North Pacific Marine Science Organization (PICES)

Tenth Annual Meeting

program abstracts

october 5-13, 2001

Victoria, B. C., Canada

Table of Contents

	Page #
Program	v
Keynote Address	1
PICES X Anniversary Symposium abstracts (S1)	2
BIO/JGOFS Topic Session abstracts (S2)	11
FIS Topic Session abstracts (S3)	25
POC Topic Session abstracts (S4)	47
POC/BIO/FIS Topic Session abstracts (S5)	62
MEQ Topic Session abstracts (S6)	80
MEQ Topic Session abstracts (S7)	87
MEQ Topic Session abstracts (S8)	98
MEQ/BIO/POC Topic Session abstracts (S9)	106
CCCC Topic Session abstracts (S10)	113
CCCC/GLOBEC Topic Session abstracts (S11)	137
TCODE Electronic Poster Session abstracts (S12)	158
REX Workshop abstracts (W1)	165
BIO Committee poster abstracts	174
CCCC Program poster abstracts	177
FIS Committee poster abstracts	179
MEQ Committee poster abstracts	186
POC Committee paper and poster abstracts	188
Index of Authors	201
PICES Acronyms	212

Abstracts are sorted first by session and then alphabetically by the main author's last name. Presenter's names are in bold 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 the abstracts in this collection have not been edited and have been printed in the condition that they were received.

Schedule

Time	Events
Fri. 5 & 6th 08:30-17:30	WG 15 Practical Workshop (W7)

(Above workshop held in Vancouver)

Fri. Oct. 5th	08:30-12:30	REX Workshop (W1)	BASS/MODEL Workshop (W2)		
	13:30-17:30				CPR Panel Meeting
Sat. 6th	08:30-12:30	CCCC Workshops Plenary Session			IFEP & C-SOLAS & Workshop
	13:30-17:30	REX/MODEL Workshop (W3)	MONITOR Workshop (W4)	WG 16 Meeting	
Sun. 7th	08:30-12:30	BASS, MODEL, MONITOR & REX Task Team Meetings		Working Groups 13 & 14 Meetings	
	12:30-13:30	Science Board Meeting *			
	13:30-17:30	CCCC IP/EC Meeting *	MBM Advisory Panel Meeting & Workshop	Working Groups 13, 14 & 15 Meetings	Governing Council Meeting *
Mon. 8th	08:30-10:30	Opening Session			
	10:30-17:30	Science Board Symposium (S1)			
Tues. 9th	08:30-12:30	POC/BIO/FIS Topic Session (S5)	CCCC Topic Session (S10)	MEQ Topic Session (S7)	F&A Committee Meeting*
	13:30-17:30			MEQ Topic Session (S8)	
Wed. 10th	08:30-12:30	CCCC Implementation Panel Meeting & CCCC Topic Session (S11)			
	13:30-17:30	BIO, FIS, MEQ, POC & TCODE Meetings			
	17:30-20:30	Poster Session / TCODE E-Poster Session / Ocean Exhibition			
Thurs. 11th	08:30-12:30	BIO Topic Session (S2)	FIS Topic Session (S3)	POC Topic Session (S4)	MEQ Topic Session (S6)	F&A Committee Meeting *
	13:30-17:30			POC Paper Session	MEQ/BIO/POC Topic Session (S9)	
	17:30-18:30	Closing Session			
Fri. 12th	08:30-12:30	Science Board Meeting *			
	13:30-17:30	Science Board Meeting *		Governing Council Meeting *	
Sat. 13th	08:30-12:30	Governing Council Meeting *			

