1814 Poster
Modeling analysis for multispecies fisheries

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Multispecies fisheries create a challenge to rationally achieve catches of individual species. The TINRO-Centre developed an approach to analyze and forecast multispecies fisheries using mathematical models. Total allowable catch (TAC) is defined for every species separately, but the fisheries forecasts involve combined species. Here, we describe the mathematical models used for analysis of multispecies fisheries. The first model estimates the Real Catch (RC) as opposed to TAC. Also, we can use this model to analyze the dynamics of the community. The TAC for a species is the assigned catch for this species, whereas RC is calculated on the basis of data on actual multispecies catches. A comparison of RC with TAC allows estimation of the effect of the illegal catches. The problem associated with realization of the TAC is solved in the second model. We calculate the TAC based on catch volume and estimates of RC. This is an optimization procedure in mathematical sense. We look for TAC and RC to agree as closely as possible. This approach can be applied to a defined ocean region for which information about specific composition of catch is available. Data must be averaged over several years.

PICES XIII FIS_P-1820 Poster
Effect of the artisanal shrimp fishery on the ichthyofauna in a subtropical coastal lagoon in the Gulf of California

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The likely effects of the artisanal shrimp fishery on the fish fauna in the Santa Maria la Reforma coastal lagoon, Mexico, were assessed. Twenty-nine stations were sampled for shrimp and fin fish monthly for 6 months, from December 2001 to May 2002, from small boats fitted with outboard engines and the three fishing methods used by the shrimp fishery in the area: a small otter trawl, a gillnet, and a cast net trawl. Each sampling period lasted five days. In total, 11,368 individuals were caught comprising 173 fish species. The species most represented in terms of numbers and biomass included the commercially important species *Eucinostomus entomelas, Sphoeroides annulatus, Urotrygon chilensis* and *Diapterus peruvianus.* The highest abundance and biomass, as determined with the log- normal-based estimator, was caught with the otter trawl. The mean total length of the fish captured was 17.5 cm, but most of the fish were between 14 and 23 cm. The fishing methods in the shrimp fishery that are likely to have the greatest effect on the fish fauna are the otter trawl and the gill net, since in this study they were the methods that caught the highest abundance, biomass and diversity of fish as well as a high quantity of small individuals. These two fishing methods caught fish fauna from the bottom and from the water column, and were the methods that showed the lowest ratio of shrimp biomass to fish biomass caught. The otter trawl caught up to 15.0 kg of fish per kg of shrimp, and the gill net caught up to 69 kg of fish per kg of shrimp.

PICES XIII FIS_P-2107 Oral
Differential food habits as a mechanism for seasonal and geographic variation in juvenile walleye pollock condition in the western Gulf of Alaska

Andre **Buchheister** and Matthew T. Wilson

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A large amount of scientific interest exists for walleye pollock, *Theragra chalcogramma*, due to their commercial and ecological importance in the North Pacific Ocean. In temperate waters, over-winter nutritional stress can be a significant source of mortality for juvenile fish, particularly in the first year of life prior to substantial accumulation of energy reserves. In this study, diets of juvenile walleye pollock from the 2000 year class were examined

seasonally in relation to body condition (weight-at-length and whole body energy density). Pollock diets consisted primarily of euphausiids, copepods, larvaceans, larval crabs, and cumaceans, varying by season and area. During the winter, mean stomach fullness decreased and euphausiids were compositionally less important as prey. These dietary changes coincided with decreases in length-specific weight and whole body energy content from fall (2000) to winter (2000/01), suggesting that nutritional stress contributed to decreased condition. Geographically, pollock off of eastern Kodiak Island tended to be more robust with higher energy densities than fish near the Semidi and Shumagin Islands, corresponding with larger amounts of energy-rich prey, such as copepods and euphausiids, in their diets. Seasonal variation in juvenile pollock diet and condition exists, but its effect on nutritional stress, and perhaps fish survival, during winter might be tempered by geographic variation in prey resources.

PICES XIII FIS_P-1976 Oral
Pollock fishery and total allowable catch in the Bering Sea

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The walleye pollock, *Theragra chalcogramma,* is one of the most important fished species in the world. Maximum catch in the Bering Sea exceeded 4 million tons in 1988. The main fishing grounds are located in the southeastern Bering Sea and in the Navarin area. Average catch for these two areas was 0.8 million tons and 0.5 million tons, respectively, during 1979-2003.

The fishery management system is based on annually estimated Total Allowable Catch (TAC), which depends on fishable stock biomass and exploitation rate (US and Russian Federation EEZ). Stock assessment research involves several different methods: ichthyoplankton surveys (western area, KamchatNIRO), acoustic and trawl surveys (all areas), and modeling approaches (all areas). In the Donut Hole the pollock fishery is regulated by the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea. Since 1993, fishing has been prohibited in this area.

Knowledge of pollock stock structure and intermixing is still largely incomplete. Practical approaches are necessary to study this problem. Data from ichthyoplankton surveys in the Bering Sea reveal two ecological spawning groups (winter and spring). Six spawning grounds (Bogoslof-1, Pribylof-2, Aleutian-1, Kommander-1, Navarin-1) are located beyond the shelf area in February-March. Eggs and larvae from these areas usually drift to the outer shelf. Spring spawning is associated with the middle shelf zone. Eggs in early stages of development are concentrated in 14 relative separated aggregations (Unimak-1, Bristol-1, Pribylof-2, St.Mattew-1, Anadyr-1, Navarin-2, Dezhnyov-1, Olyutorskyi-1, Karaginskyi-1, Ozernoy-1, Kommander-1, Aleutian-1). On the other hand, genetic methods have identified only 3-5 stock units.

A second problem concerns the precision of stock assessment methods. The power of each method should be tested. There is a need to optimize methods for analysis of stock assessment. A third problem concerns the magnitude of the exploitation rate. How should the fishery be managed, when stock biomass reaches high or low levels?

PICES XIII FIS_P-1776 Poster
New data on walleye pollock spawning in waters of the Commander's Islands Preserve

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The off-shore waters around the Commander's Islands have been characterized as highly abundant of a number of fishery objects (walleye pollock, pacific cod, shortspine thornyhead, Atka makrel, Commander's squid, ect.). High biological production of the waters caused forming large rookeries of northern fur seal and sea-lion, and aggregations of sea otter and colonial marine birds. Since 1975, fishery restricted thirty-mile zone had been set

around the islands. In 1993, there was created National Commander's Marine Preserve in order to protect biological diversity, genetic fond of flora and fauna.

Walleye pollock population has been suggested to inhabit the waters around the Commanders, although the data concerning the population are rather scarce. Last studies of Commanders walleye pollock relate to 1988-1989; on assigning the area to be a preserve the studies of walleye pollock have been stopped.

In 2001, ichthyoplankton and hydrological surveys have been carried out around the islands which indicated large-scale spawning of walleye pollock occurring around the Commanders. The obtained data allow to estimate conditions and features of spawning of the Commanders' walleye pollock. It has been found that spawning takes place in April-May at the shelf area between Bering Island and Medny Island in the warm Pacific Ocean waters and cold Bering Sea waters mixturing zone. Results of egg abundance estimation indicate current growing Commanders' walleye pollock abundance it being compared to that in 1980.

PICES XIII FIS_P-2190 Poster

Study on dynamic of fisheries resources and protection countermeasures in adjacent waters of Jiuduansha

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Adjacent water of Jiuduansha is a part of Changjiang (Yangtze River) estuarine area, where is a traditional fishing ground with high productivity. A great number of runoff with containing abundant nutrients from upper-steam of Changjiang goes down to Estuary of Yangtze River each year. It provides living nutrient basis for abundant fisheries resources. More than 100 species of fishes were recorded. On other hand, it is a habitat of many crustaceans such as shrimps and crabs. Up to now, some key species of economic fishes and crabs have been monitoring since 1997. They are *Coilia nasus* Temminek et Schlegel (long-tailed anchovy), *Coilia mystus* Linnaeus (estuary tapertail anchovy), *Hemisalanx prograthus* Regan (noodlefish), *Tenualosa reevesii* Richardson (Hilsa herring), *Eriocheir sinensis* H. Milnin Edwards (Chinese Mitten-handed crab), *Anguilla japonica* Temminck etschlegal (Japanese eel), *Acipenser Sinensis* Gray (Chinese sturgeon) *etc.*

PICES XIII FIS_P-1800 Poster

Composition and changeability of the fish community of the central seamounts of the Kyushu-Palau Ridge and some oceanographic features (Part II)

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Chaotic processes usually occur in excited oscillating systems (Nikolis G., Prigogin I., 1990; Shuster G., 1998) and they are produced by the interaction of a different range oscillations and their mixing. During last thirty years investigations showed that chaotic systems are common and may predominate in different processes of nature and society (Eremin, 2004).

As marine ecosystems are multi-component aggregations in which nonlinear phenomena are a typical, their chaotic processes are also typical as determinate processes. When energy of a system is increasing, chaotic processes occur. Chaotic and determinate structures can exist together. Seamount ecosystems provide a good example of the existence of both.

However, cycles estimated for the baroclinic layer do not reveal all oscillations above seamount summits. Near seamounts significant changes in current velocity are observed (Darnitsky, 1980; Gamsahurdia, 1990).

V.N. Zyryanov (2003) theoretically proved that, in the two-layered water column above seamounts, lens-shaped eddies should occur due to baroclinicity and velocity shift coorative processes (BVSCP), which do not penetrate the surface layer unlike usual eddies. Consequently, they can be investigated only by sounding the water column above seamount summits. Oceanographic surveys represent lens-shaped eddies as an increase of deep-water tracer concentration. Tracers are biogenic elements in intermediate layers with a lens-shaped distribution.

The layer of minimal salinity (500-600 m horizon) is influenced strongly by subsurface dynamics caused by the occurrence of summits at these depths. This is the reason for higher frequency oscillations of thermohaline features and other characteristics that affect different components of ecosystem. Thus, we cannot assess other stochastic processes in intermediate layers. As a result, the behavior of ecosystem components is more complicated in the vicinity of seamounts.

Some chaos induced in seamount ecosystems by fluctuations at different scales can have positive effects. For instance, theoretically, these ecosystems are insensitive to damage by anthropogenic influences. Nonetheless, cases of adverse effects of harvest on such seamount ecosystems, such as the Hawaiian and Emperor Ridges.

PICES XIII FIS_P-2170 Poster
Trophic relations of chum (*Oncorhynchus keta)* and pink salmon (*O. gorbuscha*) in the western Bering Sea

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The feeding ecology of chum (*Oncorhynchus keta*) and pink salmon (*O. gorbuscha*) in the western part of the Bering Sea was investigated during summer of 1993, 1995, and 2003. In the course of these long-term investigations it was established that diets of chum and pink salmon are very flexible. Salmon fed on diverse prey such as fishes, squids and plankton. Depending on conditions in each specific region, they can easily switch from one prey to another. Chum salmon diet varies significantly with body size. Smaller (< 40 cm) fish prey mainly on amphipods, whereas larger (>40 cm) fish prey mainly on jellyfish, ctenophores and fish. Diet compositions of larger chum salmon were quite similar in 1993 and 1995, but differed in 2003 when tunicates were one of the main prey items. Fishes, squids and euphausiids dominated the diet of pink salmon, occurring in over 50% of the stomachs that contained food. In summer 2003, pink salmon consumed many decapods in this region. These observed differences in diet composition of chum and pink salmon are statistically significant.

PICES XIII FIS_P-1822 Oral
Temperature-dependent stock-recruitment model for walleye pollock around Hokkaido, Japan

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Around Hokkaido, Japan, there are four walleye pollock populations including the Japanese Pacific population (JPP) and the north Japan Sea population (JSP). It is known that the stock fluctuations of JPP and JSP are mainly caused by recruits of strong year classes. To clarify the mechanism determining recruitment, we investigated the relationship between recruitment (R), spawning stock biomass (SSB) and sea surface temperature (SST) for JPP and JSP. First, we assumed three different types of stock-recruitment models (SRM): no relation model ($R=\alpha$), density-independent model ($R=\alpha SSB$) and Ricker model ($R=\alpha SSB\exp(-\beta SSB)$), where α and β are coefficients. Then, we correlated the residuals from these SRMs (log transformed) with monthly SST during the pelagic phase. In JPP, the residuals from all SRMs showed a high positive correlation with SST in February and a negative correlation with that in April. On the other hand, the residuals from all SRMs for JSP represented a strong negative correlation with SST in February and a positive correlation with that in summer. Finally, we developed the temperature-dependent SRM (TDSRM) by incorporating these SSTs as a predictor variable: no relation TDSRM ($R=\alpha\exp(\gamma SST)$), density-independent TDSRM ($R=\alpha SSB\exp(\gamma SST)$) and Ricker TDSRM ($R=\alpha SSB\exp(-\beta SSB+\gamma SST)$), where γ is a

coefficient. The model comparison using AIC indicated that the optimal model for JPP is no relation TDSRM with SST in February and April, and that for JSP is density-independent TDSRM including SST in February. These findings suggest that the recruitments of JPP and JSP are affected by environmental factors rather than density dependent factors.

PICES XIII FIS_P-1922 Poster
Estimation of catch efficiency of salmon gillnets, distance traveled by salmon, and salmon density in the Bering Sea

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Gillnets are one of the major fishing gears used for salmon fisheries both in offshore and coastal waters. Catch efficiency of a gillnet is defined as the proportion of the number of fish caught to the number of fish in the effective fishing area. The effective fishing area is defined as a product of the length of gillnet and the distance traveled by the fish during the time between set and haul of the gillnet. Fish density is defined as the number of fish per unit area in the effective fishing area. The catch efficiency of a salmon gillnet, the distance traveled by the fish, and the fish density were estimated based on the catch data of three gillnets set in parallel configuration in the Bering Sea in June-July, 1985-1987. The average catch efficiency was 0.60 for sockeye, 0.54 for chum and 0.81 for pink salmon. The average distance traveled was 5.9 km for sockeye, 5.1 km for chum and 16.2 km for pink salmon. The average density of fish was 5.1 fish/km^2 for sockeye, 50.3 fish/km^2 for chum and 16.5 fish/km^2 for pink salmon. Differences in these estimates are discussed based on the biological features of each species.

PICES XIII FIS_P-2025 Poster
Prediction of Pacific saury fishing grounds based on physical variability derived from daily satellite remote sensing data

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This study investigates the influence of the Oyashio front on saury fishing grounds and estimates daily saury fishing grounds in the northwestern North Pacific using daily satellite remote sensing data. Saury fishing grounds were defined as vessel fishing positions estimated from nighttime images of the Defense Meteorological Satellite Program (DMSP) /Operational Linescan System (OLS). The SST gradient, the Oyashio front and warm core rings were identified by NOAA/AVHRR MCSST data and TOPEX/ERS-2 altimeter maps. The distances between saury fishing grounds and the Oyashio front were calculated in order to investigate effects of the Oyashio front on saury fishing grounds. Calculated distances show large fluctuations, for example, the maximum distance was 60 km in 2001 and 130 km in 2002. A major finding of this study was that the spatial and temporal variability of saury fishing grounds were strongly affected by variability of both these distances and the SST gradient. This suggests that it is the presence of these physical features that may effect the formation of saury fishing grounds. Our study contributes to understanding the role of the Oyashio front in saury southward migration and prediction of daily saury fishing grounds.

PICES XIII FIS_P-2152 Poster
Status of Far Eastern Pacific salmon stocks during recent years (1971-2002)

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Official statistical data on catch, adult escapement and average body weight have been examined by principal spawning areas in the Russian Far East for each of five commercial species of Pacific salmon: pink, chum, sockeye, coho and chinook salmon. Stock abundance dynamics have been analyzed, and results of hatchery production in some regions and features of commercial use of the species have been considered.

PICES XIII FIS_P-2021 Poster
The variations in distribution, catch, and biology of skipjack tuna (*Katsuwonus pelamis*) induced by climate variability

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The distribution and catch of skipjack tuna was investigated to reveal the relationship between tuna populations and ocean conditions affected by climate patterns such as El Niño. Catch and effort data on skipjack tuna in the Western Central Pacific Ocean during a specific period was grouped by geographic area (5°×5° for SPC data, and 1°×1° for NFRDI data), and some biological information was collected from the Korean purse seine fisheries starting in 1993. The examination of GSI indicated that there was no clear seasonal periodicity intra-annually, though the changing patterns of males and females generally matched. The change in main fishing grounds was calculated to detect the effects of El Niño. The main fishing ground was formed near 176°W in 1997, moving to 163°E in 1998, reflecting the effect of the 1997/98 ENSO event. Higher catches in 1995 and 1998 were reported after strong El Niño events with a time lag of about 12 months, and relatively high values of condition factor also appeared in 1994-95 and 1997-98. Length frequency information, from SPC and NFRDI data, will give clues towards understanding growth processes given a time lag, and the result might be applied to predict the future biomass of skipjack tuna.

PICES XIII FIS_P-1896 Poster
Effect of the Kuroshio frontal eddy on the recruitment of jack mackerel larvae and juveniles in the Bungo Channel, Shikoku, Japan

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Bungo Channel, located between Kyushu and Shikoku, is a representative semi-enclosed coastal sea in southern Japan. With the exception of a few river discharges into the channel, its marine environments are mainly influenced by oceanic disturbances. A prominent phenomenon, named as *"kyucho"*, is most influential among these disturbances; a *kyucho*, which means a sudden strong current in Japanese, is an intrusion of warm water from the Pacific. It has been observed through long-term monitoring of water temperature in the Bungo Channel; the *kyucho* occurs when a cyclonic frontal eddy derived from the Kuroshio frontal wave is propagated from southwest of Shikoku between spring and neap tide. Time series of sea surface temperature images also demonstrate that the cyclonic frontal eddies make the Kuroshio warm waters intrude along the east coast of the Bungo Channel as the Kuroshio axis approaches the cape of Ashizuri southwest of Shikoku. Size-frequency distributions of daily jack mackerel (*Trachurus japonicus*) landings from 1985 to 2001 indicated recruits (which start to appear in April) became the target of jack mackerel catches until September along with existing local populations within the Bungo Channel. Furthermore, individuals with the smallest body length appear earlier in the southern region than in the

central region of the Bungo Channel. Coincidence of the appearance of the individuals with the *kyucho* support the hypothesis that the recruitment in April is largely derived from offshore.

PICES XIII FIS_P-1836 Poster
Changes in the composition of demersal fish communities on the western Kamchatka shelf under the influence of fishing

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Until "Rybolovstvo" was applied in 1996 it was nearly impossible to monitor changes in demersal fish communities and to assess fishing intensity by area. We analyzed data on fishing intensity on the western Kamchatka shelf over 1997 to 2003 and data from trawl surveys from 1996 to 2003. We document persistent growth of fishing intensity from 1997 to 2003. In 1996, the dominant demersal fish species on the shelf of western Kamchatka were flounders (73%), followed by Pacific cod and saffron cod (16.6%), and sculpins (7.6%). The primary flatfish species was yellowfin sole, the most abundant (about 50%) sculpins were the great sculpin, and banded and yellow Irish lords. Fish stock assessments in 2003 revealed a decrease in the biomass of flounders (39.7% of the demersal fish community on the shelf of western Kamchatka); the dominant flatfish had become Bering flounder. Also, the new dominant sculpin was purple gray sculpin. We suggest that increased fishing intensity caused these changes in the composition in the demersal fish communities on the shelf of western Kamchatka within the period of observation.

PICES XIII FIS_P-2103 Poster
The stock assessment and fishery of walleye pollock in the Sea of Okhotsk off West Kamchatka

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Stock assessment surveys of walleye pollock were conducted on their spawning grounds off West Kamchatka in 1996-2001. A rapid decline of biomass occurred in 1996-1998. By 1999, the decline still continued but at a slower rate. In 2000, biomass began to increase and the increase developed further in 2001-2003. During the period of investigation, there were significant changes in the environment, fish community structure, and biological condition of the pollock stock. In 1996, pollock constituted about 97% of trawl catches by weight, but by 1997, the percentage of pollock fell to 72%. In the next two years, there was an increase in percentage of pollock. In 1996-1999, the catches consisted mainly of pollock of older age groups. In 2000, the age composition shifted due to the predominance of fish from the 1995 year class and younger. Rather large concentrations of young fish were estimated in 2001. This rise of biomass was associated with the appearance of a large 1997 year class. In 1996-1997, the maximum number of pollock was observed in March during the period of mass spawning. In subsequent years, the largest concentrations were observed in April. Also, significant changes occurred in bathymetric distribution. The future status of this pollock stock depends on whether pollock juveniles and adults can be conserved under intense exploitation.

PICES XIII FIS_P-1937 Oral

Predictability of future recruitment by parametric and non-parametric models: Case study of Gulf of Alaska walleye pollock

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Prediction of future recruitment is a critical task in fisheries science, providing probabilistic projections of fish populations and reference information for management decisions. The difficulty of the task lies in the inherent high variability of recruitment, lack of theoretical development, inadequate length of time series, and inability to meet the required assumptions. Recruitment of stocks can be modeled as a function of environmental variables using parametric and non-parametric statistical methods. A benefit of using parametric methods is the ability to test statistically the significance of variables, while non-parametric methods can cope with the non-linearity of data and be free from rigid statistical assumptions that often don't pertain to fisheries data. This study examines the utility of several different parametric and non-parametric methods for recruitment prediction. Parametric methods tested are multiple regression and generalized Ricker models; nonparametric methods are generalized additive models (GAM) and artificial neural networks (ANN). Data from the Gulf of Alaska walleye pollock (*Theragra chalcogramma*), which span 1961-2001, are used for the analysis. Variables examined consist of recruitment and spawning biomass as well as various environmental indices, including sea surface temperature, wind mixing, precipitation, and Pacific Decadal Oscillation. The first segment (35 observations) of each data series was used to construct the various parametric and non-parametric models, and the last segment (6 observations) was reserved to test the predictive capability of the constructed models. This study demonstrates that combining the merits of both modeling approaches would improve recruitment modeling and prediction.

PICES XIII FIS_P-2013 Poster

Influence of commercial fishing on the stock conditions of Pacific herring from the northern part of the Okhotsk Sea

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After the sharp decline in the biomass of Pacific herring (*Clupea pallasi*) in the Sea of Okhotsk to a low of 1.2 million tons in 1998, biomass increased owing to strong 1996-1997 year-classes of the Okhotsk and Gijiginsko-Kamchatsk herring populations. By 2001, the total biomass of herring exceeded 2 million tons; 0.5 million tons of this biomass was attributable to the Gijiginsko-Kamchatsk population. Based on data collected during a research survey in 2003, total herring biomass in the northern part of the Sea of Okhotsk was estimated to be about 3 million tons. Surveys conducted in 2001-2003 indicated that the herring in the Sea of Okhotsk are mainly comprised of fish from Gijiginsko-Kamchatsk population, which has almost no commercial fishery, and by fishes from the western portion of the Okhotsk population. Owing to heavy commercial fishing and poor year classes in recent years, the eastern portion of the Okhotsk population has declined and contributes a diminishing portion of the overall herring abundance in the region compared to earlier years. In our view, during the next few years (*e.g.*, 2004-2006) it is necessary to establish an allocation of the total allowable catch of Okhotsk herring in the fall-winter period into two components: east and west of 147° E longitude. This split should be allocated in such a way to shift effort from the east to the west with a goal to reduce fishing mortality and promote recovery of the eastern group of Okhotsk herring.

PICES XIII FIS_P-1950 Poster
Density dependent growth of sockeye salmon in the ocean

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It has been demonstrated earlier that in the Kvichak River, Bristol Bay, Alaska the average length of each major age class of sockeye salmon decreases 20 mm or more during peak years of abundance in the 5-year cycle. The same changes in average length occur also in the sockeye salmon in the adjacent streams, the Egegik and Ugashik Rivers. These studies are being expanded to include other streams like the Wood River in the Nushagak Bay and the Togiak River. If no changes are found in the average length of the important age classes in these rivers, density dependent growth must take place in coastal waters on the return migration. Otherwise, density dependent growth occurs during the entire ocean residence on the High Seas of the North Pacific Ocean and the Bering Sea. The average size of the most recent five-year Kvichak sockeye salmon cycle is the lowest in the past nine cycles and is less than 40% of the average cycle, and thus, the density dependent effect on growth to other stocks is not expected to occur.

PICES XIII FIS_P-1879 Poster
Acoustic methods for monitoring and ecosystem studies in the Bering and Okhotsk Seas

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The TINRO-Center conducts annual echo integration-trawl surveys of pollock and other fishes in the Bering and Okhotsk Seas with Simrad EK-500 scientific echo sounders. Powerful post-processing software and information technologies are keys to efficient extraction of information from the echosounder data and to increase the precision and reliability of survey results. The system for registration and processing of acoustic data, FAMAS (Fishery Acoustic Monitoring and Analyses System), has been used. FAMAS facilitates: visualization and accumulation of acoustic data in real time; secondary processing and analysis of acoustic images; organization and maintenance of a database of acoustic and biological measurements; and estimation of large zooplankton with a two-frequency algorithm. Processing of acoustic data is combined with the information from the biological database to provide estimates of biomass and numbers at length and age. FAMAS algorithms allow echosign assignment in mixed species situations and provide for characterization of spatial features throughout the survey area and water column. Annual echo integration-trawl surveys can be used to estimate current stock status and distribution of pollock and other fishes in the northwestern Bering Sea and Okhotsk Sea. Estimates were derived of abundance and biomass of pollock, spatial distribution, and interannual variability of these parameters in the northwestern Bering Sea and Okhotsk Sea in 1997-2003. Annual age composition, distribution and biomass of pollock in the northwestern Bering Sea vary significantly. Annual variability increased over time, especially since 1998 in association with a climate shift in the Bering Sea region. Also, spatial distribution and abundance of age-0 pollock, capelin and Arctic cod are presented. In 2003, experimental research was conducted to explore potential applications of acoustic technology to estimate salmon abundance during both phases of their migration in the Sea of Okhotsk and western Bering Sea, including Pacific waters of Kamchatka. Acoustic sounding data were collected on the vertical and horizontal distributions of salmon in upper epipelagic waters. Daily and seasonal differences in vertical distribution of salmon, associated with thermal structure of the water column, were identified. To investigate large zooplankton, a two-frequency algorithm was used to obtain information on spatial distribution and daily vertical migrations in the western Bering Sea. Our experience in the use of acoustic technology in ecosystem research of the North Pacific and marginal seas demonstrates that acoustic methods offer many advantages, in particular a continuity of echosign registration and an opportunity to estimate the vertical distribution of hydrobionts. These successes indicate that it may fruitful to pursue future development and application of these methods to study “hot spots” of biological activity in the North Pacific.

PICES XIII FIS_P-1853 Poster

The distribution and prevalence of Bacterial Kidney Disease (*Renibacterium salmoninarum*) in juvenile chinook and coho salmon in the Northeast Pacific Ocean

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In the summers of 2000 and 2002, we sampled juvenile salmon in the Northeast Pacific (Northern California Current) from northern Washington to central Oregon ("northern study area" NSA) and from southern Oregon to northern California ("southern study area", SSA) as part of an effort to better understand factors affecting juvenile salmon health and condition. Bacterial Kidney Disease (BKD: caused by *Renibacterium salmoninarum*) is a focus because the infection is known to be widespread in fresh water, the disease is typically chronic (spawning females pass the bacterium to their offspring), and mortality in hatchery and naturally reproducing salmon populations can be high. Using DNA amplification (PCR) to detect the pathogen in juvenile Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*), we determined that the prevalence of infection is consistently higher in the northern study region (54.3% compared to 4.4% in 2000) and that infection prevalence in both areas varies annually as well as spatially (28.1% were infected in the NSA in 2002, compared to 15.7% in the SSA). In both these years, the percentage of infected fish tended to decline from early summer to fall, suggesting that increased mortality may be occurring in salt water. Infection prevalences were similar for Juvenile coho and subyearling and yearling Chinook. The spatial discrepancy in infection by this common pathogen suggests that salmon populations in these areas are partially segregated, which has been confirmed by genetic analysis (allozymes), although no physical barrier separates these regions.

PICES XIII FIS_P-1823 Oral

Recruitment process of the Japanese jack mackerel in the East China Sea (ECS) - Spawning ground and larval transport into fishing grounds

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The Japanese jack mackerel (*Trachurus japonicus*) is one of the most exploited fishery resources in southern Japan, especially for large- and medium-sized purse seine fisheries. The shelf-break regions of the ECS are considered to be their primary spawning ground during winter to spring. To understand the mechanisms of year-to-year variation in jack mackerel recruitment, it is necessary to examine: (1) the population's primary spawning ground and season in the ECS, (2) larval transport into the nursery ground, and (3) jack mackerels' survival during early life stages. Based on catches of just-hatched larvae (< 3 mm notochord length), the principal spawning ground for jack mackerel is formed in the southern ECS south of 28°N; peak spawning occurred in February–March. In April, juveniles (10–30 mm standard length) were abundant off the west coast of Kyushu Island and the central ECS, north of 28°N where larvae of < 3 mm NL were rarely collected. Current systems, such as the Kuroshio and its branches, transport a large number of the eggs and larvae spawned and hatched in the southern ECS northeastward into the jack mackerels' nursery and fishing grounds off southern Japan. The relationship between abundance of small larvae (< 3 mm NL) in February–March and juveniles in April during 2001–2004 suggests that larval survival fluctuates highly from year to year. Relationships to wind and current features, and larval prey condition in the ECS are also discussed.

PICES XIII FIS_P-1995 Oral

Interannual changes in Pacific hake (*Merluccius productus*) growth in response to oceanographic conditions

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Annual as well as decadal changes in oceanographic conditions have been shown to affect the growth of various fish stocks in the Northeast Pacific Ocean. Understanding past environmental variations and their effects on growth can provide information to accurately estimate annual changes in biomass for improved management decision-making. We used sagitta otoliths of Pacific hake, *Merluccius productus,* and measurements of age and year specific annuli to construct a time series of annual growth. A general linear model (GLM) was first used to assess the variation among growth increments due to age, sex, the area where sample specimens were obtained and potential interactions. While there is a statistically significant difference between sexes, this is extremely small relative to other factors. Year was then added to the model and a strong age-year interaction was found. Previously documented differences among areas and between sexes validated the use of otolith growth increments as proxies for somatic growth. Further analysis suggested that young (age 1-2), intermediates (age 3-4) and adults (ages 5 and older) showed distinct annual growth trajectories. The least-square mean annual trend for each age group was found to respond significantly to environmental factors. A non-linear growth-at-age trend function was fit to the growth increment data and the residuals were then transformed to minimize heteroscedasticity. Using these two methods, the year-to-year variability was related to various time series of oceanographic conditions. The results from the two methods are presented and differences are discussed. These results indicate that annual growth-at-age in Pacific hake is not constant but can be influenced by environmental and/or oceanographic conditions. Forty-eight, 81 and 75 percent of the year-to-year variation in the least-square mean annual increment respectively for the three age groups can be explained by two or three environmental variables. Annual changes in growth can be used as benchmarks to help determine the age of the fish; records of environmental variables can provide pre-survey assessment of biomass as well as hind cast possible historic growth trends of the population.

PICES XIII FIS_P-1805 Poster

Environmental impact of interannual variability of Okhotsk Sea pollock abundance

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The pollock stock in the Sea of Okhotsk is one of the biggest in the North Pacific. Annual catches reached 1.5-2.0 million t in periods of high abundance. Multiyear studies have shown that the interannual variability of pollock abundance in the Sea of Okhotsk depends of natural biological causes. Physical oceanographic conditions – ice distribution, storm activity, temperature, salinity, current direction, eddy formation, and scale of egg and larval drift – have no direct influence on early life stage survival. Physical conditions only determine plankton community structure and general ecosystem functioning. Feeding conditions could influence the quality of pollock gonads and quite possibly on the survival of eggs and larvae. Feeding conditions were favorable in 1984- 1987 and unfavorable in 1997-1998. The length and age of spawning pollock also have no influence on year-classes strength.

Pollock larvae inhabit the mid-water column for a protracted length of time and the period of initiation of active feeding is most critical to larval survival. As rule, large pollock year-classes do not occur when plankton, especially copepods, are low or when predatory species predominate the plankton community, regardless of whether parental stocks are abundant and other oceanographic conditions are favorable. Successful copepod and euphausiid reproduction in the pollock spawning area provides for good larval survival and strong year-classes.

Pollock larvae predominate the ichthyoplankton community in the Okhotsk Sea, so they do not compete for food with other species. Growth rate of pollock larvae is significantly lower and mortality is higher in areas of very high concentrations due to density dependence. As a result, there is no relationship between pollock spawning stock abundance and year-class strength.