* Closed Session

S1: Ten years of PICES science: Decadal-scale scientific progress and prognosis for a regime shift in scientific approach S2: Plankton size classes, functional groups, and ecosystem dynamics: causes and consequences S3: Migrations of key ecological species in the North Pacific Ocean S4: Coastal ocean physical processes responsible for biological productivity and biological resources distribution S5: The physics and biology of eddies, meanders and rings in the PICES region S6: Sediment contamination – the science behind remediation standards S7: Physical oceanography to societal valuation: Assessing the factors affecting coastal environments S8: Emerging issues for MEQ: a 10-year perspective S9: Physical, chemical and biological interactions during harmful algal blooms S10: A decade of variability in the physical and biological components of the Bering Sea ecosystem: 1991-2001 S11: Results of GLOBEC and GLOBEC-like programs (with emphasis on possible 1999 regime shift) S12: Regional and national data centers W1: REX Workshop on "Temporal variations in size-at-age for fish species in coastal areas around the Pacific Rim" W2: BASS/MODEL Workshop to review ecosystem models for the subarctic Pacific gyres W3: REX/MODEL Workshop to include higher trophic levels in the PICES NEMURO Model W4: MONITOR Workshop to review progress in monitoring the North Pacific W7: WG 15 Practical Workshop on "Taxonomy and identification of HAB species"

Vancouver - 5th - 6th October, 2001 (Friday & Saturday)

TAXONOMY AND IDENTIFICATION OF HAB SPECIES, AND DATA MANAGEMENT (08:30 - 17:30)
(Working Group 15 Practical Workshop: W7)
Co-Convenors: F.J.R. (Max) Taylor (Canada), Tatiana Orlova (Russia) & Vera Trainer (U.S.A.)

Victoria
5th October, 2001 (Friday)

TEMPORAL VARIATIONS IN SIZE-AT-AGE FOR FISH SPECIES IN COASTAL AREAS AROUND THE PACIFIC RIM (08:30 - 17:30)
(REX Workshop: W1)
Co-Convenors: William T. Peterson (U.S.A.) & Douglas E. Hay (Canada)

John H. (Jack) Helle. Size-at-age of North American chum salmon before and after the 1976-77 ocean regime change (W1-147)

Randall M. Peterman, B.J. Pyper, M.F. Lapointe and C.J. Walters. Spatial patterns of covariation in size-at-age of British Columbia and Alaska sockeye salmon stocks and effects of abundance and ocean temperature (W1-144)

Bruce MacFarlane, E. Norton and C. Royer. Influences of the 1997-1999 El Niño-La Niña on juvenile chinook salmon off central California (W1-220)

Olga S. Temnykh and S.L. Marchenko. Variability of the pink salmon sizes in connection with abundance of Okhotsk Sea stocks (W1-152)

Nikolay I. Naumenko. Temporal variations in size-at-age of the western Bering Sea herring (W1-223)

Evelyn Brown. Effects of climate and zooplankton production trends on Pacific herring, *Clupea pallasi*, population size and life history parameters in the Gulf of Alaska (W1-087)

Jake Schweigert. Pacific herring size at age variation in the North Pacific (W1-402)

Ron W. Tanasichuk. Implications of variation in euphausiid productivity on the growth, production and resilience of Pacific herring (*Clupea pallasi*) from the southwest coast of Vancouver Island (W1-069)

Ludmila A. Chernoivanova. The characteristic of growth rate of herring in Peter the Great Bay (Japan Sea) (W1-328)

Yoshiro Watanabe, Y. Hiyama and C. Watanabe. Inter-decadal fluctuations in length-at-age of Hokkaido-Sakhalin herring and Japanese sardine in the Sea of Japan (W1-149)

Steven A. Berkeley and W.D. Pinnix. Historical trends in sablefish (*Anoplopoma fimbria*) size at age one from two stocks: The Gulf of Alaska and the U.S. West Coast (W1-217)

Poster introduction

Chikako Watanabe, A. Yatsu and Y. Watanabe. Change in length-at-age with stock fluctuation of chub mackerel in the Pacific waters off central Japan since 1970 to 1997 (W1-148)

ECOSYSTEM MODELS FOR THE SUBARCTIC PACIFIC GYRES (08:30 - 17:30)
(BASS/MODEL Workshop: W2)
Co-Convenors: Michio J. Kishi (Japan), Andrei S. Krovnin (Russia), Gordon A. McFarlane (Canada) & Bernard A. Megrey (U.S.A.)