PICES XIII FIS_P-1953 Poster

Variability in sex ratio of the northern Okhotsk Sea walleye pollock spawning stock in 1997-2002

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Walleye pollock spawning stock dynamics in the northern Okhotsk Sea in 1997-2002 was provided by alternating cohorts with different productivity, which resulted in significant variability in sex ratio. Strong 1995 and 1997 year-classes that entered the spawning stock, and strong 1988 and 1989 year-classes that left the stock caused the observed pattern of variability. In the first case, earlier maturation of males compared to females led to a sharp, significant increase in their share among sexually mature fish. In the second case, rather abundant large individuals, mostly females, exited the stock. This coupled to low abundance of recruits entering the stock at that same time, also resulted in increased share of males among spawners, though this increase was somewhat lower than in the first case. When the whole Okhotsk Sea area is considered, females outnumbered males in 1997 only, with estimated shares of 59.9% and 40.1%, respectively. Such a pattern was attributable to prevailing number of females in the 1988 and 1989 cohorts, and also to small year-classes entering the spawning stock in the early 1990s. In 1998-2000, when the stock stabilized at a low level, large-sized females from the 1988 and 1989 year classes were eliminated from the stock, and pollock from the 1994-1996 year-classes, already significantly depleted by commercial fishing, began entering the spawning stock. As a result, the percentage of males increased to 54.0-55.5%, and females declined to 44.7-46.0%. In 2001-2002, numerous first maturing males of the strong 1997 year class began entering the spawning stock, resulting in an increased share of males to 63.1-65.4%, and decreased share of females to 34.6-36.9%. Significant interannual variability in the sex ratio of spawners should be taken into account when estimating reproductive potential of the northern Okhotsk Sea pollock.

PICES XIII FIS_P-1873 Oral

Maturation of walleye pollock, *Theragra chalcogramma*, in the eastern Bering Sea in relation to temporal and spatial factors

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Walleye pollock, *Theragra chalcogramma*, are both ecologically and commercially important as the most numerous fish species and support the most valuable fishery in the eastern Bering Sea (EBS). Size at maturity is a critical parameter in the stock assessment to set annual total allowable catch. Pollock maturity has not been examined in the EBS since 1976, and possible interannual and geographic variation has never been considered. Our goal is to estimate correct maturity schedules for EBS pollock. Maturity data, fish lengths and macroscopic maturity stages were collected by Pollock Conservation Cooperative personnel aboard pollock trawlers during winter 2002 and 2003 across the EBS from a total of 10,197 pollock. Similar data were collected by NMFS scientists during hydroacoustic surveys from 1989 – 2002. Histological analysis of ovary tissue confirmed appropriateness of macroscopic staging. However, some pollock classified macroscopically as "developing" may mature in either the current or following spawning seasons. Therefore, our analysis was performed with two alternative assumptions: fish classified as "developing" were either considered immature or mature. Maturity rates were estimated with a logistic regression, and spatial and temporal patterns were identified using GIS. Geographic variability exists; fish mature at the smallest lengths north of the Pribilof Islands, perhaps due to cross-shelf differences in water temperature. Size at maturity varies interannually, as well. Possible links to climate indices, sea temperature, and

variability in age class structure were investigated. Our results should improve the accuracy of future stock assessments.

PICES XIII FIS_P-1809 Oral
Environmental differentiation of pollock reproduction in the Bering Sea

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Biological phenomena leading to wide spatial separation of pollock spawning grounds, coupled to high biodiversity, may favor reproductive success, consistent recruitment, and promote a stable role of pollock in the ecosystem of the eastern Bering Sea. These features contrast with the western Bering Sea where the spatial distribution of pollock spawning grounds and ecological biodiversity are much less.

There are three distinct types of pollock spawning groups in the Bering Sea: (1) continental shelf (eastern and western Bering Sea shelf), (2) shelf along island coastlines (Pribilof Islands, Amak Is., and Commander Is.) and (3) deep water (Bogoslof Is. and Samalga and Kanaga Pass areas).

Ecological conditions over continental shelves vary very significantly on annual time scales, and associated pollock reproductive success and recruit abundances also experience short-term interannual variability. Coastal ecosystems associated with islands are spatially very limited, and therefore these areas are acceptable for reproduction by the oldest pollock only. Ecological conditions in deep water are much more stable. Deep areas are driven by long-term variability of regional physical oceanography of the North Pacific; therefore reproduction and recruitment of older pollock to deep waters also experience long-term variability.

Shelf and deep-water basin spawning pollock are quite independent in the Bering Sea ecosystem. They differ by duration of life, period and location of spawning, and age of first maturity. "Basin" pollock spawn by the end of winter and early spring in deep water (450-500 m) off the Aleutian Islands, their duration of life is 15-20 years, age of first maturity is 6 years, and they recruit to the shelf. "Shelf" pollock spawn in middle spring on the shelf, duration of life is 7-8 years, and age at first maturity is 3-4 years.

This differentiation of spawning pollock into separate groups has a specific role to support high abundance of pollock in the Bering Sea ecosystem. The shelf pollock spawning group may provide stable population abundance at average levels over the long term. High spawning activity over the shelf and in deep water could provide for periods of maximum abundance of pollock in the Bering Sea. The group that spawns on the coastal shelf off islands could serve as a reproductive reserve for periods of catastrophically low survival during early stages development of pollock on shelf and deep water spawning areas.

Winter habits of the Bering Sea pollock are stable interannually and are determined by specific oceanographic conditions (*e.g.*, relatively high temperature, intrusions of water from the Pacific Ocean, minimum ice cover). There are three main types of winter pollock concentrations: (1) winter concentrations consisting of several spawning groups of pollock; (2) those consisting of only one spawning group; and (3) concentrations consisting of immature pollock.

PICES XIII FIS_P-1959 Poster

Video analysis of the schooling behavior of Japanese surfsmelt (*Hypomesus japonicus*) under light and dark conditions using a mathematical model

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The schooling behavior of captive Japanese surfsmelt (*Hypomesus japonicus*) under light (80 lx) and dark (< 0.01 lx) conditions was observed. The fish were divided into an experimental group in which the lateral line sensory system of each fish was disabled and a control group in which the lateral lines were not altered. The two-dimensional motion of individuals during 20-min observation periods was digitized and processed, and the schooling behavior was analyzed quantitatively using the mathematical model of Sannomiya *et al.* (1996). The frequency distribution of the nearest neighbor distance in both groups was unimodal in the light and multimodal in the dark. The schooling behavior of the control group in the light was dominated by both propulsive and schooling forces, whereas the schooling behavior of this group in the dark and of the experimental group was dominated by only propulsive force. These results suggest that Japanese surfsmelt depend on vision when aggregating in a non-parallel orientation to other fish, and on both vision and their lateral line when schooling in a parallel orientation to other fish.

PICES XIII FIS_P-1857 Oral

Interannual variation in growth of larval and early juvenile Japanese anchovy in the Kuroshio-Oyashio transition region

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Since the 1990s, the distribution range of Japanese anchovy *Engraulis japonicus* has expanded from coastal waters to the eastern offshore waters off northern Japan, the Kuroshio-Oyashio transition region, with the increase in population abundance. This study aimed to examine effects of environmental conditions on early growth of *E. japonicus* in the transition region during 1997-2002. Late larvae and early juveniles were distributed in waters characterized by 15-19°C SST and 10-1000 mg dry weight m^{-2} in available copepod density. The recent growth rates (G) for 10 days before capture of late larvae and early juveniles were considered to be regulated more strongly by SST than copepod density in waters < 17°C, and more strongly by copepod density than SST in the waters < 100 mg DW m^{-2}. Annual mean G in the southwestern waters ranged from 0.7 to 0.8 mm d^{-1}, resulting from relatively high SST (> 17°C) and copepod density (> 100 mg DW m^{-2}), while those in the northern and eastern waters ranged from 0.4 to 0.8 mm d^{-1} and were variable among survey years, resulting from decreases of SST to 15-16°C and food availability to 50-100 mg DW m^{-2}. Interannual variability in the growth and survival rates during early life stages in *E. japonicus* seems to be higher in the northern and eastern waters than in the southwestern waters in the Kuroshio-Oyashio transition region. Comparisons of larval growth and survival rates between Japanese anchovy and Japanese sardine in the transition region will be discussed.

PICES XIII FIS_P-1957 Oral

Geographical variations in carbon and nitrogen stable isotope ratios of Japanese anchovy *Engraulis japonicus*

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Japanese anchovy *Engraulis japonicus* is widely distributed around Japan from inshore to offshore. Carbon and nitrogen stable isotope ratios of animals reflect the isotope ratios of prey species and therefore are used for the study of trophic relationship. We present results of the carbon and nitrogen isotope ratios of Japanese anchovy collected around Japan, including Sagami Bay, Wakasa Bay, Tsushima Strait, Kuroshio Extension area and Kuroshio-Oyashio Transition area. Adult anchovies collected from Sagami Bay, inshore habitat, showed the highest values ($\delta^{13}C$ = -15.2 ‰, $\delta^{15}N$ = 14.2 ‰ in average), and those from Kuroshio Extension and Kuroshio-Oyashio Transition areas, offshore habitat, showed the lowest values ($\delta^{13}C$ = -19.4 ‰, $\delta^{15}N$ = 8.7 ‰). Anchovies from the other areas showed intermediate values. Similar trends were found in the ratio values for larvae. In fact, larvae from Sagami Bay showed higher values than those from Kuroshio Extension and Kuroshio-Oyashio Transition areas. Such geographical variations in carbon isotope ratios may be due to the difference of the carbon source of primary production, since the inshore ecosystem is expected to be influenced more by the benthic primary production than the offshore ecosystem, where the source of primary production is expected to be mainly pelagic phytoplankton. On the other hand, the variations of nitrogen isotope ratios might be due to differences in oceanographic conditions rather than trophic level of prey items, since the anchovy stomach contents which were composed of copepods and the other crustaceans did not differ among regions.

PICES XIII FIS_P-1813 Oral

Impacts of global change on fisheries resources of a coastal ecosystem

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Both environmental and human factors affect marine resources in ocean and coastal ecosystems. Recent decades have seen more frequent and stronger climate variations and changes. Understanding the functioning of the marine ecosystem and how it responds to global change is also essential for effective management of living marine resources, such as fisheries, which have sustained human communities for centuries. Understanding the environment and its impact on ecosystem variations may lead to the sustainable management and development of fisheries in coastal ecosystems.

This report will focus on the impacts of global change on the fisheries resources of a coastal ecosystem. It will deal with the physical oceanographic and climate variations that induce changes in marine ecosystems. The relationship between living resources abundance and ocean and climate dynamics, climate-induced change in small pelagic fish productivity in Chinese waters, and the control mechanisms of decadal-scale variation of ecosystem productivity are the essential scientific issues to be addressed by Chinese scientists. Decadal-scale variations of ecosystem productivity in the Bohai Sea are described using survey data from 1959-60, 1992-93 and 1998-99. Indices of primary production, zooplankton biomass and fish productivity are used to describe the ecosystem productivity at different trophic levels. The results indicate that substantial variation in ecosystem productivity is one of the important characteristics of coastal ecosystem dynamics.

PICES XIII FIS_P-1924 Oral

Analysis of fish bycatch from the commercial shrimp fleet in the Southeast Gulf of California

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According to FAO, during the year 2000, the world demand for fishing resources was $1x10^8$ tons. This great demand could be fulfilled with incidental fishing. Every year approximately 3 to 5 x 10^6 tons of fish are discarded world-wide. The goals of this work were the identification of fish stocks of economic importance from bycatch data, the description of historical changes in their abundance, and finally to look for mechanisms that might account for their observed patterns of abundance. The study area was the coast of Sinaloa, which is in the Southeast Gulf of California. Samples came from shrimp surveys undertaken to evaluate shrimp stocks. In total, 203 species from 52 families were found. From these, 17 species represented almost 50% of the total. The main species in terms of abundance were *Orthopristis chalceus* which accounted for 8.49%, and *Selene peruviana* which accounted for 5.75%. In terms of biomass, the main species were *Synodus scituliceps* and *Pomadasys panamensis* which accounted for 8.15 % and 5.28% respectively. The diversity results for the study area were high, the Shannon index of diversity was 4.170. The annual catches from 1993 to 2003 showed that the fish bycatch could be used as a source of fish resources in this area. The fleet discarded an estimated 146,049 tons of fish in 2003. The species composition of discards did not differ a lot in the different zones. A possible explanation for the discards is the small size of the species in the catch, but there is a considerable amount of discard. Hence there is a need for regular economic use for these catches.

PICES XIII FIS_P-2088 Poster

The preliminary estimation of abundance of some fishes in adjacent waters of the Commander Islands by results of bottom long-line catching in 1995-1997

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Data on species composition and frequency of fishes in the catches of bottom auto long-line system Mustad was collected within the 30-mile conservation zone of the Komandorskiy Reserve in 1996 and in adjacent waters on the continental slope in 1995, 1997. 29 species of fishes relating to 13 families are registered in catches within the limits of the conservation zone in 1996 on depths from 35 to 680 m. The families of the rockfishes Sebastidae (7 species), flatfishes Pleuronectidae (6) and sculpins Cottidae (4) were submitted at the most miscellaneous. Among commercial species the highest frequency of occurrence was marked for Pacific cod *Gadus macrocephalus* – 98,5 %, halibut *Hippoglossus stenolepis* – 69,5 %, rock greenling *Hexagrammos lagocephalus* – 43,6 %, for different species of rockfishes: rougheye rockfish *Sebastes aleutianus* (28,3 %), Pacific ocean perch *S. alutus* (21,9 %), shortraker rockfish *S. borealis* (22,8 %), and also shortspine thornyhead *Sebastolobus alascanus* (24,8 %). In 1995 and 1997, Pacific cod was the base of longline catches on depths of 100-300 m – 87 and 43 % on biomass accordingly. The calculation of abundance and biomass of some species was conducted by the "spline surface approximating" method. The average abundance (thousand fishes) and biomass (tons) were estimated: for Pacific cod – 3550 (9574), for halibut – 38 (166), for shortraker rockfish – 34 (49), for shortspine thornyhead – 2479 (3633) in this region for 1995-1997. Based this data the large reduction of the stock of rockfishes (especially of shortspine thornyhead) is judged as the result of the poaching. Some actions for protection of marine biota of the Komandorskiy Reserve are offered.

PICES XIII FIS_P-1831 Poster

Growth and morphological development of sagittal otolith of jack mackerel *Trachurus japonicus* in larval and early juvenile stages

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Daily periodicity of growth increment formation in sagittal otoliths of jack mackerel *Trachurus japonicus* was confirmed by marking otoliths with alizarin compelxone (ALC). Analysis of otoliths of known-age juveniles confirmed that the first increment was formed on the 3rd day after hatching, associated with first feeding. A total of 198 specimens, ranging from 2.6 to 49.2 mm body length (notochord length or standard length) and from 7 to 78 days in age, were collected in the East China Sea and Tosa Bay; data were analyzed to examine the association between otolith morphological development and ontogenetic development. The relationship between body length (L) and otolith radius (R) was significantly expressed by a linear function of L=2.65+0.0425R (N=198, r^2=0.99, p<0.00001), indicating that somatic growth history can be reconstructed from otolith growth pattern. The otolith was primarily spherical in the preflexion larval stage and became elongated with the notochord flexion. The first secondary primordium (SP) was formed at about 25 days of age when fish were in the middle postflexion stage, which was associated with metamorphosis. By about 42 days of age, juveniles attained an adult-like morphology of sagittal otolith with the primary growth zone (PGZ) enclosed by the marginal growth zone (MGZ) except in the anterior rostrum area. These results indicate that age, growth and developmental stages were recorded in sagittal otolith of jack mackerel during larval and early juvenile stages. Thus, future work can use these records to study early life ecology of this species.

PICES XIII FIS_P-1830 Poster

Hatch-date dependent difference in growth and development of jack mackerel *Trachurus japonicus* during early life stages recorded in otolith microstructure

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Jack mackerel spawn in both the East China Sea (ECS) and the coastal waters of southern Japan from January to June. We hypothesized that growth and development of jack mackerel during early life stages varied with hatch-dates. We tested this hypothesis by comparing sagittal otolith microstructure of jack mackerel juveniles. A total of 308 juveniles sampled from Fukagawa Bay in southern Sea of Japan during June and September 2002 were analyzed. They were hatched from 16 January to 30 May 2002. Age of the first secondary primordium (SP) formation ranged from 19 to 54 days with a mean (±SD) of 30.4±6.1. Numbers of SP in an otolith ranged from 2 to 15 with a mean (±SD) of 6.1±1.7. Age of the first SP formation, number of SP, and increment width varied with hatch dates. A general pattern was that late-hatched fish were younger at age of the first SP formation, larger in number of SP, and wider in increment width during late larval and early juvenile stages than early-hatched fish. As increment width is a linear function of somatic growth and formation of the first SP is associated with metamorphosis in jack mackerel, variations in otolith microstructure indicated that growth rate was higher as inferred by wider increments, and developmental rate was higher as inferred by younger age of the first SP formation, for late-hatched fish than early-hatched fish. Influences of these seasonal variations in growth and development on recruitment of jack mackerel population were discussed.

PICES XIII FIS_P-2051 Poster

Current Status of Ecosystem-based fisheries management in Korea

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It is suggested that ecosystem-based management (EBM) be defined as "a strategic approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities". Based on the elements of EBM, initiatives with the spirit of EBM have been established in 14 Acts and 15 Presidential and Ministerial Orders in Korea. One of the major EBM initiatives in Korean is the "Basic Act of Ocean and Fisheries Development". Most of the Korean Acts with the spirit of EBM are more focused on the elements of the maintenance of biodiversity and protection from the effects of pollution and habitat degradation, rather than sustainability of yields and socio-economic benefits. Current main actions for the ecosystem-based fisheries management (EBFM) in Korea are precautionary TAC-based fishery management, closed fishing season/areas, fish size- and sex-controls, fishing gear restrictions, and marine protected areas (MPA). The Korean government is currently developing a comprehensive ecosystem-based marine ranching program. This program will eventually be designed for the enhancement and efficient management of fisheries resources. We present how the spirit of EBM is developing in Korean fisheries management to achieve operational objectives, and introduce some examples of how the comprehensive ecosystem-based management in Korea can prevent significant and potentially irreversible changes in marine ecosystems caused by fishing.

General Poster Session

Wednesday, October 20 17:30-19:30

Peter M. Zhadan, Marina A. Vaschenko, Dmitry L. Aminin, Irina G. Agafonova and Tatyana N. Almyashova
Lipofuscin in the gonads of the sea urchin *Strongylocentrotus intermedius* inhabiting polluted coastal waters of Peter the Great Bay (Sea of Japan) (GP-2184)

Tatyana A. Belan
Ecological investigations at the Far East State Marine Reserve Area (GP-1780)

Alexander A. Bogdanovsky, Igor E. Kochergin, Igor A. Arshinov, Sergey I. Rybalko, Valeriy P. Tunegolovets, Nikolay S. Kupera, Sergey A. Pokrashenko and John A. Wardrop
New comprehensive oil spill modeling for potential sources near Sakhalin Island (GP-1962)

John R. Bower and Kazutaka Miyahara
The diamond squid (*Thysanoteuthis rhombus*): A review of recent research and the fishery in Japan (GP-1828)

Russell W. Bradley and William J. Sydeman
Beyond biomass: Individual-based reproductive decisions of a planktivorous marine predator over 35 years (GP-1903)

Man Chang, Seunghye Park, Tae Kyun Lee and Eon Seon Jin
Superoxide dismutase in the marine alga, *Dunaliella salina* (GP-1784)

Anastasia S. Chernova, Tatyana S. Lishavskaya, Alexander V. Mocshenko and Tatyana V. Konovalova
Multiyear changes of petroleum hydrocarbons in the marine environment near the operating oil producing platform *MOLIKPAQ* (GP-2019)

Sang-Hwa Choi and Young-Gyu Park
Variability of global thermohaline circulation due to the Drake Passage (GP-2132)

Yun Hee Kang, Min-Hyuk Oh, Choon-Hwan Lee, Myung-Sook Kim and Ik Kyo Chung
The effects of antibiotics on the photosynthetic apparatus and ammonium uptake in *Porphyra yezoensis* (GP-2161)

Dong Woo Kang, Min-Hyuk Oh, Choon-Hwan Lee, Sung-Hoi Huh and Ik Kyo Chung
The effects of epiphytes on the photosynthetic apparatus of seagrass measured using the chlorophyll fluorescence imaging technique (GP-2162)

Ludmila S. Dolmatova, Olga A. Shitkova and Nelly F. Timchenko
Death of the holothurian *Eupentacta fraudatrix* phagocytes treated with toxin of bacterium *Yersinia pseudotuberculosis* (GP-1839)

David B. Field, Tim R. Baumgartner and Vicente Ferriera-Bartrina
Abundances of planktonic foraminifera indicate decadal variability and a 20th century warming in the California Current (GP-2136)

Robert J. Foy
The seasonal distribution and quality of commercial fish species: Energy flow and sustainability on the Gulf of Alaska shelf (GP-2169)

Chong-Hui Fu and Yu-Zhu Li
The impact of the transition of consumption patterns and population development in China on fisheries in the next 20 years (GP-1914)

Toyomitsu Horii and Hiromu Zenitani
Stock enhancement policy for Japanese red sea bream, *Pagrus major*, by release of juveniles and fisheries management (GP-1799)

Evan A. Howell and Donald R. Kobayashi
Using a generalized additive model to predict Bigeye (*Thunnus obesus*) CPUE at the Palmyra fishing grounds (GP-2077)

Miwako Kitagawa, Katherine W. Myers and Masahide Kaeriyama
Spatial comparison of ocean distribution and feeding habits of sockeye (*Oncorhynchus nerka*) and pink salmon (*O. gorbuscha*) in the western Gulf of Alaska during summer 2003 (GP-1862)

Leonid S. Kodolov and Vladimir B. Darnitsky
Ichthyofauna of seamounts in the North Pacific (GP-1889)

Vladimir B. Darnitsky and Leonid S. Kodolov
Seamounts researches in the West Central Tropical Pacific: Part II. Mid-Pacific and Necker Ridges (GP-1891)

Vladimir I. Korochentsev, Vladimir A. Kartashov and Vera A. Kochetova
Optic-acoustic and bio-physical complex for the shelf water and seabed research (GP-2065)

Nikolina P. Kovatcheva, R.R. Borisov, A.B. Epelbaum and A.V. Kalinin
The status of red king crab stocks in the Far Eastern Seas and their recovery by aquaculture (GP-1774)

Alexander V. Moshenko, Tatyana S. Lishavskaya and Vladimir M. Shulkin
Distribution of contaminants in sediments of the Far East State Marine Reserve and adjacent area near Tumen River mouth, Sea of Japan (GP-1779)

Olga N. Lukyanova
Biomarkers of energetic metabolism of marine shellfishes and echinoderms in the Far Eastern State Marine Reserve (Japan/East Sea) (GP-1905)

Valentina V. Moroz and Konstantin T. Bogdanov
The role of the Kuril Island straits in forming the water characteristics of the Kuril-Kamchatka Current zone (GP-1783)

Masayuki Noto and Ichiro Yasuda
Variation of the Japanese sardine population associated with SST in the Kuroshio Extension during the 20th century (GP-1848)

Sachiko Oguma, Toshihiro Usui, Kazuyoshi Oichi and Yukihiro Nojiri
Quality control methods for chemical oceanographic data (GP-1972)

Ivonne Ortiz and Kerim Y. Aydin
Reconstructing the spatial exploitation of fishery resources in the Aleutian Islands (GP-2144)

Taewook Park and Im Sang Oh
Mixing processes of the Yangtze River water in the Yellow and East China Seas (GP-2181)

Vera A. Petrova, Alexander D. Nelezin and Alexander N. Man'ko
Interannual variability of the sea surface heat fluxes in the North Pacific (GP-1945)

Peter S. Rand, Cathy Pearson, Xan Augerot and Ed Backus
Identifying population units and establishing a monitoring program for Pacific salmon conservation throughout their natural range (GP-2050)

Nina I. Savelieva, Vladimir I. Ponomarev and Alexander P. Nedashkovsky
Interannual variability of oceanographic and hydrochemical environments in the Anadyr Gulf (the Bering Sea) (GP-2053)

Saya Shimura, Shuichi Abe, John R. Bower, Tsunemi Kubodera and Yasunori Sakurai
Molecular species identification and morphology of gonatid squid paralarvae from the North Pacific (GP-1863)

Guadalupe Durga Rodríguez-Meza, Ignacio Sánchez-Rodríguez, Evgueni Shumilin, Lía Mendez-Rodríguez, Baudilio Acosta-Vargas and Dmitry Sapozhnikov
Heavy metals in seaweeds of the mining region of Santa Rosalía, Baja California Sur, Mexico (GP-2188)

Shinichi S. Tanaka and Yutaka W. Watanabe
The bubble injection effects on the concentrations of CFCs, N_2 and Ar in the Pacific (GP-2024)

Yulia N. Tananaeva, Marat A. Bogdanov and Andrei S. Krovnin
Features of the interannual variability in elaboration of the season processes and their possible influence on fishing capacity (GP-1990)

Alexander Tkalin
Marine environment pollution around the marine protected area in Peter the Great Bay (GP-1771)

Vladimir N. Tuponogov and Leonid S. Kodolov
Features of ichthyofauna species composition at the Emperor and Hawaiian seamounts (GP-1892)

Andrey V. Vinnikov, Dmitry A. Terentiev and Yuri B. Artukhin
Interactions between bottom long-line fishery and seabirds in the western Bering Sea and Pacific waters of Kamchatka (GP-2089)

Galina A. Vlasova
Climatic variability of water circulation under different pressure systems in NW Pacific (GP-1794)

Tatsuro Watanabe, Naoki Iguchi and Hideaki Kidokoro
Horizontal distribution of larvae of the euphausiid, *Thysanoessa longipes*, around the subarctic gyre in the Japan Sea (GP-1841)

Curt E. Whitmire, M.E. Clarke, W.W. Wakefield and M.A. Hixon
Mapping the distribution of structure-forming invertebrates off the U.S. west coast (GP-2153)

Jun Yamamoto, Tsuyoshi Shimura, Ryosuke Uji, Shinya Masuda, Shuyo Watanabe and Yasunori Sakurai
Vertical distribution of *Todarodes pacificus* (Cephalopoda: Ommastrephidae) paralarvae near the Oki Islands, southwestern Sea of Japan (GP-2119)

Yu-Feng Yang, Xiu-Geng Fei and Ik-Kyo Chung
Gracilaria cultivation practice and its ecological role in Chinese coastal waters (GP-2087)

PICES XIII GP-2184 Poster

Lipofuscin in the gonads of the sea urchin *Strongylocentrotus intermedius* inhabiting polluted coastal waters of Peter The Great Bay (Sea of Japan)

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In histological sections from the gonads of the sea urchin *Strongylocentrotus intermedius*, morphological lipofuscin was demonstrated and fluorescent lipofuscin was quantified using epifluorescence microscopy and image analysis. In August 2002, sea urchins and sediment samples were collected at several stations from coastal zones of Peter the Great Bay (Sea of Japan): Stations 1 and 2 were located near Vladivostok City ("near city" zone). Stations 3, 4 and 5 were in the "island" zone of the bay, and a Reference Station 6 was in a remote area far from sources of pollution. Lipofuscin was visible as yellow pigment, yellow-brown globules and granules located mainly in the cytoplasm of nutritive phagocytes (NP); accumulations of the lipofuscin granules occurred in haemal sinuses and coelom. Upon gross inspection, the gonads of the sea urchins from "near city" zones contained much more lipofuscin than the gonads of the animals from "island" zones and Station 6. For fluorescence quantification, 5–8 males and females with immature gonads were selected within each animal sample. At λ=450 nm, fluorescence intensity of 25 images of the gonad section occupied by NP was measured, and mean volume fraction (%) of lipofuscin was determined. Each animal sample contained from 1 (Station 6) to 7 (Station 1) sea urchins with high means (>1%) of lipofuscin volume fraction (LVF). High LVF means were attributed to NP containing a bulk of lipofuscin granules. In bottom sediments from Station 1, high concentrations of heavy metals and the organochlorine pesticide DDT were determined. Pollution appears to intensify the lipofuscin formation in the sea urchin gonads.

PICES XIII GP-1780 Poster

Ecological investigations at the Far East State Marine Reserve Area

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Initial studies at the Far East State Marine Reserve (FESMR) were carried out in the 1980s by the Institute of Marine Biology. These investigations provided a description of populations of benthic invertebrates and environmental factors in the southern part of FESMR. In 1993, the Expedition of Joint Company "Dalmorgeologia" and FERHRI investigated pollutant content in water and bottom sediments, as well as benthos distribution patterns in this area.

The first comprehensive ecological expedition to FESMR was organized by the Institute of Marine Biology in 1996. The main goal of this investigation was to study environmental factors, pollution levels, and the present status of benthic and pelagic ecosystems of the southern part of FESMR between the Tumangan River mouth and Furugelm Island (TREDA Project).

Analysis of data obtained showed that the FESMR study area was characterized by background pollution levels and high biomass, diversity and richness of benthic fauna. A total of 11 phyla and 211 species of macrozoobenthos were identified. Mean biomass of benthos exceeded 150 g/m^2. Non pollution-tolerant species (echinoids, amphipod crustaceans and bivalve mollusks) were prevalent. It appears that this sort of distribution typifies the normal ecological state of the area. However, increasing content of chlorinated pesticide residues (*e.g.*, prohibited DDT) was recorded in some zones, where pollution–tolerant species were detected. This would appear to be evidence of anthropogenic impact, resulting in ecologically stressed conditions in some local zones in FESMR.

PICES XIII GP-1962 Poster
New comprehensive oil spill modeling for potential sources near Sakhalin Island

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Results of new comprehensive oil spill modeling for two potentially dangerous areas near Sakhalin Island are considered. Exploratory well drilling under the Sakhalin-5 Project is going to start in 2004 northeastward of the Sakhalin-1 and 2 Project sea areas. In addition, Phase II of Sakhalin-2 includes oil and gas pipeline transport to the south of Sakhalin Island and further export by sea. Thus, Aniva Bay and adjacent waters are the other area under study. New potential oil spill sources were identified and oil behavior was modeled, both statistically and diagnostically. For the Sakhalin-5 project, we calculated oil behavior for the well control loss, bunkering and flare test cases. For the Aniva Bay area, we simulated oil behavior for 5 potential oil release points, including a tanker loading unit and four tanker route points (Aniva Bay center, a point southward of Aniva Bay, La Perouse/Soya Strait and a point nearby Rebun Island in Japan Sea). Updated oil spill modeling techniques including preparation of output results for EIA/EP (Environment Protection Documents) and OSRP (Oil Spill Response Planning) consisted of: (1) statistical modeling (simulation over the numerous possible hydromet scenarios, and averaging of results followed by constructing probability patterns for the oil transport, location, shore impact, etc.) and (2) diagnostic modeling (simulation over specific hydromet scenarios to detail oil fate under specific weather conditions including both typical, to and/or most unfavorable conditions). With respect to exploratory well drilling on the northeastern Sakhalin shelf, we analyzed pressure fields that form unfavorable hydromet conditions causing very rapid shoreline impact or/and lengthy coastline contamination. Our analysis of the Aniva Bay area revealed hydromet situations which could result in very rapid impacts upon both Russian and Japan coasts.

PICES XIII GP-1828 Poster
The diamond squid (*Thysanoteuthis rhombus*): A review of recent research and the fishery in Japan

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This poster presents a review of the biology, ecology, fisheries, and resource status of the diamond squid (*Thysanoteuthis rhombus*) focusing on recent literature published in Japan. *T. rhombus* is a large nektonic squid distributed worldwide mainly in tropical and subtropical waters, including around central and southern Japan. Near Japan, spawning occurs widely around Okinawa and in other southern waters. Part of the population is transported by the Tsushima Current into the Sea of Japan, where it is targeted by a growing fishery, but details of this migration are not known. The vertical distribution of *T. rhombus* varies regionally; in Okinawa, it occurs mainly at 300-650 m depth during the day and 0-150 m depth at night, while in the Sea of Japan it occurs mainly at 75-100 m depth during the day and 0-50 m depth at night. The life span of *T. rhombus* is thought to be about one year, and squid larger than 30 cm ML grow about 7-10 cm mo^{-1}. The main fishing grounds in Japan are the Sea of Japan, Okinawa Prefecture, and Kagoshima Prefecture, with most catches occurring in the Sea of Japan and Okinawa. In the Sea of Japan, it is fished with free-floating angling gear called “taru-nagashi” and in nearshore stationary nets. The fishery runs roughly from July through February, with peak catches occurring from September through December. Annual catches during 1998-2001 ranged between 1,900 and 3,800 tons. In Okinawa, it is fished primarily in the daytime using free-floating angling gear called “hata-nagashi”. The fishery runs mainly from November to April, with highest catches occurring in February-April. Annual catches were 2617 tons in 2000-01 and 2028 tons in 2001-02.

PICES XIII GP-1903 Poster
Beyond biomass: Individual-based reproductive decisions of a planktivorous marine predator over 35 years

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Evolutionary theory predicts that life history strategies, the way individuals allocate reproductive effort over their lifetimes, should maximize inclusive fitness. Reproductive investment and output varies between individuals, due to heterogeneity between individuals as well as environmental stochasticity. The purpose of this study is to investigate how individuals allocate resources to reproduction under varying ocean climate on an interdecadal time scale. We evaluate variation in life history strategies by long-term studies of a marine bird (Cassin's auklet, *Ptychoramphus aleuticus*) reproducing in the California Current system. This long-lived, pursuit-diving secondary predator forages primarily on *Euphausia pacifica*, *Thysanoessa spinifera*, and *Nyctiphanes* simplex along the shelf break front. Normally, there is only one breeding attempt annually.

However, some individuals may pursue a second reproductive cycle after a successful first attempt; this is an extremely rare life history strategy in marine birds. In the 1970s and early 1980s, we found that extra reproductive attempts were rarely successful and wasted reproductive effort. However, the frequency and success of this strategy increased in the late 1980s and even more in the late 1990s and early 2000s. Changes in reproductive effort and success began well before the hypothesized regime shift of the late 1990s (Peterson and Schwing 2003). This study highlights the importance of studies on individuals in long-lived iteroparous marine predators.

Long-term individual-based research is needed to understand the population level consequences of ocean climate change, as well as the evolutionary significance of specific life history attributes.

PICES XIII GP-1784 Poster
Superoxide dismutase in the marine alga, *Dunaliella salina*

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The marine alga *Dunaliella* is commercially an important organism producing ß-carotene and xanthophylls which are known to be quenching reactive oxygen species. In this work, we studied the relationship between antioxidant and the antioxidant enzyme; chloroplastic iron superoxide dismutase (Fe-SOD) from *Dunaliella salina,* under different physiological conditions. The enzyme superoxide dismutase (SOD) represents a first step in such ROS scavenging systems, catalysing the dismutation of O_2 to H_2O_2 and oxygen. Therefore this enzyme is critical in controlling the levels of reactive oxygen species in cell compartments. A cDNA-encoding Fe-SOD was isolated from *Dunaliella salina*. This Fe-SOD is nuclear-encoded; its deduced amino acid sequence is 67-75% identical to Fe-SOD isoforms from plants and cyanobacteria, respectively, and residues responsible for iron binding are fully conserved. We showed that the mRNA for Fe-SOD was induced in response to UV-B illumination and to growth under increasing light fluencies. Light-induced up-regulation of Fe-SOD expression and increments of antioxidant such as ß-carotene and xanthophylls in *D. salina* are discussed in terms of algal mass culture.

PICES XIII GP-2019 Poster

Multiyear changes of petroleum hydrocarbons in the marine environment near the operating oil producing platform *MOLIKPAQ*

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Over a four-year period (1998–2001), the impact of technological processes of the MOLIKPAQ platform (NE Sakhalin Island shelf) on pollution of water and bottom sediments by petroleum hydrocarbons was studied. Water was sampled at surface, intermediate, and bottom areas of the water column within a range of 500 m from the platform in September and October. Five subsequent samplings were carried out to analyze concentrations of petroleum hydrocarbons in bottom sediments from 1998 - 2001. Sediment samples were taken at distances of 125–5000 m from the platform. Maximum concentrations of petroleum hydrocarbons in bottom sediments of the study area were registered in June 1998 prior to the platform installation. Later, from October 1998 to 2000, significant reduction of petroleum hydrocarbon concentrations was observed. In 2001, the average concentration of petroleum hydrocarbons increased again somewhat, although this increase was slight, and statistically insignificant. Maximum concentrations of petroleum hydrocarbons in the water column near the platform were registered in October 1998 and, as in the case with concentrations of petroleum hydrocarbons in bottom sediments, then decreased continuously. Minimum petroleum concentrations were reached in October 2001. Moreover, vertical distribution of petroleum hydrocarbons changed from rather uniform for the water column in October 1998 to a significant decrease in concentrations with depth in 2000–2001. It is possible that the high concentrations of petroleum hydrocarbons with maximum values in the intermediate and bottom layers of water (both in mean and especially in extreme values) observed in October 1998 were caused by resuspension of petroleum products out of bottom sediments that took place because of high bottom hydrodynamic activity and disturbance of the sediment surface during the platform installation. The elevated concentration of petroleum hydrocarbons in sediments that was observed prior to the installation was likely to be related to natural oil seepage.

PICES XIII GP-2132 Poster

Variability of global thermohaline circulation due to the Drake Passage

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The global thermohaline circulation was simulated in an idealized ocean to verify its variability due to the presence of the shallow Drake Passage in the Antarctic Ocean. The model was represented by the NOAA/GFDL Modular Ocean Model, MOM, 3. We used a 2° by 2° latitude and longitude grid in the horizontal and used 20 vertical layers. The oceans were simplified as rectangular boxes linked together by the Antarctic Ocean. The bottom topography was almost ignored, the oceans being flatexcept in the Drake Passage. Wind over the surface layer had no zonal variation but varied only only in the meridional direction. Temperature and salinity were restored to a symmetric distribution across the equator. There were no zonal variations in any surface boundary conditions. Due to the variation of bottom topography in the Drake Passage, almost changes of thermohaline circulation occurred in the North Atlantic but for the changes of the Antarctic Circumpolar Current directly affected by it. Especially in the cases with a shallow Drake Passage, the thermohaline circulations were strengthened in the Atlantic and Pacific Oceans. In this study, we explain how the effect of bottom topography in the Drake Passage on the thermohaline circulation propagates to the northern hemisphere and the reason why circulation changes were emphasized in specific areas.

PICES XIII GP-2161 Poster

The effects of antibiotics on the photosynthetic apparatus and ammonium uptake in *Porphyra yezoensis*

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Modern integrated fish-seaweed mariculture has been tested as a means of reducing the environmental impacts of an intensive fed aquaculture. To obtain the best seaweed bioremediation performance, the effects on selected seaweed species of therapeutants used for fish disease control should be considered. As the selected seaweed, the photosynthetic activity of *Porphyra yezoensis* was tested with several commercial antibiotics such as Erysulfa, Oxytetracycline HCl, Doxycycline Hyclate, Erythromycin Thiocyanate, Pefloxacin, and Amoxicillin under batch incubation at a photon flux density of ca. 10 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at 15ºC. Among the tested antibiotics, Erysulfa, Oxytetracycline HCl, and Doxycycline Hyclate showed a decreased Fv/Fm and, in turn, the photochemical PSII efficiency of *P. yezoensis* in a dose-dependant and time-dependant manner. From a quenching analysis of chlorophyll fluorescence, three differential patterns were found in the antibiotics-treated *Porphyra*: (1) high NPQ and low qP in the case of Erythromycin Thiocyanate and Amoxicillin treatment; (2) high NPQ and high qP for Pefloxacin; and (3) low NPQ and low qP for Oxytetracycline HCl. These results indicated that each antibiotic, reflecting its unique differential lesion sites, affected the photosynthetic apparatus in various ways. In addition, the rates of ammonium uptake decreased in the antibiotics-treated *P. yezoensis* with a decreased Fv/Fm. Therefore, some antibiotics could affect the bioremediation capacity of the selected seaweed species in the integrated fish-seaweed mariculture system by decreasing, simultaneously, the photosynthetic activity and the ammonium uptake of this species.

PICES XIII GP-2162 Poster

The effects of epiphytes on the photosynthetic apparatus of seagrass measured using the chlorophyll fluorescence imaging technique

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The effects of epiphytes on seagrass (*Zostera marina*) were measured using the Pulse Amplitude Modulation (PAM) Chlorophyll (Chl) Fluorescence Imaging Technique (FluorCam, PSI, Czech Republic). The fluorescence images of seagrass leaves before and after the removal of epiphytes were compared according to the images of Fo, Fm, and Fv/Fm. The Fo images of the initial Chl fluorescence before receiving an actinic light, clearly revealed the distribution of epiphytes on the leaf surfaces. There were more epiphytes on the outside leaves than on the inside ones; and there were more in the distal leaf parts than in the lower parts. The Fm images of the maximal yield of Chl fluorescence showed a significantly low outcome. In the case of loosely-bound epiphytes, the recovery of the photosynthetic capacity of the leaves was clear but with tightly-bound epiphytes, it was not, which could have been the result of permanent damage to the leaf surface layer. Therefore, Fv/Fm images might reflect the coherent effects of epiphytes on seagrass. In addition, we examined the changes of the epiphytes' effects on the seagrass leaves. The amounts of epiphytes increased in spring and summer, but the photosynthetic activity of the seagrass decreased consistently during that period. We speculated that epiphytes on seagrass leaves may inhibit seagrass biology through the down-regulation of the photosynthetic apparatus, as deduced from observations using the PAM Chl fluorescence imaging analysis technique.

PICES XIII GP-1839 Poster

Death of the holothurian *Eupentacta fraudatrix* phagocytes treated with toxin of bacterium *Yersinia pseudotuberculosis*

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In view of the increased pollution of coastal seawaters with waste water, there is need to study the characteristics of possible bacterial influence on marine animals. The bacteria *Yersinia pseudotuberculosis* has been shown earlier to be relatively long-lived in seawater. The aim of the present study was to clarify a role of a novel thermostable toxin (TST) from *Y. pseudotuberculosis* in the bacteria-induced lethality of the Far-Eastern holothurian *Eupentacta fraudatrix***.** We demonstrated that a TST concentration of 0.2 μg/mL, which was previously shown to increase oxidant stress in holothurian phagocytes *in vitro*, decreased cell viability by 30-44% compared to the control after 48 and 72 h incubation, respectively. The cell death was closely related to TST-induced apoptosis as assessed by measuring DNA fragmentation using electrophoresis on agarose gel and by Hoechst 33342 staining: after 72 h, apoptosis was 41% higher than that in the controls. In addition, TST (0.5 μg/mL) decreased concanavalin A (con A) binding to the phagocytes by 25 and 50% compared to the controls after 18 and 72 h, respectively, as evaluated by FITC-conjugated con A staining. The last fact, apparently, indicates a decrease in functional activity of phagocytes. The results obtained show that TST of bacteria *Y. pseudotuberculosis* can damage the immune cells of holothurians by decreasing their phagocyte functional activity and killing the cells via inducing apoptosis. These data suggest also the possibility of regulating phagocyte activity with con A, and may be important for antibacterial defense of animals in aquaculture.

PICES XIII GP-2136 Poster

Abundances of planktonic foraminifera indicate decadal variability and a 20th century warming in the California Current

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Microfossils of planktonic foraminifera in marine sediments offer one of the few means available to reconstruct changes in hydrographic structure and infer the mechanisms of change in ocean climate. Here, we develop a >250-year record of variations in upper ocean structure of the California Current, inferred from the abundances of planktonic foraminifera in annually varved sediments of the Santa Barbara Basin. Temporal variability in foraminiferal abundance follows two main patterns that are reflected in a Principal Components Analysis. The first pattern (PC 1) involves a substantial 20th century increase in the abundance of mostly tropical and subtropical species that indicate a warming of near-surface waters across the annual cycle of isothermal shoaling and deepening. The second pattern (PC 2) involves species with subpolar affinities that probably reflect decadal scale dynamics within the thermocline. There is a clear separation of the two PCs after 1975 that indicates a near surface warming and isothermal deepening that is distinct from all other time periods of the record. This change coincides with the well-known shift that occurred around 1977 in the North Pacific, where an intensification in the Aleutian Low caused a warming and depression of isotherms in the eastern North Pacific, particularly during winter. While decadal variability is prominent throughout the foraminiferal records, the patterns observed in the 20th century are distinct from those of previous centuries and suggest a response of the California Current to atmospheric warming that is attributed in part to anthropogenic activity.

PICES XIII GP-2169 Poster

The seasonal distribution and quality of commercial fish species: Energy flow and sustainability on the Gulf of Alaska shelf

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The importance of seasonal, spatial and ontogenetic variability of fish energetics in the context of trophodynamic interactions of commercially targeted fish has been noted but not well studied. This study targeted demersal and pelagic fishes within the coastal shelf of the Gulf of Alaska. Multiple fish species were collected for subsequent proximate analysis from the southeast side of Kodiak Island in March, May, July and November 2000-2002. Species composition, relative abundance and trophic linkages of fishes were assessed during acoustic-trawl surveys using 38 kHz bioacoustics on 250 nm parallel east-west lines 25 nm from shore. Midwater fish species included walleye pollock, capelin, eulachon, arrowtooth flounder, Pacific sandfish, Pacific cod and king salmon. The bottom trawls, based on depth and distance from shore strata, were dominated by arrowtooth flounder, flathead sole, walleye pollock, Pacific cod, rock sole and eulachon. The proximate composition of fish differed seasonally and annually. Lipid values ranged from 0.95 to 4.7 percent in May and from 1.9 to 11.6 percent in November over 30 fish species. Moisture ranged from 76.5 to 80.7 percent in May and 69.6 to 79.5 percent in November. Protein ranged from 13.9 to 21.0 percent in May to 14.9 to 17.7 percent in November. Ash ranged from 1.5 to 3.6 percent in both May and November. Knowledge of commercial fish energetics and their prey quality has allowed us to build bioenergetic models to understand the relative flow of energy in the coastal region as it pertains to the harvest and sustainability of commercial fisheries.

PICES XIII GP-1914 Poster

The impact of the transition of consumption patterns and population development in China on fisheries in the next 20 years

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In 1995, the total aquatic product of China had reached 25 million tons, making it the largest such producer in the world. This has caused calamitous consequences to ecosystems in China. For analyzing the effects of population development and the transition of consumption patterns on fisheries in the future, this paper presents a structural model to illuminate the future demands on aquatic products, using principles of economics, demography, and biology. In this model, a macro-economics method is used for determining the relationship between the consumption of aquatic products and income level; *Profamy*, a new method of population forecasting, is utilized to project the size of populations in the next two decades . Because of the obvious differences in consumption of aquatic products between urban residents and rural ones, urbanization which will process rapidly in the future is considered as a crucial factor. In addition, oceanographic methods are used to find the sustainable limit of fisheries. We propose that these two factors, in addition to some special uncertainty, constitute the decisive factors in forecasting the future demands on aquatic products in China. Our conclusions are: (1) the amount of the consumer demands on aquatic products will be 16.7 million tons in 2020; If this were to also include the various industrial and commercial demands, the sustainable limit would be exceeded if there is no effort at alleviating the pressure on natural resources. (2) Urbanization will play a more and more important role in the increasing demands on aquatic products; its net effect will be 4 times higher in 2020 than in 2000; (3) the transition in consumption patterns caused by economic development, will have a decreasing effect on fishery resources. Finally, some suggestions are proposed for correcting the situation, with the intent of enhancing the analysts' and policymakers' understanding of the important issues in this field.

PICES XIII GP-1799 Poster

Stock enhancement policy for Japanese red sea bream, *Pagrus major*, by release of juveniles and fisheries management

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Japanese red sea bream is a major target of commercial and recreational fishing, and millions of juveniles have been released each year for stock enhancement since the early 1980s. Recovery rates and expected catches of released juveniles were estimated to be 5-17% and 20-80 tons per million juveniles, respectively, in the case of the southern coastal area. In this paper, the effects of juvenile release on the sustainable yield from two local stocks, the southern coastal area and the Seto inland sea area, were evaluated.

Numbers of recruits and brood stock biomass during 1983-1993 were estimated with virtual population analysis (VPA) from data of age composition of landed fish. When the relationships between brood stock biomass and recruits followed the Ricker model, number of 1-year-old recruits in t year (R_t) was
$R_t = A * E_{t-1} * \exp(-B * E_{t-1}) + S_{t-1} * K$

Here, A and B are the parameters of the Ricker model curve, and E_t is brood stock biomass. S_t and K are numbers of released juveniles and the survival rate of released juveniles until becoming 1-year-olds, respectively. A, B and K were estimated by the method of least squares. Using these parameters, the relationships among fishing mortality, number of releases and sustainable yield were calculated.

The increments of sustainable yield by stocking were estimated to be 20% and 2% in the two local stocks of the southern coastal area and the Seto Inland Sea area, respectively, under the current status of fishing mortality and number of released juveniles. Differences in increments were caused by differences in stocking impact and fishing mortality. The adequacy of the enhancement policy on the two local stocks is discussed.

PICES XIII GP-2077 Poster

Using a generalized additive model to predict Bigeye (*Thunnus obesus*) CPUE at the Palmyra fishing grounds

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The fishing grounds around the Palmyra Atoll can account for up to 20% of bigeye and over 55% of yellowfin tuna landed in the Hawaii Long-line Fishery since 1994. The observed availability of these two species of tuna appears to fluctuate based on environmental conditions, with catches around Palmyra dominated by yellowfin tuna, except in years of El Niño events. This variability in catch, when compounded with the travel time and cost for Hawaiian vessels, diminishes the desire to fish these productive waters. Modeling techniques were employed to attempt to decipher which parameters are important in determining the catch composition and to produce a basic prediction of the magnitude of bigeye catch. Generalized additive models (GAM) were used within a k-fold cross-validation framework to construct a predictive model of bigeye tuna (*Thunnus obesus*) catch rate on long-line fishing gear around Palmyra Atoll. This approach was contrasted with commonly used stepwise model construction techniques to examine the effects of overfitting. Preliminary results revealed that two environmental parameters with date and locations were sufficient to account for close to 70% of the bigeye CPUE. The main environmental parameter required by the model was an ecosystem indicator derived from an empirical orthogonal analysis (EOF) of altimetry data in the Pacific equatorial region. A parsimonious model using several predictor variables was also constructed and found to be satisfactory for predicting long-line fishing success.

PICES XIII GP-1862 Poster

Spatial comparison of ocean distribution and feeding habits of sockeye (*Oncorhynchus nerka*) and pink salmon (*O. gorbuscha*) in the western Gulf of Alaska during summer 2003

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We investigate spatial differences in distribution and feeding habits of sockeye (*Oncorhynchus nerka*) and pink salmon (*O. gorbuscha*) in the western Gulf of Alaska (145-160ºW, 50-58ºN). Sockeye salmon were distributed in a more to the south (51-53ºN, 155-160ºW) than pink salmon (54-56ºN, 155-160ºW). Sockeye were immature and pink salmon were maturing. They consumed diverse prey, such as fishes, squids, amphipods, decapods, and pteropods. Sockeye salmon fed on larger prey (fishes and squids) consisting of higher energy at low CPUEs of both species. Sockeye and pink salmon did not show a shift from small to large prey with increasing body size. Results of cluster analysis on stomach contents showed that sockeye salmon fed dominantly on pteropods in coastal waters, decapods in middle waters, and hyperiid amphipods and squids in offshore waters despite unclear results for pink salmon. Sockeye and pink salmon had a high degree of overlap in feeding niche (C_H>0.6) and the same dominant prey, such as pteropods and decapods, in areas of sympatric distribution. These results suggest that sockeye and pink salmon should be omnivorous and opportunistic feeders, feeding on available and abundant prey according to intra- and inter-specific competitions, food composition and oceanic environment.

PICES XIII GP-1889 Poster

Ichthyofauna of seamounts in the North Pacific

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In 1967, the Russian trawler *Astronom* found accumulations of boarfish on the Emperor Seamounts. It generated much interest in such underwater features. Later, it was found out that such underwater features, as well as islands and island arches, play an important role in creating zones of increased efficiency (Kotenev, 1977; Neumann, Krylov, 1979; Darnitsky, 1980; Uchida, Hayas, 1986, Boehert, 1986, 1987, 1988). A. Andrijashev (1979) and N. Parin (1982) showed that seamounts form a specific ecological zone, "bathyal without a shelf" or talassobathyal zone, where various organisms can be concentrated, including benthic and pelagic ecological groups. The common attributes of ichthyofauna on seamounts and in surrounding waters is determined by geographical zone and other features, including distance from continents, islands and other seamounts, current systems,, water depth at the top, area of the seamount, absence of a shelf, and weak development of the benthos.

Talassobathyal faunal communities develop by means of drift of larvae and pelagic juveniles in nearsurface currents. All abundant talassobathyal fishes have a pelagic stage in their ontogeny that can last a number of years. During the pelagic period, juvenile talassobathyal fishes serve as prey resources. They concentrate on seamounts only at upon attaining sexual maturity.

Most Northwestern and Central Pacific seamounts are located within the limits of subtropical circulation and eastern Pacific seamounts, as far as the Emperor and Hawaiian Seamounts, are populated on with Indo-West Pacific fauna. The distribution of benthonic representatives of this fauna further to the east is limited by interference by movement of quasi-meridional waters (Kozlov, 1971) and absence of large seamounts to the east. Southeast Pacific seamounts are located within the limits of northeast subarctic circulation and their fauna are typical of continental slopes of the subarctic region, northern seamounts of the Emperor Ridge, and Oregon. In the productive eddy-like zones above seamounts, high concentrations of epi- and mesopelagic fishes and even pulses of the neritic species, such as mackerel and sardine, are formed.

We report on ichthyofauna from the Emperor, Hawaiian, Kyushu-Palau, Bonin and Gulf of Alaska seamounts, as well as some oceanographic features near these different seamounts.

PICES XIII GP-1891 Poster
Seamounts researches in the West Central Tropical Pacific
Part II. Mid-Pacific and Necker Ridges

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Vortical currents, including Taylor-column eddies, above seamounts concentrate epi- and mezopelagical plankton, leading to bioefficiency. Fishes, which attain high abundance at the base and near the top of seamount ecosystems, have long (in some cases, years) pelagic stages of development. The formation of large concentrations of fishes is connected to ocean currents and fronts, taking place near these seamounts. Mid-Pacific and Necker Seamounts are located in the western-central tropical Pacific between a subtropical convergence zone and the northern periphery of the Northern Trade Currents. A reconnaissance study was conducted on 22 of the 350 seamounts. Tropical, strongly stratified waters constitute the least productive zone in the ocean. Biogenic compounds are almost absent in the 0-250 m layer. At a depth of 300 m phosphate concentration is 0.01 mkg-at/l and silicate is about 1.0 mkg-at/l. The average weight of zooplankton was less than 15 mg/m^3 at depths greater than 500 m (February, 1985). Zooplankton included only tropical species: *Eucheta marina, Eucheta wolfendeni, Candacia aetiopica, Undinula darwini*, *Stilocherion afine, Sagitta enflata, Neocalanus gracilis,* and *Euphausia*. Trawl catches included only some species of sharks: *Squalidae, Gonostomatidae, Gempylidae, Myctophidae, Sternopthychidae, Synaphobranchidae, Serrivomeridae, Nomeidae, Brotulidae*, *Chauliodontidae, Macrouridae*. Benthos on top of these underwater mountains included glass sponges, horn corals, and sea lilies. In some areas the density of sea lilies reached 2-3 per m^3, but average density of the benthos was much lower (R/V *Odissey*, 1985). The eddy-like systems at tropical seamounts have a semi-flat profile, barely impinging on the vertical structure of the water column to effect deep water upwelling. For example, an oceanographic survey at Lamont Seamount did not find vertical movements caused by geostrophic eddies near the top of seamount (Darnitskiy, Kanevskiy, 1997).

PICES XIII GP-2065 Poster
Optic-acoustic and bio-physical complex for the shelf water and seabed research

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The 18m long yacht is supplied with navigational equipment that assumes maneuvering with 10-12 knots speed according to assigned trajectory with an error about 1 m. Application of two operating modes for work, *i.e.* with working engines and non-working ones (silent) admits to increase efficiency of the acoustic system use, operating in the mode of passive noise-hearing (listening) of acoustic radiation produced by any biological objects.

Optimal application of different measuring instruments deployed onboard yacht in the instrumental department complex is provided. This complex includes autonomous undersea self-moving vehicle equipped by side-looking sonar, sector scanning (narrow-beam) sonar, optical TV and photo set-up. Possibility to install quantum magnetometer, devices to determine transparency of water, chemical contents of water and other appliances is foreseen for implementation on this undersea vehicle. There have already been tested some devices for the Fishery Department in TINRO.

Usage of acoustic vectorial receivers, measuring low-frequency echo-sounders with 2-3 ranges of frequency are envisaged also to operate onboard yacht autonomously from the undersea vehicle. The pneumatic boats are available onboard that can work autonomously either. The obtained information on physical fields is transmitted from measuring instruments to onboard devices being processed in real-time scale also documented at the same time. It may help to compile a map of bottom microrelief, contents of bottom cover. It is planned to develop further trends of research operations. Deployment and exploitation of appliances onboard yacht results in decrease of financial expenditure for conducted explorations.

PICES XIII GP-1774 Poster

The status of red king crab stocks in the Far Eastern Seas and their recovery by aquaculture

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In recent years there has been a sharp decline in the stocks of red king crab in virtually all the conventional fishing areas in the Far Eastern seas. As a consequence, the recommended volumes of the allowable catch for the recent five years have been reduced nearly ten-fold: from 30,000 tons in 1999 down to 3,583 tons in 2003. This is why we should employ every possible method to promote the introduction of more optimum techniques in the use of red king crab resources. These objectives can be reached using techniques of commercial culturing of crab. Beginning from 2000, a recycling man-made sea water system has been operating at VNIRO aquaria to experiment in obtaining and rearing of red king crab larvae up to the viable stages. Optimum conditions for development, which might be absent or tampered with in natural habitats, are being maintained in the process, especially at the plankton larval stage. The following characteristics are being reviewed in addressing the major stages of the process.

- abiotic conditions for the receipt and rearing of larvae and viable juveniles;
- stocking density and feeding regime;
- duration of the larval, post-larval and juvenile stages;
- survival and growth of larvae at each stage;
- behavioral reactions.

The results of these studies were basic in developing tentative biological standards for culturing the red king crab, and were used in designing experimental crab integrated facilities in Kamchatka, in the Far East and the Barents Sea.

PICES XIII GP-1779 Poster

Distribution of contaminants in sediments of the Far East State Marine Reserve and adjacent area near Tumen River mouth, Sea of Japan

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The southern area of the Far East State Marine Reserve (FESMR) is situated in the immediate proximity (about 15 km northward) of the Tumen River region, which is the adjoining point for the Russian, Chinese and North Korean frontiers. Last year under UN patronage, a project of accelerated industrialization was developed for this region. Realization of these plans will be accompanied by a corresponding increase in chemical contamination, and the present status of the environmental problems should be evaluated as a zero point.

The levels of various contaminants (trace metals - Cd, Cu, Zn, Pb, Ni, Co, Cr, petroleum hydrocarbons - PHC, and pesticides - sum of HCH isomers, and sum of DDT metabolites) were determined in sediments sampled from the south part of FESMR and adjacent sea area. The spatial variance of contaminants as well as grain size composition were analyzed to reveal quantitatively natural and anthropogenic controlling factors, and to assess the present status of contamination. The potentially toxic metal and PHC contents in the sediments studied do not exceed those in the background muds, and variability of them, excluding Cd, is determined by the dissipation of the fine river material. The maximum pesticide concentrations obviously exceed the background level, and their distribution is controlled by river run-off as well as by additional input associated with river-mouth wetlands.

PICES XIII GP-1905 Poster

Biomarkers of energetic metabolism of marine shellfishes and echinoderms in the Far Eastern State Marine Reserve (Japan/East Sea)

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The Far Eastern State Marine Reserve (FESMR) is located on Peter the Great Bay; this is the northwestern part of Japan/East Sea. The biodiversity of marine organisms in FESMR is very high, due to a favorable combination of natural conditions and background levels of pollutants in this environment. Molecular biomarkers of energetic metabolism were detected in somatic and reproductive organs of some species of marine shellfishes and echinoderms from FESMR and other areas of Peter the Great Bay. Caretenoids are respirative pigments, which define the important parameters of energetic pathways. High carotenoid content allows marine organisms to protect themselves against harmful effects. The carotenoid concentration in ovaries and testes of the sea urchin *Strongylocentrotus intermedius* from FESMR was 2 times higher than in individuals from polluted areas near the large seaport of Vladivostok. In contrast, the lowest carotenoid level was obtained in mussels of *Mytilus trossulus* and *Crenomytilus grayanus* collected from FESMR. Thus, there are different regulatory energetic mechanisms in both "stable" (mussels) and "unstable" (sea urchins) species. The activity of Na^+-K^+-ATPase and Mg^{2+}-ATPase was maximal in hepatopancreas of mussels from Kalevala Bay (FESMR) in comparison with mussels from other polluted bays. The metabolic processes in marine organisms from the Marine Reserve can be recognized as a "basal" level in comparison with organisms subjected to anthropogenic pollution from other areas in Peter the Great Bay.

PICES XIII GP-1783 Poster

The role of the Kuril Island straits in forming the water characteristics of the Kuril-Kamchatka Current zone

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The thermohaline structure and variability of the Kuril-Kamchatka Current zone in the Kuril Island Straits and Kamchatka peninsula border area of the Pacific ocean were studied.

For the purposes of this study we used the research vessel cruises of the POI, FEBRAS and recent hydorological and meteorological data (1989-1993) for the Kuril-Kamchatka Current zone, the 50-year synopsis (World Ocean Data Base, 1994, National Oceanographic Data Center, Washington, D.C.) together with all available atmospheric pressure, temperature and salinity data at the sea surface.

We will demonstrate the importance of the variability of the water exchange through the straits and atmospheric circulation variability was revealed for controlling the formation of water structure. New information about the variability of hydrological water characteristics will also be shown. We will show how zonations of the Kuril-Kamchatka Current area can be identified. Characteristic differences of various water modifications in the current zone will be shown.

The results can be used for developing forecasts of hydrological conditions in this area.

PICES XIII GP-1848 Poster
Variation of the Japanese sardine population associated with SST in the Kuroshio Extension during the 20th century

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Winter sea surface temperatures (SSTs) were reconstructed in the Kuroshio Extension and its southern recirculation area in the 20th century. Prior to 1948, SSTs were corrected by comparing nighttime SST and air temperature using the digitized Kobe-Collection and the COADS datasets. Periods of high SST occurred in 1911-1920, 1942-1956 and 1988-1995, and low SST occurred in 1921-1941 and 1970-1987. An abrupt increase in SST occurred in 1942 and 1988, associated with regime shifts. An empirical biomass model for the Japanese sardine with the corrected SST data reproduced the history of the sardine catch variations in the 20th century. This supports the hypothesis that the environment of the Kuroshio Extension, represented by winter SST, controls fluctuations of sardine populations.

PICES XIII GP-1972 Poster
Quality control methods for chemical oceanographic data

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Chemical oceanographic data include various kinds of values of dissolved matters in the sea water; dissolved oxygen (DO), nutrients, carbon species (DIC, TAlk, pH, x/f/pCO_2), trace dissolved gases (CFCs, SF_6, etc.), trace metals, and so on. Some biological data, such as chlorophyll-a, are used as carbon species from the viewpoint that biological processes can affect CO_2 distribution in the ocean. The integration of chemical oceanographic data is important for large spatial scale or long time scale studies of climate change; therefore, it becomes necessary to check for data that might be in error, which we define as statistically or oceanographically improbable values. To compare data sets obtained by different institutes/scientists in different decades, metadata can be valuable information sources. Since changes of observation methods can influence the accuracy and resolution of data directly, comparing metadata of original datasets supports data quality control during data integration. Namely, collection of metadata is an essential part of data quality control. We introduce a data quality control method applied for chemical oceanographic data in the western North Pacific. We hope that our method will be available for data observed in other basins. Our method will be edited and published as a manual by JODC. The manual will be available as a PDF file from JODC and IJCD web sites.