Continuous Plankton Recorder (CPR) Survey in the North Pacific Advisory Panel Meeting (13:30 - 17:30)

6th October, 2001 (Saturday)

CCCC Workshops Plenary Session (08:30 - 12:30)

Advisory Panel on Iron Fertilization Experiment Meeting and C-SOLAS Planning Meeting (08:30 - 17:30)

Working Group 16 Meeting (13:30 - 17:30)

HIGHER TROPHIC LEVELS IN THE PICES NEMURO MODEL (13:30 - 17:30)
(REX/MODEL Workshop: W3)
Co-convenors: Michio J. Kishi (Japan), Bernard A. Megrey, William T. Peterson & Vladimir I. Radchenko (Russia)

PROGRESS IN MONITORING THE NORTH PACIFIC (13:30 - 17:30)
(MONITOR Workshop: W4)
Co-convenors: David L. Mackas (Canada) & Sei-ichi Saitoh (Japan)

7th October, 2001 (Sunday)

BASS, MODEL, MONITOR & REX Task Team Meetings (08:30 - 12:30)

Working Groups 13 & 14 Meetings (08:30 - 17:30)

Science Board Meeting* (12:30 - 13:30)

Governing Council Meeting* (13:30 - 17:30)

CCCC Implementation Panel / Executive Committee Meeting* (13:30 - 17:30)

Advisory Panel on Marine Birds & Mammals Meeting (13:30 - 15:30)
CHANGES IN PREY AVAILABILITY TO MAMMALS, SEABIRDS AND FISH: MECHANISM AND EFFECTS (15:30 - 17:30)
(MBM Workshop)
Co-convenors: Anne B. Hollowed & Elizabeth A. Logerwell (U.S.A.)

Working Group 15 Meeting (13:30 - 17:30)

Papers presented from MEQ/BIO/POC Topic Session (S9):

Jose Luis Ochoa, S.E. Lluch-Cota, B.O. Arredondo-Vega, E. Nuñez-Vázquez, A. Heredia-Tapia, J. Perez-Linarez and R. Alonso. Marine biotoxins in Mexico (S9-308)

Tian Yan, M.J. Zhou and P. Qian. The role of physical, chemical and biological factors in HAB formation - Experimental study using mono and mixed cultures of three HAB species (S9-056)

Sam Geun Lee, H.G. Kim, E.S. Cho and C.K. Lee. Effects of oils and chemical dispersants on growth of harmful dinoflagellate *Cochlodinium polykrikoides* (S9-218)

➢ *Please check session schedules on display at the venue for presentation times and latest updates.* ≺

8th October, 2001 (Monday)

Registration (07:30 - 08:30)

Opening Session (08:30 - 10:30)

Opening by **Dr. Hyung-Tack Huh**, Chairman of PICES

Welcome address by **Hon. Gilbert Parent**, Ambassador of the Environment, on behalf of the Government of Canada

Remarks by representatives of Contracting Parties

Remarks by the Chairman of PICES

Keynote lecture by **Dr. Warren S. Wooster**: "PICES - The first decade and beyond"

Presentation of the first Wooster Award

Closing remarks / announcements

TEN YEARS OF PICES SCIENCE: DECADAL-SCALE SCIENTIFIC PROGRESS AND PROGNOSIS FOR A REGIME SHIFT IN SCIENTIFIC APPROACH (10:30 - 17:30)

(PICES X Anniversary Symposium: S1)

Co-Convenors: Patricia Livingston (SB), Tsutomu Ikeda (BIO), Douglas E. Hay (FIS), John E. Stein (MEQ), Susan E. Allen (POC), Thomas C. Royer (TCODE) & David W. Welch (CCCC)

Paul H. LeBlond, Y. Nagata and V.B. Lobanov. (invited) The Physical Oceanography and Climate Committee: The first decade (S1-105)