PICES XIII GP-2144 Poster
Reconstructing the spatial exploitation of fishery resources in the Aleutian Islands

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Using the REFM Observer Program database, we reconstruct the spatial distribution of fishing effort along the Aleutian Islands where sablefish, Atka mackerel, Walleye pollock, Pacific cod and Pacific Ocean perch were caught. We also analyzed the fisheries by gear, to evaluate their dynamics and preferred fishing grounds. The data analyzed is for the period 1990 to 2003, includes all gears (trawlers, hook and line, pots, and long-line) and covers the area

between 170˚E and 166˚W. In most cases, fishing effort has been steadily increasing towards the western Aleutians. The average catch per unit effort in some areas has decreased, indicating some local depletion might have occurred. Current spatial management is restricted to establishing closed areas, while the level of fishing pressure on a stock is controlled mainly by total allowable catches. The changes in the distribution of the fishing effort follow both changes in policy and availability of resources. One of the aims of this study is to elucidate the relative influence of each of these two factors (policy and availability), in order to better inform managers of the spatial response of fishing fleets and assess the need for increased spatial management.

PICES XIII GP-2181 Poster
Mixing processes of the Yangtze River water in the Yellow and East China Seas

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A three-dimensional numerical model using POM (the Princeton Ocean Model) was established in order to understand the dispersion and mixing processes of the Yangtze River water in the Yellow and East China Seas. The circulation experiments for the seas were conducted first. Throughout this experiment, monthly mean values were used for the Kuroshio Current input in the southern boundary of the model domain, for the transport through the Korea Strait, for the river discharge, for the sea surface wind, and for the heat exchange rate across the air-sea interface. And then on the basis of the results dispersion experiments for the river water were executed. The dispersion experiment was conducted using POM-oriented Random Walk diffusion submodel. The circulation model computes velocity components, and horizontal diffusivities for any point of the model domain at every time step. The number of injected particles is changed proportional to the rate of Yangtze River water inflow to describe the dispersion of river water. For the experiments, we focus on tidal mixing effects and wind effects on these processes.

During the summer, generally, low-salinity water from the river tends to spread offshore as a result of energetic vertical mixing processes due to the strong tidal current, and to spread more eastward due to the southerly wind. Observed salinity distributions support these results. The winter dispersion of the Yangtze River water follows the circulation pattern flowing southward along the east coast of China due to the strong monsoon wind.

PICES XIII GP-1945 Poster
Interannual variability of the sea surface heat fluxes in the North Pacific

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The interannual variability of the sea surface fluxes is investigated using ship-borne observations from 1984 to 1998 north of 25ºN. The latent and sensible heat fluxes, the radiation balance of the sea surface, as well as net sea surface heat flux, are calculated for each month of this period. According to the duration of the period of the accumulation and loss of heat through the sea surface, time of reaching their extreme values, four areas are allocated: northern (IN) and southern (IS) ones to the west of 180º; eastern (II) and Californian (III) areas to the east of 180º. The theory of interannual variability of the sea surface heat fluxes in different months is examined. We attempt to establish a relationship between the net sea surface heat fluxes in the different regions and that of the atmosphere circulation indexes (NPOI and SOI). We show that the largest variability of the net sea surface heat flux is observed in the fall-winter period: in the November (IN) and January (IS) - to the west of 180º, and in the September (II) and October (III) - to the east of 180º. The largest interannual amplitudes of the net sea surface heat flux (204 W/m^2), latent heat flux (202 W/m^2) and radiation balance (50 W/m2) are observed in the California (III) region, the sensible heat flux (59 W/m^2) – in the southern (IS) region. Interannually, the monthly amplitudes of the net sea surface heat flux exceed 9-10 times the monthly averaged for the whole period its values in March (region IN, II), in September (region IS) and October (region III). Computation of variance shows that the temporal variability of the net sea surface heat flux is determined by the seasonal variations to the greatest extent. The latent heat flux mainly

determines the interannual variability of the net sea surface heat flux. The sole exception being the fall-winter season in the subarctic (IN) area, when the sensible heat flux variability takes the dominant role. There is close link between the sea surface heat fluxes in the allocated areas and that between the indexes of the atmosphere circulation during some time periods.

PICES XIII GP-2050 Poster
Identifying population units and establishing a monitoring program for Pacific salmon conservation throughout their natural range

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There is a clear need to address Pacific salmon (*Oncorhynchus* spp.) conservation at the global scale, but there is little coherency in the manner in which data are collected, analyzed and interpreted across political boundaries. Through a combined effort involving the State of the Salmon Consortium (jointly administered through the Wild Salmon Center and Ecotrust) and the IUCN Salmonid Specialist Group, we propose to take the first critical step in developing a conservation action plan for salmon throughout their natural range in North Pacific waters. The program involves a two-tiered approach: 1) building a consortium of leading scientists to develop an approach for identifying discrete population units and 2) establishing a multi-level international monitoring strategy. We will mark progress toward the development of a hierarchical scheme for defining population structure using relevant ecological and genetic data. We will present a summary of our effort to identify gaps in extant monitoring and to establish more rigorous sampling to help resolve status and trends. We feel this work will help foster international collaborations, stimulate interest in standardizing approaches used in delineating populations, and establish a coherent monitoring network to better serve the needs of the global conservation community.

PICES XIII GP-2053 Poster
Interannual variability of oceanographic and hydrochemical environments in the Anadyr Gulf (Bering Sea)

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To understand better the relationships between physical and biogeochemical processes on the shelf we consider the interannual variability of oceanographic and hydrochemical parameters in the Anadyr Gulf - Bering Sea system, taking into account climate variability in the North Pacific. The Anadyr Gulf is one the most productive zones in the North Pacific. The water mass distribution is under the strong influence of riverine discharge, ice melt processes and the Bering Sea water advection that in turn are closely connected with climate change.

This investigation was based on oceanographic and hydrochemical data of several cruises carried out in the 1989, July; 1992, June; 2000, September; 2002, August-September. Different water masses have been revealed based on T/S relations. In the surface layer they are: (1) freshened waters (S=19-31‰, T up to 10°C) that is under the influence of surface runoff and ice melt; (2) the Bering Sea waters (31.56-32.6‰, 6-8°C), which are carried by the Navarin current from the south to the open and central part of the Anadyr Gulf and define the Navarin frontal zone. In the bottom layers there are three types of waters: (1) originating from the Cross Bay, CBW, (S>33.5psu, -1.99°C<T< -1.5°C) (2) St. Lawrence Island region so called bottom shelf water, BSW, (S<33psu, -1.7° < T<-1.5°C) and Providenia Inlet as well, and (3) bottom shelf water from the deep part of the Bering Sea, BSBW, (high salinity and 0°<T<2-2.5°C). CBW and BSW are formed during the cold season prior to winter freezing and remain in the Anadyr Gulf during the summer.

The concentrations of nutrients increase from surface to bottom. The highest concentrations of silica, phosphate, and nitrate are found in the densest water originating from the Cross Bay. Low regression coefficient of nitrate-phosphate (N:P=10:12) suggests that nitrate limitation is occurring in the ecosystem of the Anadyr Gulf. The transformation of hydrochemical parameters in bottom waters demonstrate nitrate deficiency having occurred in

bottom layers because of denitrification in the upper layers of bottom sediments. Our estimation of the annual flux of organic matter to the bottom sediment is about 130 gC/m^2.

Interannual variability of water structure is caused by Pacific Decadal Oscillations. During the warm phase of the PDO (cooling for the west Bering shelf) the Navarin front has a zonal orientation. The Navarin warm water was spread into the open and central part of the Gulf and there was a wide distribution of cold bottom water (CBW and BSW). During the cool phase of PDO (warming for the west Bering shelf) the frontal zone had a meridional orientation and Navarin waters in the surface layers penetrated to the north coast of the Anadyr Gulf. Bottom cold saline water occupied a much smaller region.

PICES XIII GP-1863 Poster
Molecular species identification and morphology of gonatid squid paralarvae from the North Pacific

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We describe a method to identify gonatid squid paralarvae from the North Pacific. At least 16 gonatid species inhabit this region, where they are an important prey of many nekton, including salmon. However, studies of their paralarvae are hampered by identification uncertainties, particularly for specimens smaller than 5 mm in mantle length. Paralarval specimens were collected aboard the *Oshoro Maru* during three cruises in 2003-2004 and divided into five morphotypes based on physical characteristics (relative arm lengths, chromatophore patterns, and degree of head withdrawal into the mantle cavity). Polymerase chain reaction (PCR) was used to amplify the mitochondrial cytochrome oxidase I (COI) gene from each morphotype, and the PCR products were cloned and sequenced. These sequence data were then compared with data from adults to identify the paralarval morphotypes. Our five morphotypes were identified as *Berryteuthis anonychus*, *Gonatopsis borealis* and three undetermined *Gonatopsis* spp. When we complete this study, we will construct an identification key to the newly hatched stages of the gonatids for use in future field studies.

PICES XIII GP-2188 Poster
Heavy metals in seaweeds of the mining region of Santa Rosalía, Baja California Sur, Mexico

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The town of Santa Rosalía is situated in the "El Boleo" mining district in the central part of the western coast of the Peninsula of Baja California. The extraction of copper mineral and the smelting of metallic copper by the "El Boleo" (1885-1938) and "Santa Rosalía" (1954 - 1985) companies have generated a huge quantity of solid wastes exposed to the air and seawater. The results of our previous studies in this zone have shown the presence of high concentrations of Cu, Zn, Co and Pb in the beach sands and coastal marine sediments of the adjacent part of the Gulf of California as a consequence of the above-mentioned anthropogenic activity. Nevertheless, the possible effects of these high levels of heavy metals, found in the sediments, on the marine biota are still unknown. For this reason, the following study was carried out with the objective of determining the concentrations of Cu, Zn, Co, Mn, Cd, Ni, Fe and some other trace elements in the tissues of the seaweeds, and to evaluate the possibility of using some of these species as bioindicators of metal contamination. The available seaweeds (*Colpomenia tuberculata*, *Dictyota dichotoma*, *Gracilaria sp*., *Laurencia pacífica, Padina durvillaei*, *Pterocladia capillaceae, Sargassum sinicola,*

Ulva lactuca) were collected every 3 months between March 2000 and l March 2001 at 9 stations located along the shoreline of Santa Rosalía and its vicinities. Trace metal content in homogenized dry tissues of seaweeds was determined using flame atomic absorption spectrophotometry and instrumental neutral activation analysis. Seaweed samples collected in the area of major sediment contamination due to mining and smelting activities (especially near the marina of Santa Rosalía) displayed higher concentrations of some metals than those from non-impacted reference sites. In addition to the solid wastes deposited on the beach zone and adjacent sea, other important sources of the metals detected in the seaweeds include natural inputs from the mineralized areas (dry stream freshwater discharges after episodic heavy rains and wind transport) and possibly the discharge of municipal waste waters from the town and seafood reprocessing plant. In particular, the Cu concentrations in the seaweeds varied in the range of 25 mg/kg - 650 mg/kg for *C. tuberculata*, 30 mg/kg - 630 mg/kg for *D. dichotoma*, 16 mg/kg - 400 mg/kg for *P. durvilleae, and* 10 mg/kg - 110 mg/kg for *S. sinicola*, while the concentration of Pb oscillated between much lower values: 0.4 mg/kg - 1.0 mg/kg for *C. tuberculata*, 0.2 mg/kg - 0.9 mg/kg for *D. dichotoma*, 0.4 mg/kg - 1.0 mg/kg for *P. durvilleae* and 0.05 mg/kg - 0.7 mg/kg for *S. sinicola*.

Our findings indicate that the seaweed species *Colpomenia tuberculata*, *Dictyota dichotoma and Ulva lactuca* could be recommended for use in the permanent monitoring of the anthropogenic contamination of the impacted zone by heavy metals, such as Cu, Zn and Co.

PICES XIII GP-2024 Poster
The bubble injection effects on the concentrations of CFCs, N_2 and Ar in the Pacific

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We examined a time series of CFCs (F-11 and F-12) concentrations in the North Pacific high latitude area (Funka bay, Hokkaido, 42˚N 142˚W) during the wintertime (Dec. 2001 – Mar. 2002). We found that CFCs were undersaturated (98% for F-12, 90% for F-11) in the wintertime, indicating that heat flux between air and sea was higher than CFCs flux at this time. If the air-sea gas exchange process follows the thick film model (Liss and Slater 1974), we cannot explain the large difference in saturations between F11 and F12 because F-11 and F-12 have similar values of the Schmidt number. Based on the air-sea gas exchange study ($k_{F\text{-}12}/k_{F\text{-}11}=(Sc_{F\text{-}12}/Sc_{F\text{-}11})^{-0.5}$, Nightingale et al., 2000) and the atmospheric concentrations of CFCs, we calculated the extent of bubble injection flux of CFCs (B) to total gas flux of CFCs (T). $B_{F\text{-}11}$ and $B_{F\text{-}12}$ were 16.4 ± 2.0 and 32.4 ± 4.3 pmol/m^2/month from air to sea, $T_{F\text{-}11}$ and $T_{F\text{-}12}$ were 64.4 ± 8.4 and 37.4 ± 4.2 pmol/m^2/month from air to sea. We also found that $B_{F\text{-}12}/T_{F\text{-}12}$ (86.6%) was higher than $B_{F\text{-}11}/T_{F\text{-}11}$ (25.5%). Therefore, it is possible that B is largely determined by weather conditions, and it enters the ocean interior when the water masses are formed during the wintertime. We will demonstrate the distribution of B for N_2, Ar and CFCs in the North and South Pacific Ocean interior and will discuss these results.

PICES XIII GP-1990 Poster
Features of the interannual variability in elaboration of the season processes and their possible influence on fishing capacity

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The problem of the influence of climate changes on ecosystem conditions and fish capacity is taking greater importance in recent decades.

We analyzed satellite weekly sea surface temperature maps for 1994 – 2004 years. The dominant interannual and regional differences between parts of the world ocean were described. In particular, during the most recent decade we can see faster and earlier beginning of the cold season in the North West Pacific, while the duration of this period

has increased. But in the Norwegian Sea we see a different situation. The duration and termination of the cold season has a great influence on the spring bioproductivity processes and, as a result, on the fishing capacity. We also compared our results with the hydrochemical conditions of the North West Pacific.

PICES XIII GP-1771 Poster
Marine environment pollution around the marine protected area in Peter the Great Bay

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The marine protected area, Far Eastern State Marine Reserve (FESMR), is located in the southwestern part of Peter the Great Bay (Sea of Japan). The FESMR was established in 1978 and was the first marine protected area in Russia (at that time, in the USSR). There are several threats to the state of the marine environment of the FESMR: First, poaching of sea cucumber, scallop and other species used in Chinese medicine and also utilized as a delicious seafood. Second, pollutant discharges to the marine environment. Vladivostok, a major port and industrial center in the Russian Far East, is situated approximately 100 km to the NE from the FESMR. The annual volume of sewage discharged from Vladivostok to the sea is about 400 million cubic meters, with more than 80% of that amount untreated. During high floods and northerly winds, polluted water masses can be easily transported to the FESMR. The mouth of the Tumen river (the border river between the Russia and Democratic People's Republic of Korea (DPRK) downstream and between China and DPRK upstream) is only 17 km from the FESMR to the southwest. Annual discharge of some trace metals and pesticides via the Tumen river are as follows (tons): Fe – 59925, Mn – 2982, Cu - 128, DDT – 0.9. The distribution of different pollutants in bottom sediments in and around the Far East State Marine Reserve has been studied by FERHRI specialists during the last decades in collaboration with researchers from the Institute of Marine Biology, Far East Branch of the Russian Academy of Sciences. Elevated contents of DDT and its metabolites (DDD and DDE) as well as hexachlorocyclohexane (HCH) isomers were found in bottom sediments near the FESMR. While concentrations of DDTs (up to 9.7 ng/g) were comparable with other areas of Peter the Great Bay, contents of HCHs (up to 6.2 ng/g) were higher than elsewhere.

PICES XIII GP-1892 Poster
Features of ichthyofauna species composition at the Emperor and Hawaiian seamounts

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Ichthyofauna of the Emperor and Hawaiian Seamounts are comprised of representatives from the North Pacific and Indo-West Pacific biogeographical zones. Distribution ranges of some species are restricted by seamounts within large-scale ocean gyres. Globally distributed and endemic species are also found upon some seamounts.

The northern part of the Emperor Seamounts (northward of 44°N) is within the subarctic circulation zone. Fish populating this area (30-45 species) are typical of continental slopes of the Northern Pacific. Subtropical species are practically absent here.

The central part (between 43-39°N) is located in the subarctic front. There are some subarctic, boreal (4 species of grenadiers, *Antimora microlepis*, *Alepocephalidae* spp.*)*, subtropical and tropical *(B. splendens, Allocyttus verrucosus)* species. Up to 70-80 species reside here.

The Southern Emperor and Northern Hawaiian Seamounts represent the eastern boundary of the distribution of talassobatyal Indo-West Pacific ichthyofauna in North Pacific. The faunistic barrier passes between 38-39°N. Exchange of fauna between the north-central (boreals species) and southern (benthic and meso- and bathypelagic representatives of subtropic faunas) seamounts is minimal. Approximately 23% of common species from the southern part are found in ichthyofauna of the northern and central parts (Kodolov, Kulikov, 1980; Novikov,

Kodolov, Gavrilov, 1981). Similarity between these fauna is only 0.19 (according to Preston); these fauna are nearly isolated.

Twenty five to 60 species of fishes are found in the deep sea area above the southern part of these seamounts, and more than a 100 species inhabit shallow-water seamounts. These seamounts are inhabited predominantly by mesobenthic subtropical (*Pseudopentaceros wheeleri*) and tropical (*B. splendens*) species.

PICES XIII GP-2089 Poster
Interactions between bottom long-line fishery and seabirds in the western Bering Sea and Pacific waters of Kamchatka

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A bottom long-line fishery has been conducted in the region since the early 1990s. Now, up to 15 catcher-processor vessels, equipped with an autoline system, operate year round, targeting Pacific cod (70% of the total catch), as well as halibut, rockfishes and other groundfish. In 2001-2003 the total mean annual catch was about 26,000 tons using 80 million hooks deployed annually. The long-line fishery causes incidental mortality of seabirds when birds swallow baited hooks and drown. In 2003, total estimated mortality in the region was 9,883 birds. Most of the seabirds taken were northern fulmars *Fulmarus glacialis* (65%), gulls *Larus* spp. (26%), and short-tailed shearwaters *Puffinus tenuirostris* (8%). One case of death of endangered short-tailed albatross *Phoebastria albatrus* was recorded. Also, seabirds may reduce gear efficiency. Estimated total economic loss in the long-line fleet from bait loss caused by seabirds and associated reduced fish catch may reach $0.5 million per year. Attributes (*i.e.*, abundance, attack rate, distances from the vessel stern, which birds attack baits, etc.) of seabirds feeding on bait are compared between the western Bering Sea and the eastern Bering Sea and Gulf of Alaska. Paired streamer lines, the seabird avoidance gear using in Alaskan waters, may be useful to reduce both seabird bycatch and economic losses in the region. We plan to test this mitigation measure in the Kamchatka region.

PICES XIII GP-1794 Poster
Climatic variability of water circulation under different pressure systems in NW Pacific

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Using a diagnostic hydrodynamic model to estimate water circulation we calculated transports, from the surface to 200 m depth and from the surface to the bottom for the NW Pacific, taking into account the influence of various types of the atmospheric circulation: the "north-western", "okhotsk-aleutian" and "cyclones over the ocean". The study area is confined to 20°– 50°N, 146°– 180°E. This model allows us to consider the atmospheric influence, spatial distribution of the water density, variable coefficients of the vertical and horizontal turbulent exchange, β-effect, bottom topography and the coastal outline.

The general picture of the calculated transports, from the surface to 200 m and from the surface to the bottom is on the whole preserved. But, the influence of the atmospheric circulation dominates near the surface of the ocean, and the influence of the homogeneous layer dominates to 200 m, and the influence of bathymetry geomorphology dominates the deeper transports.

In summary, hydrodynamic structures depending on the atmospheric circulation types have their peculiarities in the spatial-temporal distribution.

PICES XIII GP-1841 Poster

Horizontal distribution of larvae of the euphausiid, *Thysanoessa longipes*, around the subarctic gyre in the Japan Sea

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Distribution of larvae of the euphausiid, *Thysanoessa longipes*, around the northern part of the Japan Sea in early summer was investigated to evaluate the influence of the passive transport of zooplankton in the subarctic gyre. *Thysanoessa longipes*, which is one of the most dominant zooplankton species in the northern part of the Japan Sea, was collected with NORPAC nets (0.33-mm mesh) or bongo nets (0.5-mm mesh) in June-July 2003 from 38˚10' N to 45˚40' N along the longitude of 138˚E. Specimens were separated into eggs, larvae (calyptopis I-III and furcilia), juveniles and adults (males and females). Juveniles and adults were observed at all stations. However, larvae were observed in only two areas: around subarctic front (approximately 40˚N) and north of 43˚N. During early summer larvae of *T. longipes* are generally found north of 43˚N along 138˚E, the northwestern part of the Japan Sea. The spawning period of *T. longipes* matches the spring bloom. Hence, these results indicate that the strong eastward current established by subarctic front carries larval *T. longipes* to the eastern area where the spring bloom has already finished. This transport plays an important role in the diversity of growth of *T. longipes* in the northeastern part of the Japan Sea.

PICES XIII GP-2153 Poster

Mapping the distribution of structure-forming invertebrates off the U.S. west coast

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The increasing use of advanced survey technologies such as underwater camera sleds, submersibles, and ROVs, and several recent international symposia have drawn attention to structure-forming benthic invertebrates – especially cold-water corals. Although scientists are just beginning to understand the life cycles of these organisms, it is known that many species are long-lived and slow to recover from catastrophic disturbance. Cold-water corals (*e.g.*, Orders Scleractinia, Antipatharia, Gorgonacea) and other structure-forming invertebrates (*e.g.*, sponges) likely play important ecological roles in continental shelf and slope ecosystems and are indicators of long-term environmental conditions. Despite growing interest from researchers, conservation organizations, and policymakers, a debate continues as to whether or not these organisms provide a structural component to essential fish habitat. To date, there exist no regional surveys of structure-forming invertebrates off the U.S. west coast. However, an extensive database of observations on benthic invertebrates was compiled from ongoing regional bottom trawl surveys conducted by NOAA Fisheries over the past three decades. Although bottom trawls are not designed to target epibenthic invertebrates, over 9,000 catch samples of corals, sponges, and anemones have been recorded. Our objectives for this study are to map the distribution of structure-forming invertebrates off the U.S. west coast and use analytical results to assist in the design of comprehensive in situ surveys to investigate potential fish-invertebrate associations. Using multivariate statistics, we hope to identify correlations between the distribution of these invertebrates and various environmental variables (*e.g.*, latitude, depth, temperature, lithology).

PICES XIII GP-2119 Poster

Vertical distribution of *Todarodes pacificus* (Cephalopoda: Ommastrephidae) paralarvae near the Oki Islands, southwestern Sea of Japan

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Patterns of diel vertical distribution of Japanese common squid, *Todarodes pacificus*, paralarvae were examined using a MOCNESS in the southwest Sea of Japan near the Oki Islands, Japan, during five late-autumn surveys in 1998-2002. In total, 1511 *T. pacificus* paralarvae were collected at 63 of 68 stations. Most paralarvae were found in the thermocline in the upper 75 m. For all mantle sizes of paralarvae, weighted mean depth revealed no difference in vertical distribution between day and night. The hatchling-sized paralarvae were abundant above 25 m and mantle lengths increased with sampling depth. We concluded that *T. pacificus* paralarvae do not undergo diel vertical migration and that paralarvae gradually descend in the water column as they grow older.

PICES XIII GP-2087 Poster

Gracilaria cultivation practice and its ecological role in Chinese coastal waters

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Gracilaria is a very important industrial material for making agar-agar, as well as good feed stock for growing marine animals. It is also a good ecomaterial for reducing eutrophication of coastal waters. Gracilaria seaweed cultivation has developed along the Chinese coast since the 1950s. Main cultivation species are *G. lemaneiformis* and *G. tenuistipitata* var. *liui* Zhang et Xia. Up to now, more than 30 *Gracilaria* species have been recorded in China. Nutrient loading is a widespread phenomenon in Chinese coastal waters. Cultivation of *Gracilaria* has very high rates of productivity, and it grows well in waters with high nutrient concentrations. This seaweed has been found to be very useful with respect to decreasing N and P nutrient loading, as well as in studying photosynthesis, controlling red tides and maintaining health integrated mariculture systems. The authors believe that large-scale cultivation of *Gracilaria* is one of the more effective ecological strategies in maintaining safe water quality conditions and a healthy ecosystem in the coastal environment.

W1 MIE-AP Workshop and Advisory Panel Meeting Micronekton sampling gear inter-calibration experiment

Workshop Convenors: Michael P. Seki (U.S.A.) and Evgeny Pakhomov (Canada)

The PICES Advisory Panel on *Micronekton inter-calibration experiment* (MIE-AP) was established to evaluate the efficacy of a variety of sampling gears and the procedures employed by different investigators to sample micronekton in the North Pacific and other parts of the world ocean. An initial field effort will involve a 10-day (October 4-13, 2004) research cruise in Hawaiian waters just prior to the PICES Thirteenth Annual Meeting in Honolulu. The Hawaii cruise will serve two purposes: (1) to compare the performance of different types of sampling gears in an oligotrophic subtropical gyre to see how the choice of gear affects our perspective of the micronekton community; and (2) to use the relatively benign sea conditions of the subtropics to evaluate and refine protocols, logistics, and sampling designs. The morning workshop will review preliminary data and findings from the cruise, while the afternoon meeting of the MIE-Advisory Panel will discuss the goals, objectives, and status of the experiment and the future field program

Thursday, October 14, 2004 8:30-12:00

W2 CCCC/REX Workshop
The seasonal cycle of plankton production in continental shelf waters around the Pacific Rim

Workshop Convenors: Kaoru Nakata (Japan) and William T. Peterson (U.S.A.)

The REX Task Team has the responsibility for developing inter-comparisons among regional coastal marine ecosystems. Given that the long-term goal of the PICES CCCC Program is the application of models to understanding the influence of climate variability on plankton and fish production in the North Pacific, near-term goals are: (a) to learn more about the influence of climate variability on plankton production cycles, and (b) to determine if we can model the seasonal cycle of plankton production with the NEMURO model at many sites around the Pacific Rim.

At this workshop, we hope to locate as many site-specific studies as possible, each with several years of observations for as many boxes in the NEMURO lower tropic level model as is possible in order to facilitate model verification studies that must be conducted in the future. Since NEMURO is an NPZ model, successful model<>data comparisons will require data sets on temporal changes in light, nutrients, phytoplankton and zooplankton over (ideally) several seasonal cycles. Although the long-term objective of the workshop is to facilitate model-comparisons at many sites around the Pacific Rim (including the Bering Sea), the proximate goal is to discuss linkages and time lags between primary and secondary production cycles; and where possible, the potential match-mismatch between phytoplankton and zooplankton biomass cycles and the spawning and growth of important fish species. If long time series are available, we ask "How do interannual and decadal scales differences in the timing of the spring bloom and other blooms affect zooplankton production and fish spawning?" The possibility of publishing the results in the *Journal of Oceanography* will be explored.

Thursday, October 14, 2004 9:00-17:00

09:00-09:10 **Introduction by Convenors**

09:10-09:45 **Yasuhiro Yamanaka, Naoki Yoshie, Taketo Hoshioka and Michio J. Kishi** (Invited)
Extension of NEMURO to represent habitant segregation of plankton groups in the western North Pacific (W2-1886)

09:45-10:10 **Hiromi Kasai and Tsuneo Ono**
Variability in timing and magnitude of the spring bloom in the Oyashio water: An analysis from the "A-line" oceanographic database (1990-2003) (W2-2016)

10:10-1030 **Coffee break**

10:30-10:55 **Atsushi Yamaguchi, Tsutomu Ikeda, Toru Kobari, Gadi Padmavati, Satoko Shoden, Sei-ichi Saitoh and Kenshi Kuma**
Year-to-year variations in developmental timing of large grazing copepods at Site H in the Oyashio region (W2-1866)

10:55-11:20 **Kaoru Nakata, Kiyotaka Hidaka, Yutaka Hiroe, Akihiro Shiomoto, Tomoo Watanabe, Kosei Komatsu, Kiyo Kurita and Hiroshi Kiyosawa**
Seasonality in the community structure of planktonic ecosystem in the epipelagic layers of the subtropical water off Kuroshio (W2-2100)

11:20-11:45 **Toru Kobari**
Seasonal changes in plankton biomass, production and community structure in southern Japan (W2-1816)

11:45-12:10 **Hyun-Cheol Kim, Sinjae Yoo and Im Sang Oh**
Relation between phytoplankton blooming and wind stress in the central Japan/East Sea (W2-1887)

12:10-13:30 **Lunch**

13:30-14:05 **Young Shil Kang** (Invited)
Variability in seasonal cycles of zooplankton in the seas surrounding the Korean peninsula (W2-2126)

14:05-14:30 **Christine L. Abraham, Shaye G. Wolf, J. Mark Hipfner and William J. Sydeman**
The seasonal cycle of euphausiid zooplankton in the California Current system: A predator's perspective (W2-2074)

14:30-14:55 **William Peterson, Rian Hooff, Leah Feinberg and Tracy Shaw**
Seasonal cycle of nutrients, phytoplankton and zooplankton in the coastal upwelling zone off Oregon, U.S.A. (W2-2082)

14:55-15:15 **Coffee break**

15:15-15:40 **Thomas C. Wainwright, Rian C. Hooff and William T. Peterson**
Seasonal dynamics of plankton in the northern California Current ecosystem: A model-data comparison (W2-2045)

15:40-17:00 **Discussion of future directions**

Posters

Hui Liu, Laura M. Slater, Cheryl Clarke and Russell R. Hopcroft
Growth rates, fecundity and development times of *Neocalanus flemingeri* in the Gulf of Alaska: A synthesis of laboratory and field approaches (W2-1932)

Alexei I. Pinchuk and Russell R. Hopcroft
Egg production and early development of *Thysanoessa inermis* and *Euphausia pacifica* (Crustacea: Euphausiacea) in the northern Gulf of Alaska (W2-1933)

Hyeon Gyeong Jeong, Ho Young Soh, Yang Ho Yoon and Hae-Lip Suh
Seasonal variation of the neustonic zooplankton community in the central region of the South Sea, Korea (W2-2057)

Yeongha Jung, Hyung-Ku Kang and Yong Joo Kang
In situ egg production rate of the planktonic copepod *Acartia steueri* in Ilkwang Bay, southeastern coast of Korea (W2-1954)

PICES XIII W2-2074 Oral

The seasonal cycle of euphausiid zooplankton in the California Current system: A predator's perspective

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The abundance of euphausiid crustaceans varies both spatially and temporally, and is likely influenced by both local and basin-scale ocean climate conditions. Although long-term data sets of annual abundance of euphausiids exist for the California Current System (*e.g.* CalCOFI), few studies have examined the seasonal trends in this ecosystem. Our objective is to compare and contrast the seasonal patterns of relative euphausiid abundance at several sites in the California Current System (CCS). To meet this objective we examined the diet composition of a planktivorous marine bird (*Ptychoramphus aleuticus*). Euphausiids comprise a substantial proportion of auklet diet in this region, and these data may provide a reasonable index to relative euphausiid abundance. Seasonal patterns of euphausiid utilization appeared to differ both annually and latitudinally. Generally, in the central CCS, adult *Euphausia pacifica* was consumed more frequently in the early spring, while adult *Thysanoessa spinifera* was taken more frequently in the early summer, with seasonal peaks occasionally evident for both species. However, there were years where conspicuous seasonal trends in use were absent. *Nyctiphanes simplex*, a subtropical species, was not typically observed in the central CCS, but was present in low numbers from 1993-1995, in the El Niño year of 1998, and in 2003. In the southern CCS, *N. simplex* was consistently the most abundant species, followed by *T. spinifera or Nemetoscelis difficilis*, and seasonal trends in use were variable. We are currently attempting to elucidate causal mechanisms that drive euphausiid abundance and use by marine birds at different latitudes and on multiple time scales.

PICES XIII W2-1933 Poster

Egg production and early development of *Thysanoessa inermis* and *Euphausia pacifica* (Crustacea: Euphausiacea) in the northern Gulf of Alaska

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Early life history patterns were studied in the dominant euphausiids *Thysanoessa inermis and Euphausia pacifica* from the northern Gulf of Alaska in 2001-2004. Gravid females of *T. inermis* were observed in April and May. Most of females started to release eggs within the first 2 days of incubation. The average number of released eggs per female was similar in Day 1 and 2, but significantly smaller on Day 3 and 4. About 25% of females were continuously releasing eggs over 3 days rather than producing a single distinctive brood. In contrast, gravid females of *E. pacifica* were observed from early July through October. Most of females released eggs on the first day of observation and only 2 females produced eggs repeatedly. Average brood size appeared to increase with female size. Hatching and early development (from egg to furcilia stage) was studied at 5, 8 and 12°C. Hatching was nearly synchronous, occurring over only a few hours depending on incubation temperature. Development times from egg to the first furcilia stage ranged between 20 days and 33 days for *T. inermis* and 15 days and 45 days for *E. pacifica* at 12 and 5°C respectively.

PICES XIII W2-1932 Poster

Growth rates, fecundity and development times of *Neocalanus flemingeri* in the Gulf of Alaska: A synthesis of laboratory and field approaches

Hui Liu, Laura M. Slater, Cheryl Clarke and Russell R. **Hopcroft**

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Neocalanus flemingeri is one of the dominant copepods in the subarctic Pacific, yet there are few estimates of the rates at which many processes occur during its life-cycle. Growth and development of *N. flemingeri* CI to CIV copepodites were determined in the field by both the artificial cohort method, and the incubation of single stages, each March, April and May over 3 years at ~5°C. Development, growth, and egg production were also determined at 5°C in the laboratory at saturating food concentrations. In the field, CI to CIV stage durations ranged from 7 to more than 100 days, dependent on chlorophyll concentration, with the duration of each stage~10 days under optimal conditions. Stage durations varied from 5-24 days for NI to NVI, and 6-15 days for CI to CIV in the laboratory, with development time from egg to CV of 117 days. Weight-specific growth rates ranged from 0.23 $d^{-1}$to close to zero in the field, but was typically between 0.20 and 0.08 d^{-1} under more optimal conditions. This compares favorably to 0.07 to 0.27 d^{-1} obtained in the laboratory. In both cases, growth rate typically decreased with increasing stage. Fecundity of *N. flemingeri* was 534 ± 43 (mean ± S.E.) eggs $female^{-1}$-, representing close to 100% of the female's weight. Results are compared to rates of other copepod species determined concurrently in this ecosystem.

PICES XIII W2-2057 Poster

Seasonal variation of the neustonic zooplankton community in the central region of the South Sea, Korea

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In order to describe species composition and distribution patterns of the neustonic zooplankton, samples were collected using a David-Hempel neuston net during six field expeditions from April 2002 through January 2003 in the central region of the South Sea, Korea. Zooplankton abundance fluctuated greatly over a range of 51 ind./m^3 in November to 965 ind./m^3 in April. Copepods made up ca. 80% of the total organisms during the study periods and the other important groups were invertebrate larvae, cladocerans, chaetognaths and fish eggs. The spatial differences of neustonic zooplankton in species composition showed that cladocerans, cirripede larvae and fish eggs were abundant in the coastal area while salps, appendicularians and oceanic copepods (*Eucalanus* spp., *Euchaeta* sp.) were dominant in the offshore waters. This suggests that the distribution pattern of the neustonic zooplankton are seasonally affected by both neritic and oceanic waters as well as hydrological conditions.

Microstratification in surface water divided into two layers; upper layer (0-10 cm) and lower layer (10-25 cm). In generally, the population abundance was higher in the upper layer than in the lower layer. In particular, abundance of oceanic species such as pontellid copepods, siphonophorids, medusae and salps increase with high temperature periods in the upper layer. It seems that in spite of its rapid environmental fluctuation the upper layer may provide good habitats to some organisms.

PICES XIII W2-1954 Poster

In situ egg production rate of the planktonic copepod *Acartia steueri* in Ilkwang Bay, southeastern coast of Korea

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Egg production rate (EPR) of the planktonic copepod *Acartia steueri* was investigated in *in situ* incubations from October 1997 to September 1998 in Ilkwang Bay, southeastern coast of Korea. Water temperature ranged from 11.5 to 25.6°C, and chlorophyll *a* concentration was 0.99~11.63 mg m^{-3} with peaks in late February, early April and May-June. *A. steueri* occurred in the plankton throughout the year, except September and October, with the highest peak in March. The EPR ranged from 3.8 to 10.1 eggs $female^{-1}$ d^{-1} (mean: 7.3 eggs $female^{-1}$ d^{-1}), and the rate was the lowest in December and then increased gradually until June. Seasonal variation of population egg production rate (eggs m^{-3} d^{-1}) was similar to the abundance of *A. steueri* in this bay, showing the highest peak in March. Relationship between EPR and chlorophyll *a* concentration was highly significant and ~85% of EPR was explained by the variation of the chlorophyll *a* concentration. However, only ~37% of EPR was related to the variation of water temperature. Weight-specific growth rate ranged from 0.022 to 0.071 d^{-1} (mean: 0.047 d^{-1}) and decreased with increasing body weight of the adult female. The mean EPR in terms of eggs per female per day of *A. steueri* measured by the incubation method was similar to the result from Kang and Kang (1998), in which EPR was estimated using the equation obtained in laboratory experiments relating temperature and chlorophyll *a* concentration to egg production.

PICES XIII W2-2126 Invited

Variability in seasonal cycles of zooplankton in the seas surrounding the Korean peninsula

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The seas surrounding the Korean peninsula were representative of the Yellow Sea (the west sea of Korea), the East-China Sea (the south sea of Korea) and the East/Japan Sea (the east sea of Korea). These seas have very different physical characteristics. Considering that zooplankton production probably responded to physical oceanographic conditions, it was hypothesized that the seasonal cycles of zooplankton will be different in response to hydrographic conditionis in the three different seas, and to climate regime shifts. The seasonal cycles of zooplankton biomass and four zooplankton assemblages, copepods, amphipods, euphausiids and chaetognaths, were analyzed with long-term data in the seas surrounding Korean peninsula with consideration seasonal cycles in each sea and regime shifts, using harmonic analysis. Seasonal cycles of zooplankton biomass and four zooplankton assemblages were also analyzed to investigate step changes in response to the regime shifts in the East/Japan Sea. Three periods before and after regime shifts were compared: 1st period (1966~76), 2nd period (1977~88) and 3rd (1989~2000).

Zooplankton biomass showed a typical seasonal cycle with two peaks in spring and autumn in the seas surrounding Korean peninsula. However, there are differences in seasonal cycles in each sea. In the Yellow Sea, zooplankton biomass and copepods showed a large peak in June and a small peak in October, while the other zooplankton assemblages did not show such a peak. Chaetognaths appeared abundantly in August after the copepod peak and amphipods and euphausiids showed a peak in August and June, respectively. In the East-China Sea, zooplankton showed a large peak in October and a small peak in April and June. Copepods had a similar seasonality with zooplankton biomass. Chaetognaths appeared abundantly during August~December and euphausiids were abundant in June. In contrast with the Yellow and East China Seas, the East/Japan Sea showed the highest zooplankton biomass in February and April. Copepods were also abundant in April, while the other zooplankton assemblages had different seasonal cycles.

As compared among three periods in the East/Japan Sea, zooplankton biomass showed a large peak in February and April in the 1st period, a small peak in October in the 2nd period, and peaks in April and October in the 3rd period.

Copepods were abundant in April and June in the 2nd period and April in the 3rd period, while amphipods showed a large peak in June in the 3rd period. Chaetognaths appeared abundantly in August in the 2nd period and October in the 3rd period. Euphausiids showed peaks in April and October in 3rd period, while a small peak in June in the 2nd period.

It is concluded that zooplankton biomass showed seasonal variations that responded to physical characteristics and regime shifts. The Yellow and East China Seas showed a similar seasonal variation in zooplankton biomass, while the East/Japan Sea was different.

PICES XIII W2-2016 Oral
Variability in timing and magnitude of the spring bloom in the Oyashio water: An analysis from the "A-line" oceanographic database (1990-2003)

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Hokkaido National Fisheries Research Institute (HNFRI) has an oceanographic survey line, which is called the "A-line". The "A-line" is located in the area off eastern Hokkaido and northern Honshu in the western subarctic Pacific, and crosses the Oyashio current perpendicularly. In order to examine the spatial and temporal variability in the oceanographic environment in the Oyashio water, the "A-line" observations have been carried out 4-8 times a year since 1990. Physical, chemical and biological measurements were made using standardized methods throughout the survey period. Quality-checked data was accumulated into the database (1990-2003), and HNFRI has openeds this database to scientists at their website (*http://www.mirc.jha.or.jp/HNF/a-line/index.html*). In order to analyze the long-term variability in the oceanographic environment in the Oyashio water, we extracted the data in the Oyashio water from the database, and examined the variability of the surface concentrations of chlorophyll *a* and nutrients, and the standing stocks of netplankton within the upper wind mixed layer. The mean concentration of chlorophyll *a* at the surface in March and April was higher after 1998 than that before 1997, suggesting early initiation and development of the spring blooming after 1998. These differences in the characteristics of spring blooming between before and after 1998 seem to be associated with some phenomenon after 1998, such as high consumption of nutrients during blooming, high standing stock of netplankton in April and May, and so on. In our presentation, results from further analyses are showed, and effects of the regime-shift in 1998 to the oceanographic environment related primary productivity in the Oyashio water are discussed.

PICES XIII W2-1887 Oral
Relation between phytoplankton blooming and wind stress in the central Japan/East Sea

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The seasonal dynamics of phytoplankton in the central Japan/East Sea showed pronounced year-to-year variability as observed from SeaWiFS (1997~now) and MODIS/Terra (2000~now). The variability seems to be strongly influenced by the wind, as the timing of spring blooms has a negative correlation with wind stress while the timing of fall blooms has a positive correlation with wind stress. To study this relationship, we hypothesize as follows: in spring, the bloom will start after the water column has stabilized, which requires weakening of the wind-induced vertical mixing. In the autumn, the bloom will start when wind-driven vertical mixing resumes with seasonal increases in wind stress. To test these hypotheses, we analyzed the daily remotely sensed wind stress data (AMI-wind, NSCAT and QuickSCAT: 1997~2003) and daily chlorophyll *a* concentration from the ocean color data. The results agreed well with the hypotheses. In spring, the phytoplankton bloom started 6~10 days after the wind weakened. In fall, blooming started 1~4 days after with winds strengthened, which mixes water and supplies nutrients to the euphotic layer. We try to explain the possible mechanism by a simple box-model.

PICES XIII W2-1816 Oral

Seasonal changes in plankton biomass, production and community structure in southern Japan

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It is known that carbon flow in marine ecosystem is associated with structure of plankton food web. Since available resources for animals at higher trophic levels decrease (increase) in complex (simple) food web, such information might be important for understanding the influence of climatic variability on marine ecosystem. There are some previous studies on plankton food web and dynamics in the productive waters such as equatorial and subarctic Pacific. However, we have little knowledge on plankton food web in the subtropical waters dominated by pico- to nanoplankton. Thus, seasonal changes in plankton biomass, production and community structure were investigated from pico- to mesoplankton samples collected monthly to bimonthly in southern Japan (30˚N, 131˚E) to show structure and carbon flow in the planktonic food web. In southern Japan, bacteria, autotrophic nano-flagellate (ANF) and copepods dominated plankton biomass throughout the year, although no seasonal pattern was observed for both phyto- and zooplankton biomass. ANF dominated daily phytoplankton production but showed no clear seasonal patterns. Bacteria and heterotrophic nano-flagellate (HNF) contributed to daily zooplankton production and increased during summer. Annual phytoplankton and zooplankton production was estimated to be 177.0 and 244.3 gC m^{-2} $year^{-1}$ (in 0-50 m strata), respectively. ANF (103.7 gC m^{-2} $year^{-1}$) and bacteria (135.8 gC m^{-2} $year^{-1}$) were major producers. These results suggest that the microbial food web is important in subtropical waters of southern Japan. However, community structure and planktonic food web dynamics in southern Japan might be associated with the coastal waters with low salinity in the East China Sea.

PICES XIII W2-2100 Oral

Seasonality in the community structure of planktonic ecosystem in the epipelagic layers of the subtropical water off Kuroshio

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We examined seasonal changes in community structure of planktonic ecosystem in the subtropical water off the Kuroshio based on the samples collected seasonally from May 2002 to January 2004 during the O-line monitoring by National Research Institute of Fisheries Science. In winter, when the vertical mixing reaches to deeper than 200 m, the annual highest biomass of phytoplankton occurred, though the primary production rate was lowest, which indicates the low feeding pressure on the primary producers in winter. Pico-sized eukaryotic phytoplankton which was mainly distributed in the lower euphotic layer during the stratified seasons was dominant in the phytoplankton community through the water column in winter. Biomass of the centric diatoms, the dominant phytoplankton groups in the spring bloom in the subarctic waters, was low in the all seasons. Biomass of members of microbial loop such as HNF and cilliates was highest in spring when annual highest primary production occurs, and lowest in autumn. Biomass of large copepods whose prosomal length is longer than 1mm was lowest in summer, and tended to increase from autumn to spring. On the other hand, seasonal pattern of biomass of small copepods, the major component of the copepod communities, was obscure. In the subtropical water, diversity of copepod communities are generally high as compared with subarctic waters, which may have contributed to the obscure seasonality in the biomass of small copepods.

PICES XIII W2-2082 Oral

Seasonal cycle of nutrients, phytoplankton and zooplankton in the coastal upwelling zone off Oregon, U.S.A.

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Measurement of the seasonal cycles of temperature, nutrients, phytoplankton and zooplankton is a fundamental activity within most long-term ecological observation programs. Examples include monitoring at ocean time series stations such as at P, KNOT, A-Line, HOTS and CalCOFI, and more coastally oriented time series studies carried out at various points around the Pacific Rim by institutions associated with the PICES nations. Multi-year sampling programs allow study of year-to-year variations in the timing of the initiation and magnitude of production cycles and of how climate variability may affect production cycles. We have been sampling the hydrography and nutrients at biweekly intervals for the past nine years at several stations across the continental shelf off Newport Oregon (44 40'N latitude). In this paper, we show climatologies of seasonal cycles of temperature, nutrients, chlorophyll and zooplankton biomass and species composition, and compare seasonal cycles among years and between stations using anomalies from the nine-year averages, for a mid-shelf station (9 km from shore) and an outershelf station (40 km from shore). We show that the mid-shelf station is dominated by copepods whereas the outershelf station is dominated by euphausiids giving rise to very different seasonal cycles of plankton biomass, production and grazing potential. Thus knowledge of the species composition of the zooplankton (rather than just total biomass) may be a necessary condition if one is to understand the dynamics of seasonal cycles. However for the purposes of developing NPZ models, it should be sufficient to know the biomass of functional groups: copepods, euphausiids, and others.

PICES XIII W2-2045 Oral

Seasonal dynamics of plankton in the northern California Current ecosystem: A model-data comparison

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Seasonal dynamics of nutrients and plankton in the northern California Current ecoystem were examined using a modification of the PICES NEMURO model. The NEMURO model was coupled to a one-dimensional cross-shelf mixed-layer hydrographic model, designed to provide a computationally simple representation of wind-driven upwelling and east-west transport in the mixed layer. Physical data (winds, temperature, solar radiation) driving the model were selected to closely match conditions along the Newport Hydrographic (NH) Line. Analyses were conducted for seven years (1997-2003) for which a time-series of observations (temperature, nutrients, chlorophyl, and zooplankton) are available. These years represent a wide range of climatic conditions, and span a possible regime change. Model predictions were compared with data, both at the scale of individual samples and as seasonal averages. The model provided a rough approximation to the temporal and cross-shelf patterns of nutrient and plankton abundance, but there is much room for improvement. Implications of results for production of small pelagic fishes are discussed.

PICES XIII W2-1866 Oral

Year-to-year variations in developmental timing of large grazing copepods at Site H in the Oyashio region

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To evaluate interannual variations in developmental timing of large grazing copepods (*Neocalanus cristatus*, *N. flemingeri*, *N. plumchrus*, *Eucalanus bungii* and *Metridia pacifica*) in the Oyashio region, time-series samplings were made at Site H (rectangle defined by 41˚30' to 42˚30'N and 145˚00' to 146˚00'E) during the periods of September 1996-October 1997 and May 2002-March 2004. Zooplankton samples were collected monthly or bimonthly by vertical hauls of a 60-cm ring closing net (1996-1997) or a NORPAC net (2002-2004) with 0.1 mm mesh openings from 500 m to the surface. The timing of recruitment of early copepodid stages was December-February for *N. cristatus*, March for *N. flemingeri*, and May-June for *N. plumchrus* and *E. bungii*, showing little year-to-year variations. As an exception, the recruitment of early copepodid stages of *M. pacifica* in 2003 and 2004 occurred 1-3 months earlier than that in 1997. The presence of interannual variations in the recruitment season in *M. pacifica* may be interpreted by the shorter generation length, no diapause phase, and close coupling of feeding and spawning of this species as compared with the other species mentioned above. The incidence of salp blooms in 2003 affected the recruitment of *N. plumchrus* and *E. bungii* but not recruitment of other copepods, suggesting possible food competition between young copepodid stages of the two species and salps. The relationship between year-to-year differences in zooplankton biomass and developmental timings of large copepods will also be discussed.

PICES XIII W2-1886 Invited

Extension of NEMURO to represent habitant segregation of plankton groups in the western North Pacific

Yasuhiro **Yamanaka**[1,2], Naoki Yoshie[1], Taketo Hoshioka[1] and Michio J. Kishi[2,3]

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Our group joined in developing the NEMURO lower tropic level model, applied it to two stations in the western subarctic region (Fujii *et al.*, 2002; Yoshie *et al.*, 2004; Kishi *et al.*, 2004; Yamanaka *et al.*, 2004; Yoshie and Yamanaka, 2004) and coupled it with a 3-D model (Aita *et al.*, 2003; Hashioka and Yamanaka, *to be submitted*; Aita *et al., to be submitted*). NEMURO originally focused on subarctic plankton groups, but we are now developing a model extended from NEMURO (eNEMURO) in order to apply the model to a subtropical planktonic ecosystem. Towards this end, we have introduced two additional phytoplankton groups, one zooplankton group and bacteria within the microbial loop. In eNEMURO, an introduced coastal species of diatom has a larger maximum photosynthesis rate and half-saturation constant for nitrate than those of the original species in NEMURO, and a pico-phytoplankton group that has a temperature dependency of photosynthesis without growth at temperature < 15^{o}C. These differences produce habitat segregation among phytoplankton groups, *i.e.*, differences in the two physiological parameters result in dominance of coastal and original species of diatom in the coastal and pelagic regions, respectively. Temperature dependency also leads to habitat segregation between nano- and pico-phytoplankton. The original NEMURO is regarded as having intermediate complexity. Introducing a greater number of compartments to the ecosystem model leads to further complexity, but each compartment needs to represent more than one specific plankton group. In order to represent different ecosystem between coastal and pelagic regions or between subarctic and subtropical regions, and correspondence between modeling and observation, we will need to discuss what level of complexity is best.

W3 CCCC Workshop
Linking open ocean and coastal ecosystems II

Workshop Convenors: Kerim Aydin (U.S.A.), Shin-ichi Ito (Japan), Jin-Yeong Kim (Korea), Gordon A. McFarlane (Canada), Akihiko Yatsu (Japan)

This workshop will continue ongoing international collaborative research efforts to explore specific food web modeling approaches to link climate with coastal and oceanic biological production. Specifically, climate events may propagate through trophic levels with variable effects at each level such that coherent patterns that exist may not be detectable across all regions without further modeling synthesis. To date, models of lower trophic levels (NEMURO), forage species (NEMURO.FISH) and upper trophic levels (ECOPATH/ECOSIM) have been constructed of multiple regions of the North Pacific to examine coastal and oceanic regions with a common set of modeling tools. The next step is to compare and to evaluate these and complementary methods (such as Individual Based Models) in a Pacific-wide synthesis. The workshop will consist of three components:

1. A critical evaluation of regional and basin-wide trophic models with a focus on the recent results of the BASS, MODEL and REX Task Teams. The development of complementary and comparable approaches to: (a) modeling connections between climate and ecosystems, lower and upper trophic levels, and coastal and oceanic regions; and (b) incorporating seasonal dynamics. Discussion shall include the identification of key data requirements for North Pacific scale production modeling and forecasts.
2. As a specific example, the examination of climate-driven processes underlying changes in the distribution (expansion and contraction) of Pacific sardines, especially with respect to transitions between coastal and oceanic (gyre) ecosystems. What are the future expectations of sardine productivity and distribution under various climate change scenarios?
3. Synthesis of PICES activities to date that are applicable to BASS/REX studies, particularly Pacific-wide climate influence on ecosystems and marine resource productivity. Identification of the major issues and gaps in knowledge relating to the understanding of changes in ecosystems under a changing environment. Recommend solutions, particularly identifying fieldwork required to fill in the gaps in knowledge and to improve predictive ability.

Day 1 Friday, October 15, 2004 9:00-12:00

Section I (Co-chairmen: Gordon A. McFarlane and Shin-ichi Ito)

09:00-09:15 **Opening remarks by Convenors and introduction**s

09:15-09:45 **BASS Task Team**
Results of upper trophic level ("whole ecosystem") modeling of the subarctic gyres

09:45-10:15 **MODEL Task Team**
Results of coupled lower trophic level-fish models (NEMURO-FISH)

10:15-10:35 **Coffee break**

10:35-11:05 **REX Task Team**
Overview of REX workshop on seasonal cycles of nutrients, phytoplankton and zooplankton and discussion of opportunities for model/data comparisons among coastal ecosystems around the Pacific Rim

11:05-12:00 **Discussion**
Synthetic approaches and the potential methods for integration of models or for the testing of specific hypothesis using current models (*e.g.*, links between long-term changes in mixed-layer depth and fish production)

12:00-13:30 **Lunch**

13:30-14:10 **Kosei Komatsu** (Invited)
Modeling of transportation of phyto- and zooplankton in the Kuroshio and Kuroshio Extension (W3-2012)

14:10-14:50 **Vera N. Agostini** (Invited)
Modeling the California Current ecosystem: Can the small inform the large? (W3-2004)

15:10-15:50 **Alec D. MacCall** (Invited)
Climate-driven fluctuations in fish stocks of the California Current (W3-2063)

15:50-17:00 **Discussion**
Incorporation of spatial and/or seasonal variation into current CCCC-developed box models (NPZ, bioenergetics, or food web), or on specific places in current modeled regions (*e.g.* the subarctic North Pacific) where spatial variation and linkages will be critical to interpreting results

Day 2 Saturday, October 16, 2004 9:00-17:00
Section II (Co-Chairmen: Akihiko Yatsu and Gordon A. McFarlane)

09:00-09:15 **Introduction by Gordon A. McFarlane**

09:15-09:45 **Jake Schweigert**
Recent distribution and ecology of sardines in the north-eastern Pacific Ocean (W3-2205)

09:45-10:15 **Akihiko Yatsu, Masayuki Noto, Minoru Ishida, Hiroshi Nishida and Maki Suda**
A review of the population dynamics of Japanese sardine in the Northwestern Pacific (W3-2182)

10:15-10:35 **Coffee break**

10:35-11:05 **Motomitsu Takahashi, Hiroshi Nishida and Akihiko Yatsu**
Preliminary study of growth of larval and early juvenile Japanese sardine in the Kuroshio-Oyashio transition region (W3-2183)

11:05-12:00 **Discussion**

12:00-13:30 **Lunch**

Section III (Co-Chairmen: Kerim Aydin and Jin-Yeong Kim)

13:30-17:00 **Discussion**
Each co-convener should present a short list from their Task Team or from the workshop on "possible future projects" hopefully arising out of the earlier portions of the workshop. Goal will be to collect possibilities into a plan for future synthesis through new Task Team, CFAME (Climate Forcing and Marine Ecosystem Response). Section includes writing of workshop recommendations

Posters

Shin-ichi Ito, Miciho J. Kishi, Akihiko Yatsu, Yoshioki Oozeki, Kosei Komatsu, Yasuhiro Yamanaka, Bernard A. Megrey and Francisco E. Werner
An application of NEMURO.FISH for multi-species modeling (W3-2121)

Jin Yeong Kim, Eun Seob Cho and Woo-Jin Kim
Population genetic characteristics of the Japanese anchovy, *Engraulis japonicus*, in Korean waters (W3-2033)

Yury I. Zuenko, Victoria V. Nadtochy and Marina S. Selina
NPZ monitoring in the coastal area of the Japan Sea (W3-1845)

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

Vera N. **Agostini**

School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, 98195, U.S.A. E-mail: vagostin@u.washington.edu

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

Shin-ichi **Ito**[1], Miciho J. Kishi[2,7], Akihiko Yatsu[3], Yoshioki Oozeki[3], Kosei Komatsu[3], Yasuhiro Yamanaka[4,7], Bernard A. Megrey[5] and Francisco E. Werner[6]

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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

Jin Yeong **Kim**[1], Eun Seob Cho[1] and Woo-Jin Kim[2]

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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

Kosei **Komatsu**

National Research Institute of Fisheries Science, Fisheries Research Agency of Japan, 2-12-4, Fukuura, Kanazawa-ku, Yokohama, 236-8648, Japan. E-mail: kosei@affrc.go.jp

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

Alec D. **MacCall**

National Marine Fisheries Service, 110 Shaffer Road, Santa Cruz, CA, 95060, U.S.A. Email: Alec.MacCall@noaa.gov

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

Jake **Schweigert**

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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

Motomitsu **Takahashi**, Hiroshi Nishida and Akihiko Yatsu

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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

Akihiko **Yatsu**, Masayuki Noto, Minoru Ishida, Hiroshi Nishida and Maki Suda

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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

Yury I. **Zuenko**[1], Victoria V. Nadtochy[1] and Marina S. Selina[2]

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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.

W4 PICES/CLIVAR Workshop
Scale interactions of climate and marine ecosystems

Workshop Convenors: Richard Beamish (Canada/PICES), Kuh Kim (Korea/PICES) and Kelvin Richards (U.S.A./CLIVAR)

The physical climate system varies on a wide range of scales: changing storminess and severe weather, recognised modes of variability (such as NAO, PDO and ENSO), and changes to mean global characteristics. Likewise the marine ecosystem has many interacting scales: small-scale patchiness *vs* global, shelf *vs* deep-sea populations, and individuals *vs* communities. To date, most studies considering the impact of the complexities of climate variability on the equally complex marine ecosystem have used correlation statistics of a given population and physical climate indices. We need to go beyond simple correlations to tease out the relationships between the changing physical and biological systems if we are to understand what controls what. How do the various scales of climate variability project onto the variability of the population of a given species or the ecosystem as a whole? How does the changing climate impact on the scale interactions of the biogeochemical system? Are the time-series we have long enough to draw meaningful conclusions? What do we need to get right in models used to predict the impact of climate change on the marine ecosystem and fisheries?

The workshop will bring together experts in the physical oceanography of the Pacific, climate dynamics and variability, marine ecosystems and biogeochemistry, and fisheries. The workshop will be charged to produce statements on our present understanding or lack thereof, on the impact of climate variability on the marine eco- and biogeochemical system, on what we can hope to extract from combining extant datasets, and on strategies for numerical experimentation, observational networks and data assimilation that will improve our knowledge and predictive capabilities. Sufficient enthusiasm by the participants will result in the publication of a special issue of a leading international journal.

Day 1 Saturday, October 23, 2004 8:30-17:30

08:30-08:45 **Introduction by Workshop Convenors**

08:45-09:30 **Jacquelynne R. King and Gordon A. McFarlane** (Invited)
Implications of climate regime shifts on the management of marine resources (W4-2167)

09:30-10:15 **Shoshiro Minobe** (Invited)
Global linkages of decadal variability over the North Pacific Ocean (W4-2155)

10:15-10:45 **Coffee break**

10:45-11:30 **Elizabeth A. Logerwell and Anne B. Hollowed** (Invited)
The impact of environmental variability on the effectiveness of fisheries management strategies (W4-1992)

11:30-12:15 **Arthur J. Miller** (Invited)
Regional impacts of large-scale climate variations on the Pacific Ocean ecosystem (W4-2187)

12:15-13:30 **Lunch**

13:30-13:45 **Vladimir I. Radchenko**
Coincidence of pink salmon catch trends among the odd-years and even-years populations: Regional and basin scale views (W4-2154)

13:45-14:00 **Eleuterio Yáñez, Claudio Silva and María Angela Barbieri**
Low frequency environmental fluctuations and main Chilean pelagic fisheries (W4-1867)

14:00-14:15 **Franz J. Mueter and Bernard A. Megrey**
Spatial scales and magnitudes of covariation among fish populations in the Northeast Pacific (W4-2067)

14:15-14:30 **Paul D. Spencer and Tom W. Wilderbuer**
Relationships between environmental variability and eastern Bering Sea flatfish population distributions (W4-1996)

14:30-14:45 **Troy W. Buckley and Stanislaw Kotwicki**
Consideration of spatial scale when assessing the influence of environmental variability on walleye pollock in the eastern Bering Sea (W4-2099)

14:45-15:00 **Peter W. Lawson**
Climate impacts on OPI coho salmon, *Oncorhynchus kisutch*, production: Insights from a species sensitive to habitat change at daily to centennial time scales (W4-2111)

15:00-15:15 **S. Lyn McNutt, Two Crow (AKA, Jim Schumacher) and Phil Mundy**
Integrated adaptive management applied to the Gulf Ecosystem Monitoring and Research (GEM) Program (W4-1811)

15:15-15:30 **Coffee break**

15:30-16:15 **Nathan J. Mantua** (Invited)
To upscale or downscale? Thoughts on bridging disparate scales of space and time in linking the planetary to the plankton (W4-2048)

16:15-17:30 **Discussion**

Day 2 Sunday, October 24, 2004 08:30-17:30

08:30-09:15 **Sinjae Yoo, Hyun-Cheol Kim and Stewart M. McKinnell** (Invited)
Variability of Chl-a in the North Pacific marine ecosystems (W4-2156)

09:15-10:00 **Sei-ichi Saitoh and Takahiro Iida** (Invited)
Temporal and spatial variability of phytoplankton biomass and productivity in the Bering Sea in relation to climate variability (W4-1997)

10:00-10:30 **Coffee break**

10:30-11:15 **Cara Wilson, Steven J. Bograd and Franklin B. Schwing** (Invited)
Temporal variability of sea surface chlorophyll and biophysical coupling in the Pacific (W4-2141)

11:15-12:00 **Yi Chao and Fei Chai** (Invited)
The impact of Pacific climate forcing on marine ecosystem (W4-2110)

12:00-12:15 **Ichiro Yasuda and Hiroaki Tatebe**
Tide-induced North Pacific Intermediate Water circulation and impact on climate (W4-2026)

12:15-12:30 **Vladimir I. Ponomarev, Aleksandr S. Salomatin, Dmitry D. Kaplunenko and Natalya I. Rudykh**
Relationship of different scales of climate variability in the Asian Pacific (W4-1964)

12:30-13:30 **Lunch**

13:30-14:15 **Richard A. Feely, C. L. Sabine, R. Wanninkhof, A. Murata, R. Key, C. Winn, M. F. Lamb and D. Greeley** (Invited)
CLIVAR/CO_2 Repeat Hydrography Program in the North Pacific Ocean (W4-1984)

14:15-15:00 **Raghu Murtugudde** (Invited)
Tropical and extratropical modes of ecosystem variability (W4-1925)

15:00-15:30 **Coffee break**

15:30-17:30 **Structured discussion, summary, recommendations**

Posters

C. Franco-Gordo, E. Godinez-Dominguez and J. Freire
Interannual variability of the diversity and ichthyoplankton community in the central Pacific off Mexico (W4-1851)

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

Troy W. **Buckley** and Stanislaw Kotwicki

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

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

Yi **Chao**[1] and Fei Chai[2]

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

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

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

Richard A. **Feely**[1], C. L. Sabine[1], R. Wanninkhof[2], A. Murata[3], R. Key[4], C. Winn[5], M. F. Lamb[1] and D. Greeley[1]

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

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

C. **Franco-Gordo**[1,2], E. Godínez-Domínguez[1,2] and J. Freire[2]

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

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

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

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

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

PICES XIII W4-1992 Invited

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

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

PICES XIII W4-2048 Invited

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

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

PICES XIII W4-1811 Oral

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

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

PICES XIII W4-2187 Invited

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

W5-HAB MEQ Workshop and HAB Meeting Developing a North Pacific HAB data resource - II

Co-sponsored by Intergovernmental Oceanographic Commission (IOC)

Workshop Convenors: Henrik Enevoldsen (Denmark/IOC), Hak-Gyoon Kim (Korea/PICES) and Vera Trainer (U.S.A./PICES)

Harmful Algal Blooms (HABs) are comprised of rapidly growing toxic and non-toxic species, and affect the marine ecology and economy of coastal nations. Monitoring and research activities aimed towards achieving effective predictive and mitigative strategies are underway in each PICES member nation, in many cases dealing with similar organisms or problems. These efforts will benefit from building a common data resource among PICES nations that allow inter-comparison of HAB species composition and the magnitude of environmental and economic impacts. At last year's joint PICES/IOC Workshop on "Harmful algal blooms – Harmonization of data", representatives from PICES member countries accepted an offer from IOC/ICES to utilize their successful harmful algal event meta-database (HAE-DAT) format on a trial basis. The goal of this workshop is to provide an interim "report card" on the use of this database. The central tasks are: (i) to ascertain how well the database process worked; (ii) to identify any difficulties in data delivery from member nations; (iii) to assess the effectiveness of the interactive web-based window to the developing resource; and (iv) to determine if further modifications are needed to encompass unique aspects of Pacific Rim marine resources.