D.E. Harrison and N. Smith. (invited) Ocean observing systems and prediction: The next ten years (S1-032)

Tsutomu Ikeda and P.A. Wheeler. (invited) Ocean impacts from the bottom of the food web to the top: Biological Oceanography Committee retrospective (S1-263)

Timothy R. Parsons. (invited) Future needs for biological oceanographic studies in the Pacific Ocean (S1-024)

Richard F. Addison, J.E. Stein, A.V. Tkalin, J.Y. Zhou and U. Varanasi. (invited) PICES Marine Environmental Quality Committee - The first ten years (S1-403)

Robie W. Macdonald, B. Morton and R.F. Addison. (invited) Marine environmental issues in the North Pacific: What are the dangers and how do we identify them? (S1-020)

Douglas E. Hay, R.J. Beamish, G. Boehlert, V.I. Radchenko, Q.S. Tang, T. Wada, D.M. Ware, C.I. Zhang and S.M. McKinnell. (invited) Ten years of PICES: An introspective, retrospective, critical and constructive review of Fisheries Science in PICES (S1-344)

Steve Murawski. (invited) Ecosystem considerations in fisheries management: The future of science and policy (S1-021)

R. Ian Perry and A.B. Hollowed. (invited) A review of the PICES Climate Change and Carrying Capacity Program (S1-301)

Berrien Moore III. (invited) Marine science - IGBP: Partners in the 21st century (S1-019)

Welcoming Reception (Royal British Columbia Museum, 18:30)

9th October, 2001 (Tuesday)

Finance & Administration Committee Meeting* (08:30 - 12:30)

PHYSICAL OCEANOGRAPHY TO SOCIETAL VALUATION: ASSESSING THE FACTORS AFFECTING COASTAL ENVIRONMENTS (08:30 - 12:30)

(MEQ Committee Topic Session: S7)

Co-Convenors: Julia K. Parrish & John E. Stein (U.S.A.)

Julia K. Parrish, K. Bell, E. Logerwell and C. Roegner. (invited) Indicators of estuarine structure and function: Physics, biology and socioeconomics (S7-023)

Barbara M. Hickey and N. Banas. Oceanography of the Pacific Northwest coastal zone and its coastal estuaries (S7-179)

Gordon Swartzman, B.M. Hickey and C. Wilson. Mesoscale biotic features of the coastal nearshore environment (S7-180)

Elizabeth Logerwell, N. Mantua, P. Lawson and R. Francis. Relating salmon survival to environmental variables using generalized additive models (S7-181)

Curtis Roegner, B.M. Hickey, J. Newton, A. Shanks and D. Armstrong. Bloom and plume intrusions into Pacific Northwest estuaries (S7-182)

Jennifer Ruesink, C. Roegner, B. Dumbauld and D. Armstrong. Assessing benthic-pelagic coupling through demography of oysters (*Crassostrea gigas*) (S7-183)

Ronald M. Thom, A.B. Borde, S. Rumrill, G. Williams, D. Woodruff and J. Southard. Historical changes and short-term spatial and interannual variability in marshes and seagrass meadows in Willapa Bay, Washington, and Coos Bay, Oregon (S7-184)

David Armstrong, C. Rooper and D. Gunderson. Estuarine-ocean coupling and link to coastal fisheries: Dungeness crab and English sole (S7-185)

Daniel Huppert, R. Johnson and K. Bell. Assessing the status of human communities in Pacific Northwest coastal estuaries (S7-186)

Thomas Leschine, A. Bennett, M. Pico, K. Bell, D. Huppert, B. Ferriss and S. MacWilliams. Toward better use of scientific information in the environmental management of Pacific Northwest coastal estuaries (S7-187)

THE PHYSICS AND BIOLOGY OF EDDIES, MEANDERS AND RINGS IN THE PICES REGION

(08:30 - 17:30)

(POC/BIO/FIS Committees Topic Session: S5)