W5 (MEQ) Workshop
Friday, October 15, 2004 9:00-17:30

09:00-09:30 **Henrik Enevoldsen and Monica Lion**
The joint IOC-ICES-PICES Harmful Algal Event Data-base, HAE-DAT (W5-2179)

09:30-10:00 **Nicolaus G. Adams, Diedre Crawford, William P. Cochlan and Vera L. Trainer**
Use of the ICES harmful algal event meta-database to archive data from the west coast of the United States (W5-2159)

10:00-10:30 **Coffee break**

10:30-11:00 **Mingyuan Zhu, Ruixiang Li and Zongling Wang**
HAB data in China (W5-2197)

11:00-11:30 **Hak Gyoon Kim, Young Shil Kang, Chang Kyu Lee, Gui Young Kim, Wol Ae Lim, Sook Yang Kim, Young Tae Park, Soo Jung Chang and Hee Dong Jeong**
Use of Korean HAB data for the joint ICES/PICES HAE-DAT database (W5-2193)

11:30-12:00 **Ichiro Imai, Shigeru Itakura, Yasunori Watanabe, Akira Ishikawa and Yasuwo Fukuyo**
HAB data in Japan and a trial for joining PICES database (W5-2192)

12:00-13:30 **Lunch**

13:30-14:00 **Tatiana Yu. Orlova**
Entry of HAB data from the east coast of Russia into the ICES/PICES HAE-DAT database format (W5-2194)

14:00-14:30 **Angelica Peña and Melanie Quenneville**
Testing the ICES harmful algal event meta-database to archive data from the west coast of Canada (W5-2195)

14:30-15:00 **Discussion of usefulness and possible modifications to HAE-DAT for PICES member countries**

1. How will HAE-DAT be used in the future by PICES?
2. Who will enter data?
3. Will any historical data be entered?

15:00-15:20 **Coffee break**

15:20-16:00 **Nicolaus Addams**
SURFER demonstration

16:00-16:30 **Robin Brown**
TCODE integration with HAB database efforts

16:30-17:00 **Jeanne S. Allen**
Data integration issues within the Gulf of Mexico (W5-2086)

17:00-17:30 **Summary and wrap up**

HAB Meeting
Saturday, October 16, 2004 8:30-17:00

08:30-09:00 **Hak Gyoon Kim and Vera Trainer**
Welcome by Co-Chairmen and introduction of HAB Section

08:50-09:20 **Mingyuan Zhu, Ruixiang Li and Zongling Wang**
The occurrences of HAB in Chinese coastal waters in recent three years (HAB-1825)

09:20-09:50 **Ichiro Imai, Tomotaka Shiraishi, Kiyohito Nagai, Shingo Hiroishi, Shigeru Itakura, Yasunori Watanabe, Akira Ishikawa and Yasuwo Fukuyo**
Monitoring of the shellfish-killing dinoflagellate *Heterocapsa circularisquama* in Japanese coastal sea by indirect fluorescent antibody technique (HAB-2199)

09:50-10:10 **Coffee break**

10:10-10:40 **Angelica Peña**
Preliminary proposal of a Canadian Program on the Ecology and Oceanography of Harmful Algal Blooms (HAB-2200)

10:40-11:10 **Tatiana Yu. Orlova**
Harmful algal bloom data for the Russian east coast (HAB-1970)

11:10-11:40 **Hak Gyoon Kim, Young Shil Kang, Chang Kyu Lee, Gui Young Kim, Wol Ae Lim, Sook Yang Kim, Young Tae Park, Soo Jung Chang, Young Sang Suh and Hee Dong Jeong**
Recent approaches for the prediction and mitigation of *Cochlodinium polykrikoides* blooms in Korean waters (HAB-2201)

11:40-12:10 **Vera L. Trainer, Barbara M. Hickey, Mark Wells and William P. Cochlan**
Ecological linkages between physical and oceanographic conditions and the seasonal growth and distribution of *Pseudo-nitzschia* blooms on the U.S. west coast (HAB-2198)

12:10-13:30 **Lunch**

13:30-14:00 **Michelle C. Tomlinson, Richard P. Stumpf, Dana L. Woodruff, Nathan R. Evans and Susan Dunham**
The use of remote sensing and meteorological data for monitoring HABs through ecological associations (HAB-2039)

14:00-14:30 **Yinglin Zou, Mingyuan Zhu, Ruixiang Li and Zhenxing Wu**
Monitoring toxic HAB in the Chinese waters during the recent three years (HAB-1864)

14:30-15:00 **Hak Gyoon Kim and Vera Trainer**
Summary of the PICES XIII workshop on "Developing a North Pacific HAB Data Resource – II"

15:00-15:20 **Coffee break**

15:20-17:00 **Discussion of HAB Section future tasks**

W5 Workshop Abstracts

PICES XIII W5-2159 Oral
Use of the ICES harmful algal event meta-database to archive data from the west coast of the United States

Nicolaus G. **Adams**[1], Diedre Crawford[2], William P. Cochlan[2] and Vera L. Trainer[1]

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To develop a common data resource that could be used by PICES member nations, it was agreed that each nation would use report forms designed for the ICES Harmful Algal Event (HAE) meta-database and enter one year's data. We decided to enter data from 1998 for the west coast of the United States. Previous records that have been entered into the ICES database for 1998 do not contain detailed information regarding location, toxin, and phytoplankton assemblage that better represent the number, magnitude, and duration of HAEs. For example, in Puget Sound, Washington shellfish harvest closures occur annually and there are many inlets in Puget Sound where shellfish harvesting occurs. However, multiple closures in Puget Sound in a given year are currently considered to be a single closure in the ICES database format. To better understand the extent of closures in 1998, we analyzed monitoring data and listed the sites where toxin levels exceeded the regulatory safety limits. At each of these sites we recorded the magnitude of the toxic event as well as its duration. Maps were then made of the number of samples that exceeded the regulatory limits, the magnitude of toxicity, and the duration of HAEs. From these data we formulated suggested modifications to the current ICES HAE report forms that may better suit the needs of PICES member countries.

PICES XIII W5-2086 Oral
Data integration issues within the Gulf of Mexico

Jeanne S. **Allen**

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The Harmful Algal Blooms Observing System (HABSOS) is a collaborative project between the Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration's (NOAA) National Coastal Data Development Center (NCDDC), and over 30 federal, state, academic and industry organizations. Within the past year, the Mexican Gulf States have joined HABSOS resulting in an international collaboration to monitor HAB events and response without regard to political boundaries.

HABSOS encountered difficulties in data collection and integration in the formative stages. Communication pathways within the five U.S. Gulf of Mexico coastal states were non-existent or only partially developed. NCDDC found that not all data was publicly accessible, different units of measurement were used in the region for the collected data, and the information was stored in different formats. A data storage system was developed to incorporate the five individual coastal states data into one comprehensive database facilitating the ability to perform the time series function built into the HABSOS ArcIMS site.

Currently, an on-line data entry tool is being finalized to aid in the continuation of data collection and storage. Each of the five coastal states and the Mexican Gulf States will be able to use this on-line data entry tool to upload data or individually enter data that will be utilized by the NCDDC HABSOS Near Real-Time ArcIMS site.

PICES XIII W5-2179 Oral
The joint IOC-ICES-PICES Harmful Algal Event Data-base, HAE-DAT

Henrik **Enevoldsen**[1] and Monica Lion[2]

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The IOC and ICES have jointly developed the Harmful Algal Event Data base HAE-DAT with the view to expand the partnership and thereby build a global harmful algal event database. At present the HAE-DAT covers the North Atlantic. IOC and ICES have invited PICES to become partner in HAE-DAT and to that effect PICES is testing the reporting format during 2004. In parallel, the IOC is developing a new software platform for HAEDAT which will ease input of data and generation of maps. The progress will be presented for comments and discussion in conjunction with the evaluation of PICES experience in using the data input format.

PICES XIII W5-2192 Oral
HAB data in Japan and a trial for joining PICES database

Ichiro **Imai**[1], Shigeru Itakura[2], Yasunori Watanabe[2], Akira Ishikawa[3] and Yasuwo Fukuyo[4]

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In Japanese coastal areas, HABs have been monitored by many prefectural research organizations regularly to avoid mass mortalities of aquaculture fish and bivalves, to maintain the safety of marine foods, and to detect abnormal changes of coastal environments. The type and intensity of monitoring varies depending on purpose, area and season. HAB monitoring is one of the most important undertakings on the Japanese coast, because Japanese people value the importance of marine resources. Intensive monitoring has been carried out and extremely abundant data have been accumulated. These HAB monitoring data are all described in Japanese. Consequently, there is an inherent difficulty for Japan in joining the PICES database effort. However, for the purpose of international cooperation, we have translated and input the data into an English style database limiting the HAB events to those with fishery damage such as mass mortalities of fish and bivalves, shellfish poisoning, and color-bleaching damage of *Porphyra* (Nori). Trial entries were made for HAB data from the year 2000. The Japanese coast was divided into 7 regions. Total incidence of red tides were 292 in 2000, and those with fishery damage, hence qualifying for data input, were 45. The most severe damage occurred in the Kyusyu area (Yatsushiro Sea) with a fish kill valued at ca. 4 billion yen caused by the dinoflagellate *Cochlodinium polykrikoides*, and color bleaching of Nori valued at ca. 14 billion yen (Ariake Sea) caused by long-lasting diatom red tides. Paralytic shellfish poisoning (PSP) caused 18 closures of shellfish harvesting in 2000, and most of them occurred in west Japan. Diarrhetic shellfish poisoning (DSP) caused 21 closures of shellfish harvesting in 2000, and most of them occurred in north and east Japan (Tohoku and Hokkaido). As a result of the year 2000 HAB data trial, the total number of HAB incidents qualifying for data input reached as many as 84. The input of HAB data, restricted to the incidents resulting in fishery damage, is a practical and realistic treatment for Japan HAB data. Although HAB events with no fishery damage are excluded, the above data treatments could contribute to the establishment of an international cooperative PICES database.

PICES XIII W5-2193 Oral
Use of Korean HAB data for the joint ICES/PICES HAE-DAT database

Hak Gyoon Kim, Young Shil Kang, Chang Kyu Lee, Gui Young **Kim**, Wol Ae Lim, Sook Yang Kim, Young Tae Park, Soo Jung Chang and Hee Dong Jeong

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In order to conform to the joint ICES/PICES HAE-DAT database on a trial basis, we decided to enter harmful algal bloom (HAB) data from 1998 especially for the fish killing dinoflagellate, *Cochlodinium polykrikoides* that bloomed and persisted for about 5 weeks from late August to early October in the South Sea of the Korean peninsula. We compiled the data from the initiation stage to subsequent development of this dinoflagellate bloom, which consists of time, location, density of harmful algae species, water quality, especially nutrients, meteorological observations, and fish mortalities. All those HAB and environmental data were produced daily and compiled at the National Fisheries Research & Development Institute (NFRDI). These HAB data are disseminated immediately to the public stakeholders such as aquaculturists, decision-makers, journalists, and scientists for their practical use through paper reports such as Today's HAB News, HAB Year Book and Internet on-line services. We are planning to compile such HAB data at the Korean Oceanographic Data Center (KODC) designated by IOC, the Korea Oceanographic Data Management Center, and the Ministry of Maritime Affairs and Fisheries (MOMAF) and established by NFRDI. The Korean HAB data format differs from HAE-DAT and in some respects, we find that further modifications are needed to encompass the goal of HAE-DAT database network for effective predictive and mitigative strategies of member countries.

PICES XIII W5-2194 Oral
Entry of HAB data from the east coast of Russia into the ICES/PICES HAE-DAT database format

Tatiana Yu. **Orlova**

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Report forms designed for the ICES/PICES Harmful Algal Event (HAE-DAT) meta-database were used to enter data from the east coast of Russia. Use of the database format to provide an interim "report card" revealed some difficulties in the delivery of Russian data. We decided to enter data from 2003. According to ICES format recommendations, the Russian coastline was divided into 200 km length sections with longitudinal/longitudinal information. However, this division was not appropriate because of the huge coastline (more than 30,000 km) and because the Russian east coast is mostly an unpopulated area. We suggest instead a division of the coastline into regions which correspond to the Russian Federation administrative territories on the Pacific coast (such as Primorskii Krai, Khabarovskii Krai, Magadanskaya Oblast, *etc.*) with longitudinal/longitudinal information and a central dot as the reference point. Another significant problem with completing ICES format "report card" is the lack of HAE data for the Russia east coast. This is due to the fact that there is no official HAB monitoring in Russian waters. The Russian data on HAE are not sufficient for the completion of many data fields in the recommended ICES-PICES National HAB Report form. Available data mainly include causative organisms, their abundance, location, date and some environmental conditions. There are no data on socio-economic impacts due to the presence of toxic or harmful microalgae and on biotoxin accumulation in seafood. Establishment of permanent Federal program of HAB monitoring in Russian coastal waters is a necessity.

PICES XIII W5-2195 Oral
Testing the ICES harmful algal event meta-database to archive data from the west coast of Canada

Angelica **Peña** and Melanie Quenneville

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As part of PICES' effort to develop a common harmful algal blooms (HAB) data resource among PICES nations, we used report forms designed for the ICES Harmful Algal Event meta-database to enter data from 2003 for the west coast of Canada. The data were obtained from the Canadian Food Inspection Agency which maintains a shellfish monitoring program of PSP and ASP but does not have a phytoplankton monitoring component. These data have not been previously entered into the ICES database. Our first task was to divide the west coast of Canada coastlines into areas of about 100-200 km in length. Twenty-eight regions were defined based on the existing Pacific fishery management areas for the entire British Columbia Coast. Then, the data were analyzed and those where toxin levels exceeded the regulatory safety limits (80 µg/100 gm for PSP and 20 ppm for ASP) in a region were reported. At each of these sites we recorded the magnitude of the toxic event and when possible its duration. Maps were then made of the number of samples that exceeded the regulatory limits and the magnitude of toxicity.

PICES XIII W5-2197 Oral
HAB data in China

Mingyuan **Zhu**, Ruixiang Li and Zongling Wang

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Harmful algal blooms (HABs) are a serious marine environment problem in the coastal waters of China. Before 1990s, HAB monitoring was coordinated together with routine marine environment monitoring. Now, there are 23 dedicated monitoring and control zones for HABs along Chinese coast. The provincial oceanic and fishery bureaus are responsible for the monitoring activities. HAB data in China include location, time, area, causative species and economic loss of each event. Often, events can be missed. We can provide the HAB monitoring data from 1998 to 2000 in format of the ICES/PICES HAE database as a contribution to the formation of a collaborative PICES HAB database.

HAB Meeting Abstracts

PICES XIII HAB-2199 Oral

Monitoring of the shellfish-killing dinoflagellate *Heterocapsa circularisquama* in Japanese coastal sea by indirect fluorescent antibody technique

Ichiro **Imai**[1], Tomotaka Shiraishi[1], Kiyohito Nagai[2], Shingo Hiroishi[3], Shigeru Itakura[4], Yasunori Watanabe[4], Akira Ishikawa[5] and Yasuwo Fukuyo[6]

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In Japanese coastal water, *Heterocapsa circularisquama* is the most noxious dinoflagellate to shellfish aquaculture due to high density blooms causing mass mortalities of both natural and cultured bivalves such as oysters, short-necked clams, mussels and pearl oysters. The population dynamics of *H. circularisquama* has remained unclear, because of the the difficulties in monitoring this organism due to small size and the presence of other species having strong morphological similarities. To identify this species precisely and to monitor its population dynamics, a fluorescent antibody technique using monoclonal or polyclonal antibodies has been employed. We carried out the monitoring of *H. circularisquama* with an indirect fluorescent antibody technique using monoclonal antibodies. Sampling was done once a week in the summer and twice a month in other seasons at 6 locations in Ago Bay, Mie Prefecture, Japan from April 2001 to March 2003. Seawater samples were immediately fixed with formaldehyde (final concentration, 0.37%), then *H. circularisquama* cells were detected by the fluorescent antibody method. The direct counting of the cells was also done using a normal optical microscope. In 2001, *H. circularisquama* cells were detected in Ago Bay from May 14 until January 21, 2002 using the indirect fluorescent antibody technique. On the other hand, the cells were detected only in July by the conventional direct counting. Later in 2002, detection of *H. circularisquama* was from May 20 until November 11 using the fluorescent antibody technique. On the contrary, the cells could be only detected from June through October by the common direct counting. This work demonstrates that the indirect fluorescent antibody technique allows for the detection of this species even at low cell densities and is the powerful and feasible monitoring tool.

PICES XIII HAB-2201 Oral

Recent approaches for the prediction and mitigation of *Cochlodinium polykrikoides* blooms in Korean waters

Hak Gyoon **Kim**, Young Shil Kang, Chang Kyu Lee, Gui Young Kim, Wol Ae Lim, Sook Yang Kim, Young Tae Park, Soo Jung Chang, Young Sang Suh and Hee Dong Jeong

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A fish killing dinoflagellate, *Cochlodinium polykirkoides*, has caused recurring widespread and persistent blooms in Korean coastal water since 1995. A comprehensive HAB monitoring program has been developed and implemented as a four-dimensional monitoring system composed of cruises, coastal waterfront patrol, aircraft surveillance, and satellite remote sensing to predict the initiation and subsequent development of the blooms. Present monitoring and prediction is based on bloom dynamics of this species. *C. polykrikoides* blooms have been initiated in the mixing frontal zone of Tsushima warm current and eutrophic coastal waters, where the optimal condition for the outbreaks of *C. polykrikoides* bloom have been triggered by heat energy from the Tsushima warm current and nutrients from eutrophic coastal waters. In early July, just before the initiation of this bloom, swimming cells were found more than 100 km offshore waters from Jeju island and *C. polykrikoides*-like benthic resting cysts were also found in the sediment of South Sea of Korea, even though excystment of this dinoflagellate species has not yet been described. To

understand where the bloom inoculum originates, NFRDI plans to track the advection of *C. polykrikoides* from the west Pacific to the south coast of Korean peninsula and neighbouring countries to undertake germination experiments with the *C. polykrikoides*-like cysts. New developments such as light microscopes equipped with self-identification programs, lectin or DNA probes, and visible light spectra highly sensitive to *C. polykrikoides* are underway. Another important approach is to develop a dependable prediction model to replace the imprecise model system that is currently being used.

PICES XIII HAB-1970 Oral
Harmful algal bloom data for the Russian east coast

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The east coast of Russia is known as an area where harmful algal blooms have occurred. HAB data for the Russian east coast mostly include data of HAB research and HAB monitoring. These data focus mostly on biological parameters: the causative organisms, occurrence and abundance. There is a great disparity in the amount of HAB data available for the Russian east coast. The most complete record of numbers and seasonal dynamics of harmful algae, as well as HAB events can be found for the coastal waters of Primorye and Kamchatka. In coastal waters of Vladivostok city there is a single sampling location which is routinely sampled by phytoplanktonologists of the Institute of Marine Biology. The increasing frequency and negative impact of HABs has promoted establishment of HAB monitoring in the area of aquaculture. Since 1990, HAB routine monitoring was established at the mollusc farms in Peter the Great Bay. There is a plankton-monitoring program, which is focused on HAB species. Data include mainly causative organisms, site of occurrence, and abundance. Potentially toxic species were found, among which *Pseudo-nitzschia, Alexandrium* and *Dinophysis* predominated. Toxicity of *Pseudo-nitzschia multiseries* and *Alexandrium tamarense* from Russian marine waters has recently been documented. The density of these species exceeded the reportedly harmful level throughout the summer. These data document the significant risk of shellfish contamination by toxins from HABs in Russian marine waters. There is no official HAB monitoring related to PSP and domoic acid poisoning in Russian waters. Establishment of permanent Federal program of HAB monitoring in Russian coastal waters is highly recommended.

PICES XIII HAB-2200 Oral
Preliminary proposal of a Canadian Program on the Ecology and Oceanography of Harmful Algal Blooms

Angelica **Peña**

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The Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) Programme, initiated by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC), is aimed at fostering and promoting international co-operative research directed toward improving the prediction of harmful algal bloom events. A group of Canadian oceanographers and specialists on harmful algae has proposed a joint research program among several institutions. The proposed research follows the science guidelines of the international program, but focuses on harmful algal species of major concern in Canadian waters and draws on the expertise within universities and government agencies (DFO and NRC) in Canada. This presentation will outline the objectives and main research activities that are being proposed and will provide information on the status of the GEOHAB-Canada proposal.

PICES XIII HAB-2039 Oral

The use of remote sensing and meteorological data for monitoring HABs through ecological associations

Michelle C. **Tomlinson**[1], Richard P. Stumpf[1], Dana L. Woodruff[2], Nathan R. Evans[2] and Susan Dunham[1]

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There are multiple ways to use remote sensing for monitoring harmful algal blooms (HABs). When the toxic species dominates or correlates to total phytoplankton biomass, ocean color is effective. Relative increases in chlorophyll as identified through chlorophyll anomalies from SeaWiFS, have successfully identified new blooms of *Karenia brevis* in the Gulf of Mexico, USA. In addition, chlorophyll anomalies are useful in tracking transport along the coast.

Toxic events often occur when the causative organism is a relatively small component of the biomass. In these cases, associations involving links to specific meteorological and oceanographic features are more useful for monitoring. The use of ocean color data for detecting *K. brevis* in the Gulf of Mexico is more effective when coupled with wind patterns, since certain wind patterns lead to *K. brevis* blooms rather than other non-toxic blooms. Along the west coast of the United States, backscatter from ocean color sensors can identify the Columbia River plume due to its high sediment loading. Preliminary evidence suggests that the Columbia River plume may prevent blooms of the diatom *Pseudo-nitzschia* spp. and associated domoic acid toxicity from moving onshore, along Washington state's southern beaches. Along the northern beaches, upwelling areas identified from sea surface temperature (SST) imagery may distinguish patterns leading to HAB development. The analysis of meteorological forcing mechanisms may also identify conditions conducive for these blooms to reach the coast.

PICES XIII HAB-2198 Oral

Ecological linkages between physical and oceanographic conditions and the seasonal growth and distribution of *Pseudo-nitzschia* blooms on the U.S. west coast

Vera L. **Trainer**[1], Barbara M. Hickey[2], Mark Wells[3] and William P. Cochlan[4]

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Domoic acid has been responsible for mortalities of brown pelicans, Brandt's cormorants and sea lions along the Pacific Northwest coast. Beach and harvest closures resulting from toxic *Pseudo-nitzschia* blooms have also had a severe impact on both coastal economies and tribal communities. If the location and transport of toxic *Pseudo-nitzschia* blooms can be understood and forecast, coastal managers can then take preventative action to minimize the impact to affected coastal resources. A 5-year, multi-disciplinary, regional ECOHAB project is studying the physiology, toxicology, ecology and oceanography of toxic *Pseudo-nitzschia* species off the Pacific Northwest coast, a region in which both nutrient supply and current patterns are primarily controlled by seasonal coastal upwelling processes. Researchers are testing the hypothesis that harmful algal blooms affecting Washington State coastal communities are largely caused by *Pseudo-nitzschia* growing in the Juan de Fuca eddy (a nutrient rich environment "bioreactor" favorable for phytoplankton growth) and subsequently transported to nearshore waters by storms. The long term project goal is to develop a mechanistic basis for forecasting toxic *Pseudo-nitzschia* bloom development and transport in the Pacific Northwest, and in other similar coastal regions in Eastern Boundary upwelling systems. Results from the field and survey studies, when synthesized with predictive bio-physical models, will benefit coastal managers by providing insights into possible predictors of toxic *Pseudo-nitzschia* blooms as well as helping identify oceanic/atmospheric conditions favorable for the transport of toxic cells onshore.

PICES XIII HAB-1825 Oral
The occurrences of HAB in Chinese coastal waters in recent three years

Mingyuan **ZHU**, Ruixiang Li and Zongling Wang

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China is one of the countries facing serious HAB problems. There is a rapid increase of the occurrences of HAB in the coastal waters of China. Till 2003, there were 647 HAB events recorded. In the last two decades of 20 century, the number of HAB events tripled during every decade. In the last three years, 275 HAB occurred, accounting for 42% of the total HAB records.

The Bohai Sea in the north, the coastal water of Yangtze River Estuary and the Zhejiang Province in the East China Sea and coastal water along Guangdong Province in the South China Sea are the three areas with frequent HAB occurrences. In last three years, HABs in the Bohai Sea and South China Sea did not increase in frequency, however, HABs in the East China Sea did become more frequent.

In the East China Sea, blooms of *Prorocentrum* have reoccurred for 5 years over an area larger than 1,000 km^2. These blooms occur in May along the frontal area between Zhejiang coastal current and Taiwan warm current, in a water depth of between 30-50 meters. In May 2004, a *Prorocentrum* bloom extending over 10,000 km^2 was observed. In the Bohai Sea, HABs caused by new organisms, such as *Phaeocystis sp* and *Karenia sp* have recently been discovered. In the coastal water of Guangdong Province, the HABs are usually found in the Pearl River estuary in areas of dense aquaculture.

It is clear that the occurrences of HABs in China are still increasing and more efforts in research and management of HABs are needed.

PICES XIII HAB-1864 Oral
Monitoring toxic HAB in the Chinese waters during the recent three years

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A three-year HAB monitoring program as well as a study of early warning and prediction was conducted in Jiaozhou Bay in northern China beginning in 2001. The sampling sites are located in a mariculture area where the dominant product is the Manila clam *Ruditapes philippinarum*. This monitoring program includes sampling of clams and phytoplankton every month, with analysis and reporting from May to September of each year. We found that DSP is much more frequent than PSP in the north sea of China. It has been dramatically increasing in recent years. DSP toxicity detected by the mouse bioassay is higher than that by HPLC. The results of toxic algae and shellfish toxin monitoring do not always correlate well with each other, which suggested that phytoplankton monitoring serves best as a tool of early warning.

Another survey (2002~2004) of shellfish toxins has been carried out in Zhoushan islands of the East China Sea, the most serious HAB area in China during recent years. The HAB season is this area is from early May to mid June. PSP and DSP toxins were analyzed by mouse assay and HPLC. During these investigations 20 species of wild shellfish samples were collected, extracted and analyzed. Low amounts of PSP and DSP toxins were measured in a few species except for *Nassarius* sp., collected from Liuheng Island, which showed 3.84MU/g and 8.8MU/g PSP toxicity by mouse assay, yet showed no PSP toxins by HPLC. It suggested that there might be a new PSP derivative or a new neurotoxic toxin that exists in this *Nassarius* sample.

W6 MBM-AP Workshop
Combining data sets on diets of marine birds and mammals: Phase II

Workshop Convenors: Hidehiro Kato (Japan) and William J. Sydeman (U.S.A.)

The workshop on "Combining data sets on distributions and diets of marine birds and mammals" at PICES XII led to enhanced knowledge of relations of marine birds and mammals and the environment. Continuation of this workshop would further our understanding of coupled climate-ecosystem fluctuations in the North Pacific Ocean. The PICES Advisory Panel on *Marine birds and mammals* identified four species (2 birds and 2 mammals) with extensive spatial and temporal datasets on food habits and prey characteristics, which are not reviewed at PICES XII and could be examined. Species of interest include: Dall's porpoise, northern fur seal, common murre and Cassin's auklet (a planktivorous seabird). Reports on other species that have appropriate time series are also welcome.

Thursday, October 14, 2004 8:30-12:00

09:00-09:30 **Hiroshi Ohizumi and Hidehiro Kato**
Food of toothed whales in the northern North Pacific: Geographic and temporal variation (W6-2125)

09:30-10:00 **Rolf R. Ream and Tonya K. Zeppelin**
Historical and contemporary diet of northern fur seals in the North Pacific (W6-2177)

10:00-10:30 **Coffee break**

10:30-11:00 **Alexander Kitaysky, Larisa Zelenskaya and Elena Golubova**
Reproductive responses of planktivorous and piscivorous birds to climate variability in the northern Sea of Okhotsk (W6-2118)

11:00-11:30 **Shaye G. Wolf, Christine L. Abraham, L. Mark Hipfner and William J. Sydeman**
Spatio-temporal variation in the zooplankton prey of Cassin's auklets in the California Current system (W6-2149)

11:30-12:00 **Tomio Miyashita and Hidehiro Kato**
Distribution of cetaceans in the western North Pacific inferred from systematic sighting survey (W6-1973)

PICES XIII W6-2125 Oral
Food of toothed whales in the northern North Pacific: Geographic and temporal variation

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We propose a review of diet variation of Dall's porpoise (*Phocoenoides dalli*) and other dolphins inhabiting wide areas from the transitional to subarctic North Pacific such as Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*) and short-beaked common dolphin (*Delphinus delphis*). Dall's porpoises in the North Pacific feed mainly on myctophids, although the prey species varies among areas. Important prey myctophids are *Diaphus theta*, *Protomyctophum thompsoni*, *Notoscopelus japonicus*, and *Stenobrachius leucopsarus*. In the Bering Sea, three gonatid squids *Gonatus onyx*, *Gonatopsis borealis*, and *Gonatopsis annonychus* are important, especially for immature porpoises. In the Sea of Japan and Okhotsk Sea off Hokkaido Japan, Japanese pilchard (*Sardinops melanostictus*) was exclusively important in the 1980s, but prey switched to walleye pollock (*Theragra chalcogramma*) in the Sea of Japan, and to magistrate club-hook squid (*Berryteuthis magister*) in the Okhotsk Sea after population decline of Japanese pilchard in the 1990s. Foods of Pacific white-sided dolphin and northern right whale dolphin are closely similar; they feed mainly on myctophids in the central North Pacific. These dolphins are distributed overlap in transitional zone, suggesting a potential competition for food. Common dolphin in the western North Pacific also feed on myctophids, especially *Ceratoscopelus warmingi*.

PICES XIII W6-2118 Oral
Reproductive responses of planktivorous and piscivorous birds to climate variability in the northern Sea of Okhotsk

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We used long-term (1987-2003) series of observations on seabird reproductive success and oceanographic change in Tauyskaya Bay (Okhotsk Sea, north-western Pacific) to evaluate the hypothesis that changes in marine climate may favor the productivity of one group of upper trophic level predators over another through fluctuations in the availability of their prey. We found that in the continental shelf ecosystems in the north-western Pacific (Talan I., northern Okhotsk Sea), birds foraging on macro-zooplankton and birds foraging on forage fish show opposite reproductive trends. This pattern was strongly correlated with inter-annual climate variability in the North Pacific. A positive North Pacific Index of atmospheric pressure anomaly, early dates of ice disappearance, and warm local sea-surface temperature were positively correlated with productivity of piscivorous and negatively correlated with productivity of planktivorous seabirds. A “warm” regime was associated with high abundance of meso-zooplankton, which may in turn affect forage fish abundance. Macro-zooplankton organisms, which are the main prey of planktivorous seabirds, were more abundant during a “cold” regime. During a “warm” regime, when in-flow of oceanic waters into shelf areas was weak, proportions of oceanic copepods in seabird diets were lower compared to those during a “cold” regime when in-flow of oceanic waters was relatively strong. Thus, climate-driven alternations in a composition and timing of peak of zooplankton communities and abundance of forage fish probably represent causal mechanisms responsible for opposite trends in reproductive performance of piscivorous and planktivorous seabirds. We will discuss availability of data on the diet composition of seabirds in the north-western Pacific.

PICES XIII W6-1973 Oral

Distribution of cetaceans in the western North Pacific inferred from systematic sighting survey

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During the dedicated sighting surveys conducted by National Research Institute of Far Seas Fisheries since 1982, eight rorqual whales (blue, fin, sei, Bryde's, common minke, humpback, North Pacific right and gray), three sperm whale species (sperm, pygmy sperm and dwarf sperm), five beaked whales (Cuvier's, Baird's, Hubbs' and Stejneger's and Longman's), 16 dolphin species (killer, short-finned pilot, false killer, pygmy killer, melon-headed, Risso's, long-finned common, short-finned common, striped, spinner, pantropical spotted, bottlenose, Pacific white-sided, northern right whale dolphin, rough-toothed and Fraser's) and three true porpoises (Dall's, harbor and finless) were positively identified. The distribution of these species in mid summer is analyzed related to the environmental factors such as water temperature, water depth *etc*. Some species have tendency to concentrate in the particular waters related to the oceanic convergence in the mid-latitudinal waters, while some species are distributed in the whole waters regardless of the oceanic conditions.

PICES XIII W6-2177 Oral

Historical and contemporary diet of northern fur seals in the North Pacific

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Northern fur seals (*Callorhinus ursinus*) are opportunistic predators whose distribution at sea varies among seasons. Beginning each fall, fur seals spend approximately eight months at sea across much of the North Pacific. During summer fur seals return to breeding islands in Russia, Alaska and California and behave as central place foragers, making short duration feeding trips from the islands. We examined spatial and temporal variation of fur seal prey by reviewing historical diet data (1958-1974) from pelagic collections and by analyzing recent diet samples from specific breeding islands (1988-2000). Pelagic diet data was determined from stomachs of animals collected across a range of months and regions. Diet in the northern regions (Gulf of Alaska, British Columbia) was dominated by a few primary prey species, particularly Pacific herring, though frequencies varied among months. In southern regions (Washington to California), diet was distributed more evenly among primary prey species. Northern anchovy and market squid were primary prey common among the southern regions, while Pacific hake was particularly important off California. Recent diet information from breeding islands was determined from fecal samples collected on land. Prey consumption varied according to the physical and biological environment surrounding each island. Juvenile walleye pollock was the most common prey on St. Paul Island (Pribilof Islands, Alaska), gonatid squid was the most common prey at Medny Island (Commander Islands, Russia), while both prey types were common at St. George Island (Pribilof Islands). On Bogoslof Island (Alaska), northern smoothtounge and squid were the most common prey types.

PICES XIII W6-2149 Oral

Spatio-temporal variation in the zooplankton prey of Cassin's auklets in the California Current system

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Variability in oceanographic conditions at high and low frequencies affects the abundance, distribution, and timing of zooplankton, although these relationships are not well understood. Seabirds such as the Cassin's auklet (*Ptychoramphus aleuticus*) which specialize on zooplankton prey and which have a broad geographic range provide effective sampling tools for elucidating the relationships between oceanographic variability and zooplankton population fluctuations over a wide range of temporal and spatial scales. We examine inter-annual relationships between mean seasonal oceanographic conditions and zooplankton abundance in Cassin's auklet diet at 4 sites in the California Current System: southern British Columbia, central California, southern California, and the central Baja California peninsula. Specifically, we correlate local sea surface temperature and upwelling metrics, as well as basin-scale PDO and SOI indices, derived from buoy and remotely sensed data with annual abundances of the principal zooplankton prey species at each site. These focal species are the subtropical euphausiid *Nyctiphanes simplex*, the temperate euphausiids *Nematoscelis difficilis, Euphausia pacifica,* and *Thysanoessa spinifera*, and the copepod *Neocalanus cristatus*. Because seasonal zooplankton abundance is thought to lag behind oceanographic fluctuations and to depend upon species-specific generation times, we correlate oceanographic metrics lagged at different time scales with seasonal zooplankton abundances. Such studies of zooplankton population fluctuations derived from seabird diet data should supplement and enhance more traditional sampling studies that link biological and oceanographic variability.

Index of Authors

Presenter Name:	Paper #:	Page #:
(bold numbers indicate presenting author)		
A		
Abakumov, Alexander I.	**FIS_P-1814**	p.171
Abe, Shuichi	GP-1863	p.208
Abraham, Christine L.	**W2-2074**	p.219
	W6-2149	p.263
Acosta-Vargas, Baudilio	GP-2188	p.208
Adams, Nicolaus G.	**W5-2159**	p.251
Agafonova, Irina G.	GP-2184	p.193
Agostini, Vera N.	**S2-1934**	p.17
	S2-2001	p.21
	W3-2004	p.229
Aguilar-Rosas, Luis E.	S5-2139	p.67
Aguirre, Hugo	FIS_P-1820	p.171
Aita, Maki N.	**S10-1960**	p.143
Alheit, Juergen	**S9-1900**	p.117
Allen, Jeanne S.	**W5-2086**	p.251
Almyashova, Tatyana N.	GP-2184	p.193
Amezcua, Felipe	**BIO_P-1835**	p.159
	FIS_P-1820	p.171
Aminin, Dmitry L.	**GP-2184**	p.193
Anderson, David	S4-2058	p.54
	S4-2060	p.55
Andreev, Andrey G.	**S8-2015**	p.99
	S8-2124	p.99
Antonov, John	S8-1817	p.103
Aoki, Ichiro	FIS_P-1957	p.185
	S2-1956	p.27
Arai, Mary Needler	**S3-1824**	p.33
Ardron, Jeff	S6-1869	p.71
Armstrong, J.	S3-1979	p.33
Arshinov, Igor A.	GP-1962	p.194
Artukhin, Yuri B.	GP-2089	p.211
Auad, Guillermo	S9-2014	p.119
Augerot, Xan	GP-2050	p.207
Aumont, Olivier	S8-2140	p.108
Auth, Toby D.	**S9-1856**	p.117
Avdeev, Gennady V.	FIS_P-1953	p.182
Awkerman, Jill	S4-2060	p.55
Aydin, Kerim Y.	**S2-2109**	p.17
	S2-2003	p.20
	GP-2144	p.205
	S4-2143	p.51
Azumaya, Tomonori	FIS_P-1922	p.175
B		
Backus, Ed	GP-2050	p.207
Baier, Christine T.	S2-2106	p.24
Bakun, Andrew	S9-1900	p.117
	S2-1934	p.17
	S2-1852	p.18
Baldwin, Rebecca E.	**S9-1936**	p.118
Balogh, Gregory	S4-2058	p.54
Barbieri, María Angela	W4-1867	p.245
	S7-1854	p.90
Barth, John A.	**S9-1986**	p.118
Batchelder, Harold P.	**S9-1931**	p.119
Batten, Sonia	**S7-1819**	p.79
Baturina, Viktoria	S8-2124	p.99
Baumgartner, Tim R.	**S9-2014**	p.119
	GP-2136	p.198
Baytalyuk, Alexey A.	BIO_P-2078	p.164
Beamish, Richard J.	**S2-2066**	p.18
Beier, Emilio	S7-2196	p.92
Belan, Ludmila S.	BIO_P-1781	p.159
Belan, Tatyana A.	**BIO_P-1781**	p.159
	GP-1780	p.193
	S5-1777	p.61
Belonenko, Tatyana V.	**S11-1806**	p.151
Belyaev, Vladimir A.	FIS_P-1800	p.173
Bhuthimethee, Mary	S9-1936	p.118
Bidigare, R.R.	**S1-2185**	p.3
Bills, Jena M.	**S5-2036**	p.61
Block, Barbara	S4-2020	p.45
	S4-2105	p.49
	S4-2097	p.54
Bocharov, Lev N.	FIS_P-1814	p.171
Bodtker, Karin M.	**S1-1994**	p.3
Boehme, Jennifer	**S5-2094**	p.62
Bogdanov, Konstantin T.	GP-1783	p.204
Bogdanov, Marat A.	GP-1990	p.209
Bogdanovsky, Alexander A.	**GP-1962**	p.194
Bograd, Steven J.	**S9-2084**	p.120
	W4-2141	p.245
	S4-2020	p.45
	S4-2097	p.54
	S1-2096	p.9
Boldt, Jennifer	S9-2035	p.124
	S9-1868	p.133
Bollens, Stephen M.	S5-2157	p.66
Bomko, Svetlana P.	FIS_P-1800	p.173

Boo, Sung Min	S5-2139	p.67
Borisenko, G.S.	S6-2104	p.73
Borisov, R.R.	GP-1774	p.203
Boustany, Andre	S4-2105	p.49
Bower, John R.	**GP-1828**	p.194
	GP-1863	p.208
	S1-1827	p.4
Boyer, Tim	S8-1817	p.103
Bradley, Russell W.	**GP-1903**	p.195
Brix, Holger	S8-2140	p.108
Brodeur, Richard D.	S9-1856	p.117
	S9-1872	p.120
	S3-1865	p.38
	S4-2046	p.52
Brown, Evelyn	BIO_P-2059	p.165
Buchheister, Andre	**FIS_P-2107**	p.171
Buckley, Troy W.	**W4-2099**	p.237
Budaeva, Valentina D.	BIO_P-1781	p.159
Buitenhuis, Eric	S8-2140	p.108
Bulatov, Oleg A.	**FIS_P-1976**	p.172
Bullister, John L.	S8-2102	p.107
	S8-1988	p.108
Buslov, Alexander V.	**FIS_P-1776**	p.172

C

Calambokidis, John	S2-2148	p.27
Canny, D.	S4-2168	p.45
Carmack, Eddy	S7-1782	p.88
Casillas, Edmundo	S9-1902	p.126
	FIS_P-1853	p.180
Chai, Fei	S8-2140	p.108
	S10-2083	p.146
	W4-2110	p.237
	S8-2146	p.99
Chan, Francis	S9-1986	p.118
Chang, Man	**GP-1784**	p.195
Chang, Soo Jung	W5-2193	p.253
	HAB-2201	p.255
	S3-2127	p.36
	S3-2129	p.36
Chao, Yi	**W4-2110**	p.237
	S1-2185	p.3
	S8-2146	p.99
Chavez, Francisco	S2-2148	p.27
Chen, Chen-Tung Arthur	**S8-2055**	p.100
	S8-2015	p.99
Chen, Liqi	**S8-2180**	p.100
Chen, Shang	**S9-1807**	p.121
Chen, Yaqu	**FIS_P-2190**	p.173
Chen, Yongli	S7-2176	p.92
Chen, Yuanquan	FIS_P-2190	p.173
Cherniawsky, Josef	S7-1870	p.81
Chernova, Anastasia S.	**GP-2019**	p.196
Chiba, Sanae	**S9-1944**	p.121
	S9-2030	p.128
Chierici, Melissa	**S8-2008**	p.101
Childers, Amy R.	S9-2175	p.139
Cho, Eun Seob	**BIO_P-1980**	p.160
	W3-2033	p.229
Cho, Kyu Dae	S9-1949	p.130
Choi, K.H.	S5-2036	p.61
Choi, Kwang Ho	S9-1949	p.130
Choi, Sang Duk	BIO_P-2064	p.162
Choi, Sang-Hwa	**GP-2132**	p.196
Chou, Wen-Chen	S8-2055	p.100
Christensen, S.	S1-2185	p.3
Christian, James	**S8-2005**	p.101
Chung, Chang-Soo	S10-1798	p.147
Chung, Ik-Kyo	**GP-2162**	p.197
	GP-2161	p.197
	GP-2087	p.213
Clapham, Phillip	S2-2145	p.19
Clarke, Cheryl	W2-1932	p.220
	S3-1883	p.34
Clarke, M.E.	GP-2153	p.212
Cochlan, William P.	W5-2159	p.251
	HAB-2198	p.257
Colbert, Jim J.	FIS_P-1995	p.181
Cordell, Jeffery R.	S5-2157	p.66
Cosslett, Chris	S6-1792	p.74
Costa, Daniel	**S4-2020**	p.45
	S4-2097	p.54
Coyle, Kenneth O.	**S9-1859**	p.122
	S9-1850	p.122
Crane, Kathleen	S8-2174	p.111
Crawford, Diedre	W5-2159	p.251
Crawford, William R.	**S7-2160**	p.79
	S7-2164	p.87
	S9-2084	p.120
	S9-2158	p.122
Cui, Mao-Chang	**S7-1801**	p.80
Cummins, Patrick	S7-1870	p.81
Curchitser, Enrique N.	**S9-1993**	p.123
	S9-2040	p.125
	S11-2042	p.152
Cury, Philippe	**S2-1846**	p.18

D

Dagg, Michael **S3-1979** p.33
Daly, Elizabeth A. S9-1872 p.120
S3-1865 p.38
Danielson, Seth S9-2072 p.136
Darnitsky, Vladimir B. **FIS_P-1800** p.173
GP-1889 p.201
GP-1891 p.202
Davidova, Svetlana V. **S9-1907** p.123
de la Mare, William **S6-2203** p.71
De Velasco, G. Gutierrez S4-1942 p.47
Dellinger, Thomas S11-1935 p.153
DeMaster, Douglas P. **S2-2145** p.19
Denman, Ken S8-2147 p.104
Deutsch, Curtis **S8-1834** p.102
Dewar, Heidi S4-2105 p.49
Dilg, Justin S8-2151 p.102
Dmitrieva, Elena V. S11-1788 p.154
Dobbins, Elizabeth L. S9-1993 p.123
S9-2040 p.125
S10-2041 p.144
S11-2042 p.152
Dolmatova, Ludmila S. **GP-1839** p.198
Doney, Scott C. S8-2031 p.103
Dorner, Brigitte S9-2108 p.135
Drinkwater, Kenneth F. **S2-2085** p.19
Dudarev, Vitali **BIO_P-1812** p.160
Dulepov, Vladimir I. BIO_P-1965 p.163
Dulepova, Elena **FIS_P-2170** p.174
Dunham, Susan HAB-2039 p.257

E

Emerson, Steven S8-1834 p.102
Enevoldsen, Henrik **W5-2179** p.252
Epelbaum, A.B. GP-1774 p.203
Etnoyer, Peter **S11-2171** p.151
S4-2168 p.45
S6-2098 p.72
Evans, Nathan R. HAB-2039 p.257

F

Fagan, Kathryn E. **S8-2151** p.102
Fair, Lowell FIS_P-1950 p.179
Farwell, Charles S4-2105 p.49
Fayman, Pavel A. **S7-2009** p.80
S7-1967 p.80
S7-2010 p.81
Feely, Richard A. **S8-1985** p.102
Feely, Richard A. S8-2031 p.103
S8-2140 p.108
S8-1988 p.108
W4-1984 p.238
Fei, Xiu-Geng GP-2087 p.213
Feinberg, Leah W2-2082 p.224
Ferriera-Bartrina, Vicente GP-2136 p.198
Field, David B. **GP-2136** p.198
Field, John C. **S2-2003** p.20
Fischenko, Vitaly K. S11-1849 p.152
Fischer, Karen S4-2060 p.55
Floerl, Oliver S5-1795 p.65
Flood, Per S3-1930 p.39
Foreman, Michael **S7-1870** p.81
Foux, Victor R. S4-1815 p.53
Fox, David S. S9-1986 p.118
Foy, Robert J. **GP-2169** p.199
Francis, Robert C. S2-1934 p.17
S2-2003 p.20
Franco-Gordo, C. **W4-1851** p.238
S7-2189 p.82
Fransson, A. S8-2008 p.101
Freeland, Howard J. S9-2084 p.120
S1-1818 p.4
Freire, J. W4-1851 p.238
S7-2189 p.82
Fu, Chong-Hui **GP-1914** p.199
Fujii, Yosuke S7-2029 p.83
Fujimura, Masahiko S8-1918 p.105
Fujise, Yoshihiro **S4-1983** p.46
Fukuwaka, Masaaki S9-1789 p.131
FIS_P-1922 p.175
Fukuyo, Yasuwo W5-2192 p.252
HAB-2199 p.255
S5-2163 p.62
S5-2178 p.63
Funamoto, Tetsuichiro **FIS_P-1822** p.174
Funes-Rodriguez, R. S4-1942 p.47

G

Gaichas, Sarah K. S2-2109 p.17
Gallucci, Vincent F. **S4-2034** p.46
Gao, Zhongyong S8-2180 p.100
Garcia, Hernan E. **S8-1817** p.103
Gende, Scott M. **S4-1793** p.46
Gertsev, Vladimir V. S2-1858 p.20
Gertseva, Vladlena V. **S2-1858** p.20
Glebova, Svetlana Yu. **S9-1804** p.124

Glubokov, Alexander I.	**S1-1773**	p.5
Godinez-Dominguez, E.	W4-1851	p.238
	S7-2189	p.82
Godwin, L. Scott	**S5-1901**	p.63
Golik, Andrew V.	**S11-1849**	p.152
Gollasch, Stephan	**S5-2191**	p.64
	S5-1969	p.64
Goloubeva, Elena N.	S7-1803	p.87
Golubova, Elena	W6-2118	p.261
Gonzalez-Armas, Rogelio	**S4-1942**	p.47
Gould, W. John	**S7-1981**	p.82
Grantham, Brian A.	S9-1986	p.118
Greeley, D.	S8-1985	p.102
	W4-1984	p.238
Green, Yanira	BIO_P-1835	p.159
Gregr, Edward J.	S1-1994	p.3
Grimes, Churchill B.	S4-2071	p.56
Grosch, Chester E.	S9-2072	p.136
	S2-2148	p.27
Gruber, Nicolas	**S8-2031**	p.103
	S8-1988	p.108
	S8-2140	p.108
Guan, Dao-Ming	BIO_P-1778	p.161
Guo, Xinyu	**S10-1919**	p.143
	FIS_P-1896	p.176

H

Haeseker, Steven L.	S9-2108	p.135
Haidvogel, Dale B.	S9-1993	p.123
	S9-2040	p.125
	S10-2041	p.144
	S11-2042	p.152
Haldorson, Lewis	**S9-2035**	p.124
	S3-1979	p.33
Hales, Burke	S9-1986	p.118
Hall, Julie A.	**S9-2131**	p.125
	S1-2133	p.5
Hallegraeff, Gustaaf M.	**S5-2022**	p.64
Hamner, William M.	**S3-2095**	p.33
Han, Geng-Chen	BIO_P-1778	p.161
Hao, Y.J.	S2-1802	p.29
Harada, Koh	S8-2134	p.110
Hare, Steven R.	**S2-1904**	p.20
Hashimoto, Shinji	BIO_P-1844	p.164
Henry, Mike	S7-1819	p.79
Heo, Seung	BIO_P-1958	p.163
Heppell, Scott S.	S11-1935	p.153
Heppell, Selina S.	S11-1935	p.153
Hermann, Albert J.	**S9-2040**	p.125
	S10-2041	p.144
	S11-2042	p.152
Hermann, Albert Y.	S9-1993	p.123
Hickey, Barbara M.	HAB-2198	p.257
Hidaka, Kiyotaka	W2-2100	p.223
	S3-1961	p.34
Hinckley, Sarah	**S10-2041**	p.144
	S10-2112	p.146
	S11-2042	p.152
Hipfner, J. Mark	W2-2074	p.219
	W6-2149	p.263
Hiroe, Yutaka	W2-2100	p.223
Hiroishi, Shingo	HAB-2199	p.255
Hixon, M.A.	GP-2153	p.212
Hollowed, Anne B.	S9-1868	p.133
	S2-2001	p.21
	W4-1992	p.240
Holt, Carrie	**S9-2032**	p.126
Honda, Satoshi	FIS_P-1822	p.174
Hooff, Rian C.	S9-2081	p.135
	W2-2082	p.224
	W2-2045	p.224
Hopcroft, Russell R.	**W2-1933**	p.219
	W2-1932	p.220
	S3-1883	p.34
Horii, Toyomitsu	**GP-1799**	p.200
Hoshioka, Taketo	W2-1886	p.225
Howell, Evan A.	**GP-2077**	p.200
Hsieh, Hung-Yen	**BIO_P-1912**	p.160
Hsu, Pei-Kai	**S3-1908**	p.35
Huh, Sung-Hoi	GP-2162	p.197
Hunt Jr., George L.	**S2-1826**	p.21
	S2-2106	p.24
	S9-1868	p.133
Huo, Chuan-Lin	**BIO_P-1778**	p.161
Huyer, Adriana	S9-1986	p.118
	S9-2084	p.120
	S9-1871	p.139
Hwang, Doojin	BIO_P-2064	p.162
Hyrenbach, David	S4-2058	p.54
	S4-2060	p.55
	S7-1819	p.79
	S4-1885	p.47
	S4-2115	p.50
Hyun, Karen	S9-2052	p.130

I

Ianson, Debby **S8-2147** p.104
Ichihara, Morio **BIO_P-2101** p.161
Ichii, Taro S1-1827 p.4
Iguchi, Naoki GP-1841 p.212
Iida, Takahiro W4-1997 p.244
Ikeda, Motoushi S7-1926 p.86
Ikeda, Tsutomu **BIO_P-1888** p.162
W2-1866 p.225
Ilynskiy, Evgeniy N. S3-1838 p.40
Imai, Ichiro **W5-2192** p.252
HAB-2199 p.255
Inagake, Denzo **S1-2018** p.6
Inai, Taisuke FIS_P-1896 p.176
Inoue, Hisayuki Y. **S8-1876** p.104
S8-1915 p.105
S8-1895 p.107
S8-2140 p.108
Irons, David BIO_P-2059 p.165
Ishida, Minoru W3-2182 p.232
Ishida, Yukimasa **FIS_P-1922** p.175
Ishii, Masao S8-1876 p.104
S8-1918 p.105
S8-1915 p.105
S8-1895 p.107
S8-2140 p.108
S8-1917 p.110
Ishikawa, Akira W5-2192 p.252
HAB-2199 p.255
Ishiko, Nozomi **FIS_P-2025** p.175
Ishizaki, Shiro S7-2029 p.83
Ishmukova, Irina V. **S10-1920** p.144
Itakura, Shigeru W5-2192 p.252
HAB-2199 p.255
Ito, Shin-ichi **S10-2120** p.145
W3-2121 p.229
Itoh, Hiroshi S1-1833 p.11
BIO_P-1840 p.163
Itoh, Sachihiko K. **S4-1947** p.48
Iwasaki, Keiji **S5-2135** p.65

J

Jacobson, Kym FIS_P-1853 p.180
S9-1936 p.118
S9-1902 p.126
Jacoby, Charles S3-1930 p.39
James, Corinne S7-2044 p.91
Jamieson, Glen S. **S6-1869** p.71
Jeong, Hae-Jin S9-1894 p.127
Jeong, Hee Dong W5-2193 p.253
HAB-2201 p.255
Jeong, Hyeon Gyeong **W2-2057** p.220
Jiang, Mingshun S8-2146 p.99
Jin, Eon Seon GP-1784 p.195
Jodice, Patrick BIO_P-2059 p.165
Johnston, Dave S2-2148 p.27
Jorgensen, Salvador J. S4-1897 p.52
Jun, Mo S7-1801 p.80
Jung, Woongsic S4-1913 p.50
Jung, Yeongha W2-1954 p.221

K

Kaeriyama, Masahide **GP-1862** p.201
Kalinin, A.V. GP-1774 p.203
Kamachi, Masafumi **S7-2029** p.83
Kamiya, Hitomi S8-1915 p.105
S8-1895 p.107
Kaneda, Atsushi FIS_P-1896 p.176
S3-1916 p.35
Kaneko, Ikuo S8-1918 p.105
Kang, Dong Woo GP-2162 p.197
Kang, Dong-Jin S8-2080 p.106
Kang, Geoyoung S4-1913 p.50
Kang, Hyung-Ku **W2-1954** p.221
Kang, Jung-Hoon **S9-1894** p.127
Kang, Sukyung S2-2023 p.26
S4-2011 p.48
Kang, Yong Joo W2-1954 p.221
Kang, Young Chul S8-1893 p.109
Kang, Young Shil **W2-2126** p.221
W5-2193 p.253
HAB-2201 p.255
S3-2129 p.36
S3-2127 p.36
Kang, Yun Hee GP-2161 p.197
Kaplunenko, Dmitry D. S7-1974 p.88
S11-1975 p.153
W4-1964 p.243
Karedin, Evgeny P. FIS_P-1814 p.171
Karl, David M. S1-2185 p.3
S8-2047 p.106
Karpenko, Vladimir I. **FIS_P-2152** p.176
Kartashov, Vladimir A. GP-2065 p.202
Kasai, Hiromi **W2-2016** p.222
Kato, Hidehiro **W6-2125** p.261
W6-1973 p.262

Kato, Hidehiro	S4-1983	p.46
Katugin, Oleg N.	**S1-2113**	p.6
	S1-2114	p.7
Kawahara, Shigeyuki	BIO_P-2101	p.161
Kawai, Hiroshi	S5-2139	p.67
Kawano, Takeshi	S8-1915	p.105
Keister, Julie E.	**S9-2075**	p.127
	S3-1865	p.38
Key, R.	S8-1985	p.102
	W4-1984	p.238
Key, Robert M.	S8-2031	p.103
	S8-1988	p.108
Kidokoro, Hideaki	GP-1841	p.212
	S2-2000	p.28
Kikuchi, Takeaki	S5-2163	p.62
Kim, Chul Ho	S8-1893	p.109
Kim, Dong Seon	S8-1893	p.109
Kim, Duk-Jin	S7-2006	p.85
Kim, Eun Jung	**FIS_P-2021**	p.176
Kim, Eung	S11-1975	p.153
Kim, Gui Young	**W5-2193**	p.253
	HAB-2201	p.255
Kim, Hak Gyoon	W5-2193	p.253
	HAB-2201	p.255
Kim, Hee-Yong	**FIS_P-1896**	p.176
Kim, Hye Seon	**BIO_P-2064**	p.162
Kim, Hyun-Cheol	**W2-1887**	p.222
	W4-2156	p.246
Kim, Jin Yeong	**W3-2033**	p.229
Kim, Kuh	S7-2006	p.85
	S7-2007	p.87
Kim, Kyung-Ryul	S8-2080	p.106
Kim, Myung-Sook	GP-2161	p.197
Kim, Sook Yang	W5-2193	p.253
	HAB-2201	p.255
Kim, Suam	S9-2052	p.130
	FIS_P-2021	p.176
	S2-2023	p.26
	S4-2011	p.48
	S4-1913	p.50
Kim, Woo-Jin	W3-2033	p.229
Kim, Woong-Seo	S9-1894	p.127
Kim, Young Ho	S7-2006	p.85
Kim, Yun-Bae	S7-2006	p.85
Kimmerer, W.J.	S5-2036	p.61
Kimura, Ryo	S2-1956	p.27
Kimura, Shingo	S4-1947	p.48
	S4-1951	p.49
King, Jacquelynne R.	**W4-2167**	p.239
Kino, Seiji	S5-2163	p.62
Kirincich, Anthony R.	S9-1986	p.118
Kishi, Michio J.	S10-1960	p.143
	S10-2083	p.146
	W2-1886	p.225
	S10-2120	p.145
	W3-2121	p.229
Kitagawa, Miwako	GP-1862	p.201
Kitagawa, Takashi	**S4-2105**	p.49
Kitaysky, Alexander	**S2-2116**	p.22
	W6-2118	p.261
Kiyofuji, Hidetada	FIS_P-2025	p.175
Kiyosawa, Hiroshi	BIO_P-1840	p.163
	W2-2100	p.223
Klimley, A. Peter	S4-1897	p.52
Kline Jr., Thomas C.	**S9-1855**	p.128
Kobari, Toru	**S9-2030**	p.128
	W2-1816	p.223
	W2-1866	p.225
Kobayashi, Donald R.	GP-2077	p.200
	S7-2002	p.83
Kochergin, Igor E.	GP-1962	p.194
	S7-1967	p.80
Kochetova, Vera A.	GP-2065	p.202
Kochevar, Randy	S4-2020	p.45
Kodolov, Leonid S.	**GP-1889**	p.201
	GP-1891	p.202
	GP-1892	p.210
Koh, Jeong-Rack	FIS_P-2021	p.176
Kohama, Takeshi	**S3-1921**	p.36
	S3-1923	p.37
Koldunov, Alexey V.	S11-1806	p.151
Komatsu, Kosei	W2-2100	p.223
	W3-2121	p.229
	W3-2012	p.230
Konishi, Yoshinobu	FIS_P-1823	p.180
	FIS_P-1831	p.187
Konovalova, Tatyana V.	GP-2019	p.196
Korochentsev, Vladimir I.	**GP-2065**	p.202
Korostelev, Sergey G.	**FIS_P-1836**	p.177
Kosro, P. Michael	S9-1871	p.139
Kotwicki, Stanislaw	W4-2099	p.237
Kovatcheva, Nikolina P.	**GP-1774**	p.203
Kozyr, Alexander	S8-2031	p.103
	S8-1988	p.108
Krovnin, Andrei S.	**S9-1987**	p.129
	GP-1990	p.209

Kruse, Gordon H.	FIS_P-1873	p.182
	S2-1929	p.29
	S4-2034	p.46
Kubodera, Tsunemi	GP-1863	p.208
Kubota, Hiroshi	S2-1956	p.27
Kuma, Kenshi	W2-1866	p.225
Kupera, Nikolay S.	GP-1962	p.194
Kuragano, Tsurane	S7-1911	p.89
Kurihara, Yukio	S7-1911	p.89
Kurita, Kiyo	BIO_P-1840	p.163
	W2-2100	p.223
Kurita, Yutaka	S10-2120	p.145
Kuroda, Kazuki	S9-2030	p.128
Kuzin, Victor I.	**S7-2090**	p.84
Kuznetsov, Michail	FIS_P-1879	p.179
Kuznetsov, V.V.	**FIS_P-2103**	p.177
Kuznetsova, E.N.	FIS_P-2103	p.177
Ladah, Lydia B.	**S9-1881**	p.129

L

Lamb, M. F.	S8-1985	p.102
	W4-1984	p.238
Landry, Michael R.	**S1-2049**	p.8
Lawson, Peter W.	**W4-2111**	p.239
Le Quere, Corinne	S8-2140	p.108
Lee, Chang Kyu	W5-2193	p.253
	HAB-2201	p.255
Lee, Choon-Hwan	GP-2162	p.197
	GP-2161	p.197
Lee, Chung Il	**S9-1949**	p.130
Lee, Derek	S2-2148	p.27
Lee, Dong Woo	S9-2052	p.130
Lee, Hye Eun	S3-2127	p.36
	S3-2129	p.36
Lee, Jae Bong	**S9-2052**	p.130
	FIS_P-2051	p.188
Lee, Jae Hak	S8-1893	p.109
Lee, Kitack	**S8-2080**	p.106
	S8-1988	p.108
Lee, Ming-An	S3-1908	p.35
Lee, Sam Geon	**BIO_P-1958**	p.163
Lee, Tae Kyun	GP-1784	p.195
Lee, Yong-Woo	**FIS_P-1937**	p.178
Lee, Youn-Ho	S4-2011	p.48
	S4-1913	p.50
Leising, Andrew W.	**S10-2062**	p.145
Lelyukh, Natalia N.	**BIO_P-1965**	p.163
Letelier, R.M.	S1-2185	p.3
Letelier, Ricardo	S7-2196	p.92
Levitus, Syd	S8-1817	p.103
Li, Michelle	**S7-2202**	p.84
Li, Ruixiang	S2-1802	p.29
	W5-2197	p.254
	HAB-1825	p.258
	HAB-1864	p.258
Li, Shujiang	S1-2122	p.11
Li, Y.	S2-1802	p.29
Li, Yu-Zhu	GP-1914	p.199
Lim, Wol Ae	W5-2193	p.253
	HAB-2201	p.255
Lin, Pengfei	S7-2176	p.92
Lion, Monica	W5-2179	p.252
Lishavskaya, Tatyana S.	GP-2019	p.196
	GP-1779	p.203
Liu, Don-Chung	BIO_P-1912	p.160
	S3-1909	p.39
Liu, H.	S3-1979	p.33
Liu, Hui	W2-1932	p.220
Livingston, Patricia A.	S2-2109	p.17
Lluch-Belda, Daniel	S2-1991	p.25
Lo, Wen-Tseng	BIO_P-1912	p.160
	S3-1908	p.35
	S3-1909	p.39
Lobanov, Vyacheslav B.	S11-1975	p.153
	S7-2054	p.84
Loboda, Sergey V.	**FIS_P-2013**	p.178
Locarnini, Ricardo	S8-1817	p.103
Logerwell, Elizabeth A.	**W4-1992**	p.240
	S6-1938	p.72
Lubchenco, Jane	S9-1986	p.118
Lucano-Ramírez, G.	S7-2189	p.82
Lukas, R.	S1-2185	p.3
Lukyanova, Olga N.	**GP-1905**	p.204
Lutcavage, Molly	S4-1989	p.53
	S11-1935	p.153