Co-Convenors: William R. Crawford (Canada), Jeffrey J. Polovina (U.S.A.) & Takashige Sugimoto (Japan)

Poster introduction

Kuroshio and Kuroshio-Oyashio Transition Region

Nikolai Maximenko. On the Kuroshio meander formation south of Japan (S5-222)

Humio Mitsudera and T. Waseda. Chaotic advection of Kuroshio coastal waters (S5-163)

Hideaki Nakata. (invited) Effect of Kuroshio frontal eddies on the biological production and pelagic fish recruitment (S5-022)

Takashige Sugimoto, H. Tameishi, S. Itoh and P. Mishura. Warm-core rings and streamers and their effect on fish migration and larval transport in the Kuroshio-Oyashio transition region (S5-159)

Japan Sea and off Kuril Islands

Konstantin A. Rogachev and E.C. Carmack. (invited) Eddies in the western subarctic Pacific: Dynamical structure, biological significance and linkages to the regime shift phenomena (S5-028)

Andrey Andreev, M. Kusakabe, Y. Kumamoto, V.B. Lobanov and I. Zabin. Effects of the Bussol anticyclonic eddy on water masses, chemical parameters and chlorophyll distributions in the western subarctic Pacific (S5-001)

Alexei M. Orlov and A.T. Mandych. Eddy and meanders around underwater plateau off the central Kuril Islands: Oceanological features and biological effects (S5-164)

Myoung Sook Park and I.S. Oh. A numerical study on the physical processes and seasonal variability of eddies in the East/Japan Sea (S5-258)

Poster introduction

Haida Eddy and Alaskan Coast

Albert J. Hermann, P.J. Stabeno and M. Spillane. Twenty years of eddies in the Alaska Coastal Current (S5-154)

William R. Crawford and J.Y. Cherniawsky. A review of Sitka and Haida eddies and their impact on the Gulf of Alaska (S5-190)

Michael G. Foreman, W.R. Crawford and J.Y. Cherniawsky. (invited) Numerical modelling of the generation of the Haida eddy (S5-009)

Frank A. Whitney and M. Robert. Form and fortune of Haida eddies (S5-043)

Melissa Chierici, L.A. Miller, F.A. Whitney, W.K. Johnson and C.S. Wong. Seasonal changes in the oceanic carbon dioxide system in the Haida-2000 eddy in the Northeast Pacific Ocean (S5-120)

David L. Mackas and M.D. Galbraith. Zooplankton distributions and dynamics in a large anticyclonic eddy of coastal origin: Haida 2000 (S5-158)

Hawaiian Islands and California Gulf and Coast

Michael P. Seki, R.R. Bidigare, R. Lumpkin, P. Flament and J.J. Polovina. Biological and fishery implications of cyclonic eddies in Hawaiian waters (S5-109)

Robert R. Bidigare, M.P. Seki, C.L. Leonard, C. Benitez-Nelson, R.D. Vaillancourt and J.J. Polovina. (invited) Influence of cyclonic eddies on new production rates in the vicinity of the Hawaiian Islands (S5-002)

Hector G. Manzo-Monroy. Mesoscale physical links between coastal upwelling and pelagic tuna fishery in the Eastern Tropical Pacific Ocean (ETPO) (S5-160)

Jack Barth, T.J. Cowles, S. Pierce and W.T. Peterson. Mesoscale meanders in the Northern California Current System (S5-138)

Douglas J. Neilson, A.J. Miller, E. Di Lorenzo, B.D. Cornuelle and J.R. Moisan. Dynamics of the Southern California Bight oceanic ecosystem response to physical forcing (S5-157)

A DECADE OF VARIABILITY IN THE PHYSICAL AND BIOLOGICAL COMPONENTS OF THE BERING SEA ECOSYSTEM: 1991-2001 (08:30 - 17:30)

(CCCC Program Topic Session: S10)