M

MacCall, Alec D.	**W3-2063**	p.230
Mackas, David	S9-2204	p.134
Mackenzie, Fred T.	S8-2151	p.102
Macklin, S. Allen	FIS_P-1937	p.178
Madec, Gurvan	S8-2140	p.108
Madrid, Juan	FIS_P-1820	p.171
Magome, Shinya	**S3-1923**	p.37
Maier-Reimer, Ernst	S8-2140	p.108
Makarov, Vyacheslav G.	BIO_P-1781	p.159

Man'ko, Alexander N.	GP-1945	p.206
Mantua, Nathan J.	**W4-2048**	p.240
Martinez, Felipe Amezcua	FIS_P-1924	p.186
Martínez, Guillermo	S7-1854	p.90
Martínez-Tovar, Ivan	BIO_P-1835	p.159
Maschner, Herbert D. G.	S2-1821	p.28
Masuda, Reiji	FIS_P-1831	p.187
Masuda, Shinya	GP-2119	p.213
Mate, B.	S4-2168	p.45
Mathisen, Ole A.	**FIS_P-1950**	p.179
Matsuda, Hiroyuki	**S2-2117**	p.22
Matsueda, Hidekazu	S8-1918	p.105
	S8-1895	p.107
Matsumoto, Kazuhiko	S8-1915	p.105
Matsuoka, Koji	S4-1983	p.46
Maximenko, Nikolai A.	**S7-1810**	p.85
Maxwell, Sara	S6-2098	p.72
McCarthy, Abigail L.	**S11-1935**	p.153
McDermott, Susanne F.	S6-1938	p.72
McFarlane, Gordon A.	S2-2066	p.18
	W4-2167	p.239
McKinley, Galen	S8-2140	p.108
McKinnell, Stewart M.	S9-2032	p.126
	W4-2156	p.246
McNutt, S. Lyn	**W4-1811**	p.241
Mecking, Sabine	**S8-2102**	p.107
Megrey, Bernard A.	S10-2120	p.145
	FIS_P-1937	p.178
	W3-2121	p.229
	S2-2043	p.23
	W4-2067	p.242
Melnikov, Igor V.	**S2-1948**	p.23
Melo, Arturo Muhlia	S4-1897	p.52
Mendelssohn, Roy	S1-2096	p.9
Mendez-Rodríguez, Lía	GP-2188	p.208
Menge, Bruce A.	S9-1986	p.118
Metzl, Nicolas	S8-2140	p.108
Midorikawa, Takashi	S8-1876	p.104
	S8-1915	p.105
	S8-1918	p.105
	S8-1895	p.107
Miller, Arthur J.	S9-2014	p.119
	W4-2187	p.241
	S2-1821	p.28
	S8-1988	p.108
Min, Gisic	S4-1913	p.50
Minchin, Dan	**S5-1795**	p.65
Minobe, Shoshiro	**W4-2155**	p.242
Mishchenko, Mikhail V.	S7-1967	p.80
Miyahara, Kazutaka	GP-1828	p.194
Miyamura, Tsuyoshi	S7-1946	p.89
Miyanaga, Sachi	S2-1939	p.26
Miyasaka, Hitoshi	S3-1921	p.36
Miyashita, Kazushi	BIO_P-2101	p.161
	FIS_P-1959	p.184
Miyashita, Tomio	**W6-1973**	p.262
Miyazawa, Yasumasa	S10-1919	p.143
Mocshenko, Alexander V.	GP-2019	p.196
Moiseenko, Georgy	S11-1943	p.154
Moku, Masatoshi	S1-1833	p.11
Moon, Dae-Yeon	FIS_P-2021	p.176
Moon, Woo-il M.	S7-2006	p.85
Moore, Christopher W.	S11-2042	p.152
Moore, Sue E.	S2-2106	p.24
Morgan, Ken	S7-1819	p.79
	S4-1885	p.47
	S4-2115	p.50
Morgan, L.	S4-2168	p.45
Morgan, Lance E.	**S6-2098**	p.72
Morita, Kentaro	**S9-1789**	p.131
Morita, Shoko H.	S9-1789	p.131
Moroz, Valentina V.	**GP-1783**	p.204
Moshenko, Alexander V.	GP-1779	p.203
Moury, George P.	S9-1987	p.129
Moyseychenko, G.V.	**S6-2104**	p.73
Mueter, Franz J.	**S2-2038**	p.23
	W4-2067	p.242
Muhlia-Melo, A.	S4-1942	p.47
Mukai, Daiki	S10-2120	p.145
	S10-2083	p.146
Mundy, Phil	W4-1811	p.241
Murase, Hiroto	BIO_P-2101	p.161
	S4-1983	p.46
Murata, A.	S8-1985	p.102
	W4-1984	p.238
Murata, Akihiko	S8-1876	p.104
Murtugudde, Raghu	S8-2140	p.108
	W4-1925	p.243
Myers, Katherine W.	GP-1862	p.201
Myers, Paul	S7-2202	p.84

N

Nadtochy, Victoria V.	W3-1845	p.232
Nagai, Kiyohito	HAB-2199	p.255
Nagai, Naoki	S9-2030	p.128
Nagano, Shinya	S3-1921	p.36

Nagasawa, Toru	FIS_P-1922	p.175
Nakano, Toshiya	S7-2029	p.83
Nakata, Hideaki	S9-2014	p.119
Nakata, Kaoru	**BIO_P-1840**	p.163
	W2-2100	p.223
	S3-1961	p.34
Nam, SungHyun	**S7-2006**	p.85
Napp, Jeffrey M.	**S2-2106**	p.24
Navrotsky, Vadim V.	**S9-1971**	p.131
Nechaev, Dmitri	S7-1926	p.86
Nedashkovsky, Alexander P.	GP-2053	p.207
Nelezin, Alexander D.	GP-1945	p.206
Nelson, Wendy	S5-2139	p.67
Nemoto, Kazuhiro	S8-1876	p.104
	S8-1915	p.105
	S8-1895	p.107
Ni, Yong	FIS_P-2190	p.173
Nielsen, Jennifer L.	**S2-2068**	p.24
Nielsen, Karina J.	S9-1986	p.118
Nieto, Karen	S7-1854	p.90
Nihira, Akira	**S9-2142**	p.132
Niiler, Pearn P.	S7-1810	p.85
Nikolaev, Alexander	**FIS_P-1879**	p.179
Nishida, Hiroshi	S1-1833	p.11
	FIS_P-1857	p.184
	W3-2183	p.231
	W3-2182	p.232
Nishida, N.	BIO_P-2128	p.165
Nishikawa, J.	BIO_P-2128	p.165
Nishiwaki, Shigetoshi	S4-1983	p.46
Noh, Jae-Hoon	S9-1894	p.127
Nojiri, Y.	S8-2008	p.101
Nojiri, Yukihiro	S8-2134	p.110
	S8-1882	p.111
	GP-1972	p.205
Norcross, Brenda L.	S2-2038	p.23
Noto, Masayuki	**GP-1848**	p.205
	W3-2182	p.232
Novinenko, George	**S7-1861**	p.86

O

O'Brien, James J.	S10-1978	p.146
Occhipinti, Anna	S5-1795	p.65
Oguma, Sachiko	**GP-1972**	p.205
Ogura, Miki	S1-2018	p.6
Oh, Im Sang	**S9-2186**	p.132
	GP-2181	p.206
	W2-1887	p.222
Oh, Min-Hyuk	GP-2162	p.197
	GP-2161	p.197
O'Hara, Patrick D.	**S4-2115**	p.50
Ohizumi, Hiroshi	W6-2125	p.261
	S4-1977	p.51
Ohshimo, Seiji	FIS_P-1957	p.185
Oichi, Kazuyoshi	GP-1972	p.205
Okuda, Noboru	S3-1921	p.36
Oleynik, Elena V.	BIO_P-1781	p.159
Ono, Tsueno	S8-1988	p.108
	W2-2016	p.222
Oozeki, Yoshioki	**S9-2076**	p.133
	W3-2121	p.229
	S2-1956	p.27
Orlov, Alexei M.	**S5-1775**	p.66
Orlova, Tatiana Yu.	**W5-2194**	p.253
	HAB-1970	p.256
Orr, James	S8-2140	p.108
Ortega-García, Sofía	S2-1991	p.25
Ortiz, Ivonne	**GP-2144**	p.205
	S4-2143	p.51
Overland, James	**S9-1868**	p.133
Ovsyannikov, Evgeny E.	FIS_P-1953	p.182
Ovsyannikova, Svetlana L.	FIS_P-1953	p.182
Ozaki, Kiyoaki	S4-2058	p.54
	S4-2060	p.55

P

Pachepsky, Elizaveta	S5-1928	p.67
Padmavati, Gadi	W2-1866	p.225
Pages, Francesc	S3-1930	p.39
Pahorukov, Nikolay P.	FIS_P-1800	p.173
Pakhomov, Evgeny A.	**S3-1898**	p.37
Palmer, Michael C.	S2-2038	p.23
Panteleev, Gleb	**S7-1926**	p.86
Parada, Carolina	**S10-2112**	p.146
Park, Geun-Ha	S8-2080	p.106
Park, Jong Jin	S7-2006	p.85
	S7-2007	p.87
Park, Kyung-Ae	S7-2006	p.85
	S7-2007	p.87
Park, Seunghye	GP-1784	p.195
Park, Taewook	**GP-2181**	p.206
Park, Young Tae	W5-2193	p.253
	HAB-2201	p.255
Park, Young-Gyu	GP-2132	p.196
Pearson, Cathy	GP-2050	p.207
Peña, Angelica	**W5-2195**	p.254

Peña, Angelica	**HAB-2200**	p.256
	S7-2164	p.87
Peng, Tsung-Hung	S8-1988	p.108
	S8-2146	p.99
Perle, Chris	S4-2105	p.49
Perry, Ian	**S9-2204**	p.134
Peterman, Randall M.	**S9-2108**	p.135
Peterson, William	**S9-2081**	p.135
	W2-2082	p.224
	S9-2075	p.127
	W2-2045	p.224
	S3-1865	p.38
Petrova, Vera A.	**GP-1945**	p.206
Piccolo, Jack	S9-2035	p.124
Pinchuk, Alexei I.	S9-1859	p.122
	W2-1933	p.219
Platov, Gennady A.	**S7-1803**	p.87
Pokrashenko, Sergey A.	GP-1962	p.194
Polovina, Jeffrey J.	S9-2084	p.120
Ponomarev, Vladimir I.	GP-2053	p.207
	W4-1964	p.243
	S7-1974	p.88
Popov, Serguei B.	S1-1773	p.5
Powell, Thomas	S9-1993	p.123
Power, Mary E.	**S2-2173**	p.25
Propp, Luisa N.	BIO_P-1781	p.159
Purcell, Jennifer E.	**S3-1899**	p.38
Pyper, Brian J.	S9-2108	p.135

Q

Qu, Weizheng	S1-2122	p.11
Quenneville, Melanie	W5-2195	p.254

R

Radchenko, Vladimir I.	**S9-1842**	p.136
	W4-2154	p.244
Ralston, Steve	S2-2148	p.27
Rand, Peter S.	**GP-2050**	p.207
Rassadnikov, O.A.	FIS_P-2152	p.176
Ream, Rolf R.	**W6-2177**	p.262
Reese, Douglas C.	**S4-2046**	p.52
Richert, John E.	**S4-1897**	p.52
Rintoul, Chris	S4-2115	p.50
Rios, Aida F.	S8-1988	p.108
Ro, Young J.	S11-1975	p.153
	S7-1974	p.88
Roby, Daniel	BIO_P-2059	p.165
	S4-2058	p.54
Roby, Daniel	S4-2060	p.55
Rodgers, Keith B.	**S8-2140**	p.108
Rodriguez, Omar	FIS_P-1995	p.181
Rodríguez-Meza, Guadalupe Durga	GP-2188	p.208
Rodríguez-Sánchez, Rubén	**S2-1991**	p.25
Roemmich, Dean	S7-1981	p.82
Rogachev, Konstantin	**S7-1782**	p.88
Rojo-Vázquez, J.	S7-2189	p.82
Rollwagen-Bollens, Gretchen	**S5-2157**	p.66
Romanov, Alexander	S7-1860	p.90
Rostov, Igor D.	S11-1788	p.154
Rostov, Vladimir I.	**S11-1788**	p.154
Royer, Thomas C.	**S9-2072**	p.136
Rudykh, Natalia I.	S11-1788	p.154
	W4-1964	p.243
Ruggerone, Gregory T.	S2-2068	p.24
Ruiz, G.M.	S5-2036	p.61
Ruíz-Ramírez, S.	S7-2189	p.82
Rybalko, Sergey I.	GP-1962	p.194
	S7-1967	p.80

S

Sabine, C. L.	S8-1985	p.102
	W4-1984	p.238
	S8-2031	p.103
	S8-1988	p.108
Sadler, Daniel W.	S8-2151	p.102
	S8-2069	p.109
Saino, Toshiro	S9-1944	p.121
	S9-1968	p.137
Saito, Hiroaki	S9-2076	p.133
	S9-1968	p.137
Saito, Shu	S8-1915	p.105
	S8-1918	p.105
Saitoh, Katsuya	S11-1941	p.154
	S4-1940	p.57
Saitoh, Sei-Ichi	S11-1941	p.154
	FIS_P-2025	p.175
	W2-1866	p.225
	W4-1997	p.244
	S4-1940	p.57
	S7-1946	p.89
	S7-2027	p.91
Sakurai, Toshiyuki	**S7-1911**	p.89
Sakurai, Yasunori	GP-1863	p.208
	GP-2119	p.213
	S2-1939	p.26
Salomatin, Aleksandr S.	W4-1964	p.243

Samko, Eugene V.	**S4-1815**	p.53
Samuelsen, Annette	**S10-1978**	p.146
Sánchez-Rodríguez, Ignacio	GP-2188	p.208
Sandell, Todd	**FIS_P-1853**	p.180
Sano, Fumikazu	BIO_P-1888	p.162
Sapozhnikov, Dmitry	GP-2188	p.208
Sarmiento, Jorge L.	S8-2031	p.103
Saruwatari, Toshiro	FIS_P-1831	p.187
Sasaki, Hiroaki	S7-1946	p.89
Sasaoka, Kosei	BIO_P-1844	p.164
	S7-1946	p.89
Sassa, Chiyuki	**FIS_P-1823**	p.180
	FIS_P-1831	p.187
Sato, Fumio	S4-2058	p.54
	S4-2060	p.55
Sato, R.	S3-1979	p.33
Savelieva, Nina I.	**GP-2053**	p.207
Savini, Dario	S5-1795	p.65
Savinikh, Vadim	BIO_P-1812	p.160
	BIO_P-2078	p.164
	S1-2079	p.8
Schabetsberger, Robert A.	S9-1872	p.120
Scherbinin, Alexey F.	S7-1967	p.80
Schick, Robert S.	**S4-1989**	p.53
Schirripa, Michael J.	**FIS_P-1995**	p.181
Schneider, Niklas	**S1-2150**	p.8
Schumacher, Jim	W4-1811	p.241
Schweigert, Jake	**W3-2205**	p.231
Schwing, Franklin B.	S9-2084	p.120
	W4-2141	p.245
	S4-2097	p.54
	S1-2096	p.9
Seki, Michael P.	**S1-2165**	p.9
Selina, Marina S.	BIO_P-1781	p.159
	W3-1845	p.232
Seo, Hyunju	**S2-2023**	p.26
Seong, Ki-Baek	S4-1913	p.50
Seong, Kibeik	S2-2023	p.26
Sereda, Nataliya	S8-2015	p.99
Shaffer, Scott	S4-2060	p.55
Shaw, Tracy	W2-2082	p.224
Sheiko, Boris A.	FIS_P-2088	p.186
Sheridan, Cecelia C.	S1-2049	p.8
Sheu, David D.	S8-2055	p.100
Shevchenko, George	S7-1861	p.86
	S7-1860	p.90
Shevchenko, Igor	**S11-1943**	p.154
Shevtsov, Gennadiy A.	S1-2113	p.6
Shi, Lei	S8-2146	p.99
Shim, Jeong Hee	**S8-1893**	p.109
Shimura, Saya	**GP-1863**	p.208
Shimura, Tsuyoshi	GP-2119	p.213
Shiomoto, Akihiro	**BIO_P-1844**	p.164
	W2-2100	p.223
Shiraishi, Tomotaka	HAB-2199	p.255
Shitkova, Olga A.	GP-1839	p.198
Shlyk, Natalya	S7-1782	p.88
Shoden, Satoko	W2-1866	p.225
Shulkin, Vladimir M.	GP-1779	p.203
Shumilin, Evgueni	**GP-2188**	p.208
Shutta, Keizo	S8-1918	p.105
Sievert, Paul	S4-2058	p.54
Sigler, Mike	S4-1793	p.46
Silva, Claudio	W4-1867	p.245
	S7-1854	p.90
Slater, Laura M.	W2-1932	p.220
Slaughter, Anne M.	S5-2157	p.66
Slobodskoy, Evgenyi V.	S1-2114	p.7
Smirnov, Anatoly V.	**FIS_P-1805**	p.181
	FIS_P-1953	p.182
Smith, G.	S5-2036	p.61
Smith, Robert L.	S9-2084	p.120
	S9-1871	p.139
Smolin, Vladimir	S8-2174	p.111
Soh, Ho Young	BIO_P-2064	p.162
	W2-2057	p.220
Son, Min Ho	S3-2127	p.36
	S3-2129	p.36
Spencer, Paul D.	**W4-1996**	p.245
Springer, Alan	S2-2116	p.22
Stabeno, Phyllis	S9-1868	p.133
Stahl, Jennifer P.	**FIS_P-1873**	p.182
Stegmann, Petra M.	S4-2097	p.54
Stepanenko, Mikhail A.	**FIS_P-1809**	p.183
Stockwell, Dean A.	S9-2175	p.139
Strub, P. Ted	**S7-2044**	p.91
	S7-2196	p.92
Stumpf, Richard P.	HAB-2039	p.257
Su, Jian	S10-1798	p.147
	S10-1796	p.147
Su, Jie	S1-2122	p.11
Su, Wei-Cheng	BIO_P-1912	p.160
	S3-1909	p.39
Suchman, Cynthia L.	**S3-1865**	p.38
Suda, Maki	W3-2182	p.232
Sugimoto, Takashige	S9-2030	p.128

Sugisaki, Hiroya	S9-1944	p.121
	S9-1968	p.137
Suh, Hae-Lip	W2-2057	p.220
Suh, Young Sang	HAB-2201	p.255
Suntsov, Andrei V.	**S1-1877**	p.10
	S1-1878	p.10
Suryan, Robert	**BIO_P-2059**	p.165
	S4-2058	p.54
	S4-2060	p.55
Sutherland, Peter	S7-2160	p.79
Suzuki, Katsuya	**FIS_P-1959**	p.184
Sydeman, William	**S2-2148**	p.27
	S7-1819	p.79
	GP-1903	p.195
	W2-2074	p.219
	W6-2149	p.263
	S4-1885	p.47
	S4-2115	p.50

T

Tadokoro, Kazuaki	S9-2030	p.128
	S9-1968	p.137
Takagi, Kaori	S1-1833	p.11
Takagi, Tsutomu	FIS_P-1959	p.184
Takahashi, Masakazu	S9-2142	p.132
Takahashi, Motomitsu	**FIS_P-1857**	p.184
	W3-2183	p.231
Takahashi, Taro	S8-2140	p.108
Takasuka, Akinori	FIS_P-1957	p.185
	S2-1956	p.27
Takemura, Hiroki	**S7-2027**	p.91
Takeoka, Hidetaka	FIS_P-1896	p.176
	S3-1916	p.35
	S3-1921	p.36
	S3-1923	p.37
Tanaka, Hiroshige	**FIS_P-1957**	p.185
Tanaka, Shinichi S.	**GP-2024**	p.209
Tananaeva, Yulia N.	**GP-1990**	p.209
Tang, Qisheng	**S9-1880**	p.137
	FIS_P-1813	p.185
Tatebe, Hiroaki	W4-2026	p.246
Taylor, Peter	**S6-2123**	p.73
Teel, David	FIS_P-1853	p.180
Telmer, Kevin	S4-2011	p.48
Tepnin, Oleg B.	FIS_P-1776	p.172
Terentiev, Dmitry A.	FIS_P-2088	p.186
	GP-2089	p.211
Thomas, Andrew	S7-2196	p.92
Thomas, Andrew C.	S7-2044	p.91
Thompson, Luanne	S8-1834	p.102
Tian, Tian	**S10-1798**	p.147
Tian, Yongjun	**S2-2000**	p.28
Tilbrook, Bronte	S8-1988	p.108
Timchenko, Nelly F.	GP-1839	p.198
Tkalin, Alexander	**GP-1771**	p.210
Toczko, Sean	**BIO_P-2128**	p.165
Tokieda, Takayuki	**S8-1917**	p.110
Tokranov, Alexei M.	FIS_P-2088	p.186
Tomlinson, Michelle C.	**HAB-2039**	p.257
Tong, Ling	**FIS_P-1813**	p.185
Toratani, Mitsuhiro	BIO_P-1844	p.164
Torisawa, Shinsuke	FIS_P-1959	p.184
Tovar, Ivan Martinez	**FIS_P-1924**	p.186
Trainer, Vera L.	W5-2159	p.251
	HAB-2198	p.257
Trasviña-Castro, A.	S4-1942	p.47
Tremblay, Yann	S4-2060	p.55
Trites, Andrew W.	**S2-1821**	p.28
	S1-1994	p.3
Trusenkov, Serge T.	S7-1974	p.88
Trusenkova, Olga O.	S7-1974	p.88
Tsao, Fan	S6-2098	p.72
Tsukamoto, Katsumi	S4-1951	p.49
Tsurushima, Nobuo	**S8-2134**	p.110
Tunegolovets, Valeriy P.	GP-1962	p.194
Tuponogov, Vladimir N.	**GP-1892**	p.210

U

Uehara, Kazuyuki	S1-2018	p.6
Ueno, Yasuhiro	S10-2120	p.145
Uiblein, Franz	S3-1930	p.39
Uji, Ryosuke	GP-2119	p.213
Uosaki, Koji	S1-2018	p.6
Usui, Norihisa	S7-2029	p.83
Usui, Toshihiro	GP-1972	p.205
Uwai, Shinya	**S5-2139**	p.67

V

Valle-Levinson, A.	S4-1942	p.47
van Hardenberg, Peter	S7-2160	p.79
Vaschenko, Marina A.	GP-2184	p.193
Vasik, Olga	S11-1943	p.154
Vasilets, P.M.	FIS_P-1836	p.177
Velikanov, Anatoliy Ya.	**S4-1787**	p.55
Venegas, Roberto M.	**S7-2196**	p.92
Vera, Juan Madrid	FIS_P-1924	p.186

Vinnikov, Andrey V. **FIS_P-2088** p.186
GP-2089 p.211
Vlasova, Galina A. **GP-1794** p.211
S4-1797 p.56
Voelker, Christoph S8-2147 p.104
Volkov, Yury N. S7-1967 p.80
Vorobyov, Pavel V. FIS_P-2013 p.178

W

Wada, Yozo FIS_P-1957 p.185
Wade, Paul S2-2145 p.19
Wainwright, Thomas C. S2-1858 p.20
W2-2045 p.224
Wakefield, W.W. GP-2153 p.212
Waldvogel, Jim S4-2071 p.56
Wallace, Douglas W.R. S8-1988 p.108
Wang, Fan **S7-2176** p.92
Wang, Ju-Ying BIO_P-1778 p.161
Wang, Rong **BIO_P-1770** p.166
Wang, Shu-Lun S8-2055 p.100
Wang, Z.L. S2-1802 p.29
Wang, Zongling W5-2197 p.254
HAB-1825 p.258
Wanninkhof, R. S8-1985 p.102
W4-1984 p.238
S8-1988 p.108
S8-2140 p.108
Wardrop, John A. GP-1962 p.194
Warner, Mark J. S8-2102 p.107
Watanabe, Hikaru BIO_P-2101 p.161
S4-1977 p.51
Watanabe, Shuyo GP-2119 p.213
Watanabe, Tatsuro **GP-1841** p.212
S2-2000 p.28
Watanabe, Tomoo W2-2100 p.223
Watanabe, Yasunori W5-2192 p.252
HAB-2199 p.255
Watanabe, Yoshiro S9-1807 p.121
FIS_P-1857 p.184
FIS_P-1831 p.187
FIS_P-1830 p.187
Watanabe, Yutaka W. S8-2134 p.110
GP-2024 p.209
Wei, Hao S10-1798 p.147
Weingartner, Thomas **S9-2138** p.138
S9-2072 p.136
Welch, David S4-2011 p.48
S7-1819 p.79
Welch, David **S7-1832** p.93
Wells, Brian K. **S4-2071** p.56
Wells, Mark HAB-2198 p.257
S5-2094 p.62
Werner, Francisco E. S10-2120 p.145
W3-2121 p.229
S2-2043 p.23
Westbrock, Mark S4-2060 p.55
Wetzel, Patrick S8-2140 p.108
Wheeler, Patricia A. S9-1986 p.118
S9-1871 p.139
Whitledge, Terry E. **S8-2174** p.111
S9-2175 p.139
Whitmire, Curt E. **GP-2153** p.212
Wilderbuer, Tom W. W4-1996 p.245
Wilkinson, Tara S6-2098 p.72
Williams, Tom S4-2105 p.49
Wilson, Cara **W4-2141** p.245
S4-2097 p.54
S4-2073 p.56
Wilson, Matthew T. FIS_P-2107 p.171
Winn, C. S8-1985 p.102
W4-1984 p.238
Wolf, Shaye G. W2-2074 p.219
W6-2149 p.263
Wong, C.S. S8-1988 p.108
S8-1882 p.111
Wong, Lai-Ah S10-1796 p.147
Wong, Shau-King Emmy S8-1882 p.111
Wonham, Marjorie J. **S5-1928** p.67
Wood, Kevin R. S8-2174 p.111
Woodruff, Dana L. HAB-2039 p.257
Wu, Zhenxing HAB-1864 p.258

X

Xie, Songguang **FIS_P-1830** p.187
FIS_P-1831 p.187
Xu, Suqing S8-2180 p.100
Xu, Zhaoli FIS_P-2190 p.173

Y

Yabuki, Keizo FIS_P-1822 p.174
Yamada, Harumi S1-2018 p.6
Yamagata, Toshio S10-1919 p.143
Yamaguchi, Atsushi BIO_P-1888 p.162
W2-1866 p.225
Yamakawa, Takashi S2-1956 p.27
Yamamoto, Jun **GP-2119** p.213

Yamamoto, Jun	S2-1939	p.26
Yamanaka, Yasuhiro	S8-2140	p.108
	S10-1960	p.143
	S10-2120	p.145
	W2-1886	p.225
	W3-2121	p.229
Yamashita, Norio	S1-1833	p.11
Yamashita, Tomohiro	S3-1923	p.37
Yamashita, Yoh	FIS_P-1831	p.187
Yáñez, Eleuterio	**W4-1867**	p.245
	S7-1854	p.90
Yang, Yu-Feng	**GP-2087**	p.213
Yasuda, Ichiro	GP-1848	p.205
	W4-2026	p.246
Yatsu, Akihiko	**S1-1833**	p.11
	FIS_P-1857	p.184
	W3-2121	p.229
	W3-2183	p.231
	W3-2182	p.232
Yelland, Doug	**S4-2206**	p.57
Yen, Peggy	S7-1819	p.79
	S4-2115	p.50
	S4-1885	p.47
Yeon, In-Ja	FIS_P-2051	p.188
Yoo, Sinjae	W2-1887	p.222
	W4-2156	p.246
Yoon, Yang Ho	BIO_P-2064	p.162
	W2-2057	p.220
Yoshida, Katsumi	S5-2163	p.62
Yoshida, Tsutomu	S7-1946	p.89
Yoshie, Naoki	W2-1886	p.225
Youn, Yong-Hoon	S7-2007	p.87
Youngbluth, Marsh	**S3-1930**	p.39
Yu, Shwu-Feng	**S3-1909**	p.39
Yun, Jae-Yul	S7-2006	p.85

Z

Zainuddin, Mukti	**S11-1941**	p.154
	S4-1940	p.57
Zavolokin, Alexander V.	**S3-1838**	p.40
Zelenskaya, Larisa	W6-2118	p.261
Zenitani, Hiromu	GP-1799	p.200
Zeppelin, Tonya K.	W6-2177	p.262
Zhadan, Peter M.	GP-2184	p.193
Zhang, Chang Ik	S9-2052	p.130
	FIS_P-2051	p.188
Zhang, L.H.	S2-1802	p.29
Zhang, Liyang	S8-2180	p.100
Zhang, Xuelei	**S2-1802**	p.29
Zhao, Jinping	**S1-2122**	p.11
Zhdanov, Mikhail	S8-2174	p.111
Zheng, Jie	**S2-1929**	p.29
Zhou, Qiulin	**S6-1792**	p.74
Zhu, M.Y.	S2-1802	p.29
Zhu, Mingyuan	**W5-2197**	p.254
	HAB-1825	p.258
	HAB-1864	p.258
Zou, Yinglin	**HAB-1864**	p.258
Zuenko, Yury I.	**W3-1845**	p.232
Zuo, Tao	BIO_P-1770	p.166

PICES Acronyms

AP	Advisory Panel	
APN	Asia Pacific Network	
BASS	Basin Scale Studies Task Team	
BIO	Biological Oceanography Committee	
CCCC	Climate Change and Carrying Capacity Program	
CLIVAR	Climate Variability and Predictability Program	
EC/IP	Executive Committee / Implementation Panel for CCCC	
F&A	Finance and Administration Committee	
FIS	Fishery Science Committee	
GC	Governing Council	
GP	General Poster Session	
HAB	Harmful Algal Blooms Section	
IFEP-AP	Advisory Panel on Iron Fertilization Experiment in the Subarctic Pacific Ocean	
MBM-AP	Advisory Panel on Marine Birds and Mammals	
MEQ	Marine Environmental Quality Committee	
MIE-AP	Advisory Panel on Micronekton Intercalibration Experiment	
MODEL	Conceptual / Theoretical and Modeling Studies Task Team	
MONITOR	Monitor Task Team	
POC	Physical Oceanography and Climate Committee	
REX	Regional Experiments Task Team	
S1	Session 1:	Science Board Symposium on *Beyond the continental slope - complexity and variability in the open North Pacific Ocean*
S2	Session 2:	BIO Topic Session on *Mechanisms that regulate North Pacific ecosystems: Bottom up, top down, or something else?*
S3	Session 3:	BIO Topic Session on *Role of gelatinous zooplankton in coastal and oceanic ecosystems*
S4	Session 4:	FIS/ BIO Topic Session on *Hot spots and their use by migratory species and top predators in the North Pacific*
S5	Session 5:	MEQ Topic Session on *Introduction of marine species*
S6	Session 6:	MEQ Topic Session on *Marine protected areas*
S7	Session 7:	POC/MONITOR Topic Session on *Application of global observing systems to physics, fisheries, and ecosystems*
S8	Session 8:	POC Topic Session on *The impacts of climate change on the carbon cycle in the North Pacific*
S9	Session 9:	CCCC Topic Session on *The impacts of large-scale climate change on North Pacific marine ecosystems*
S10	Session 10:	CCCC/MODEL Topic Session on *Modeling approaches that integrate multiple spatial scales and trophic levels between shelf and open oceans*
S11	Session 11:	TCODE Electronic Poster Session on *Data visualization of open ocean processes in the North Pacific*
SB	Science Board	
SGEBM	Study Group on Ecosystem-based management science and its application to the North Pacific	
TCODE	Technical Committee on Data Exchange	
W1	Workshop 1:	MIE-AP Workshop and Advisory Panel Meeting on *Micronekton sampling gear inter-calibration experiment*
W2	Workshop 2:	CCCC/REX Workshop on *The seasonal cycle of plankton production in continental shelf waters around the Pacific Rim*
W3	Workshop 3:	CCCC Workshop on *Linking open ocean and coastal ecosystems II*
W4	Workshop 4:	PICES/CLIVAR Workshop on *Scale interactions of climate and marine ecosystems*
W5	Workshop 5:	MEQ Workshop on *Developing a North Pacific HAB data resource II*
W6	Workshop 6:	MBM-AP Workshop on *Combining data sets on diets of marine birds and mammals II*
WG	Working Group	