Co-Convenors: Suam Kim (Korea), Allen Macklin (U.S.A.), Vladimir I. Radchenko (Russia) & Sei-ichi Saitoh (Japan)

George L. Hunt. (invited) Climate change and the control of energy flow in the eastern Bering Sea (S10-014)

Shoshiro Minobe. Interannual to multidecadal changes of temperature structures in the Bering Sea (S10-207)

Amy C. Hirons and B.P. Finney. Modern and paleoceanographic features as indicators of ecological changes in the Bering Sea (S10-170)

Igor P. Semiletov. Changes in the Bering Sea atmosphere - Ice-water system in the second half of the twentieth century (S10-324)

Phyllis J. Stabeno and N.A. Bond. Decade of change over the southeastern Bering Sea shelf (S10-375)

Sei-ichi Saitoh, T. Iida and K. Sasaoka. Temporal and spatial variability of spring blooms in the Bering Sea during 1997-1999 - Approach using satellite multi-sensor remote sensing (S10-236)

Akihiro Shiomoto, S. Saitoh, K. Imai, M. Toratani and Y. Ishida. (invited) Interannual variation in phytoplankton biomass in the Bering Sea basin in the 1990s (S10-031)

Kozo Takahashi and M. Yanada. (invited) Temporal flux changes of shell-bearing plankton particles in the Bering Sea during the last ten years since 1990 (S10-033)

Takahiro Iida, T. Miyamura, M. Toratani, H. Fukushima and S. Saitoh. Temporal and spatial variability of coccolithophore blooms in Eastern Bering Sea Shelf (S10-283)

Young Shil Kang and S. Kim. Interannual variations in the zooplankton community in the Bering Sea during the mid-1990s (S10-297)

Poster introduction

Vadim F. Savinykh, I.I. Glebov, V.V. Napazakov and E.O. Basyuk. The decadal changes of the mesopelagic fishes abundance in the western Bering Sea (S10-353)

Takashi Yanagimoto and A. Nishimura. The interannual variability of biological characteristics on walleye pollock in the Aleutian Basin in the 1990s (S10-391)

M. Elizabeth Conners, A.B. Hollowed and E. Brown. Trawl survey catch in the Southeast Bering Sea: 1960-2000 (S10-293)

Vladimir I. Radchenko. (invited) The western Bering Sea: Changes in physical environment and pollock stocks (S10-026)

Nikolay I. Naumenko, P.A. Balykin and E.A. Naumenko. Long-term fluctuations in the pelagic community of the western Bering Sea (S10-226)

Yukimasa Ishida, T. Azumaya, M. Fukuwaka and N.D. Davis. Interannual variability in stock abundance and body size of Pacific salmon in the central Bering Sea (S10-209)

Kerim Y. Aydin and P. Livingston. Comparisons of food web models and field diet studies for major fish species in the eastern Bering Sea during the 1990s - Implications for top-down vs. bottom-up control (S10-211)

Lorenzo Ciannelli, R.C. Francis, R.D. Brodeur and B. Robson. Ecosystem analysis of the Pribilof Archipelago during the decade of 1990-2000 (S10-169)

Cynthia T. Tynan. Changes in carbon flow on the southeast Bering Sea shelf: Importance of large whales during the late 1990s (S10-206)

Sue E. Moore, J.M. Waite, N. Friday and R.C. Hobbs. Preliminary estimates of cetacean abundance on the central and eastern Bering Sea Shelf with observations of oceanographic and prey associations (S10-311)

EMERGING ISSUES FOR MEQ: A 10-YEAR PERSPECTIVE (13:30 - 17:30)
(MEQ Committee Topic Session: S8)

Co-Convenors: Richard F. Addison (Canada) & Ming-Jiang Zhou (China)

Robie W. Macdonald. (invited) Emerging issues: Danger or opportunity? (S8-016)

Michael G. Ikonomou. New-era environmental contaminants: What do we know? (S8-404)

Dan Jaffe, H. Price, A. McClintick, P. Weiss, E. Prestbo and I. McKendry. Long-range atmospheric transport of pollutants across the Pacific: An overview of current knowledge (S8-189)

Stan Bertold and **Albert van Roodselaar**. The Greater Vancouver Regional District (GVRD) planning for the future: A science-based receiving environment approach to municipal wastewater management (S8-292)

John E. Elliott and L.K. Wilson. Contaminants in surf scoters wintering in the Strait of Georgia, British Columbia, Canada (S8-406)

Peter S. Ross. Pacific marine mammals as sentinels of local and trans-Pacific contamination by Persistent Organic Pollutants (POPs) (S8-266)

Igor Kochergin, T.A. Gavrilova, A.A. Bogdanovsky and V.F. Putov. Possible impact of heavy metals on marine environment from offshore drilling (S8-135)

Extravaganza Dinner (Herald Street Caffe, 18:30)

10th October, 2001 (Wednesday)

RESULTS OF GLOBEC AND GLOBEC-LIKE PROGRAMS (WITH EMPHASIS ON A POSSIBLE 1999 REGIME SHIFT) & CCCC Implementation Panel Meeting (08:30 - 12:30)
(CCCC Program Topic Session co-sponsored by GLOBEC: S11)

Co-Convenors: Makoto Kashiwai (Japan) & David W. Welch (Canada)

P. Christopher Reid. (invited) The North Atlantic: Evidence for a change in ocean climate in recent years (S11-027)

William T. Peterson and J.E. Keister. The 1998/99 regime shift in the northern California Current: What are the copepods telling us? (S11-200)

Atsamon Limsakul, T. Saino, J.I. Goes and T. Midorikawa. Effects of large-scale climate variability on the lower trophic ecosystems of the western subtropical Pacific and Oyashio Waters: Comparison of possible linking mechanisms and biological responses (S11-204)

Ya-Qu Chen, Z. Xu, Y. Wang and M. Jiang. Study on annual variation of biomass of zooplankton in the East China Sea (S11-333)

Franklin B. Schwing. (invited) The 1998 regime shift in the North Pacific: Physical mechanisms and ecological consequences (S11-030)

Daniel Lluch-Belda, M. Laurs, D.B. Lluch-Cota and S.E. Lluch-Cota. Long-term empirical forecasting of interannual change at the California Current System (S11-286)

R. Ian Perry. Upper trophic level surprises off B.C. during the 1990s and their physical and biological oceanographic drivers: Global changes in action? (S11-302)

Andrei Krovnin, G. Khen, M. Bogdanov, N. Klovatch, A. Mandych, A. Orlov and G. Moury. Some evidence of regime shift in the Northwest Pacific during 1998/1999 (S11-134)

Yongjun Tian, Y. Ueno, M. Suda and T. Akamine. Decadal-scale variation in the abundance of Pacific saury (*Cololabis saira*) and its response to sea surface temperature in the northwestern Pacific during the last half century (S11-078)

Jae Bong Lee, D. Lim, W.D. Yoon, Y.J. Im, H.J. Hwang, J.Y. Yang, S.H. Hong, Y. Lee and S.Y. Park. Possible 1998/99 regime shift and their impacts on marine ecosystem and fisheries resources in the Yellow Sea off Korea (S11-241)

BIO, FIS, MEQ & POC Committee and TCODE Meetings (13:30 - 17:30)

REGIONAL AND NATIONAL DATA CENTRES (17:30 - 20:30)
(TCODE E-Poster Session: S12)
Co-convenors: Thomas C. Royer (U.S.A.), Igor I. Shevchenko (Russia) & Toru Suzuki (Japan)

Ocean Exhibition (17:30 - 20:30)

Wine & Cheese Poster Session (17:30 - 20:30)

11th October, 2001 (Thursday)

Finance & Administration Committee Meeting* (08:30 - 12:30)

SEDIMENT CONTAMINATION - THE SCIENCE BEHIND REMEDIATION STANDARDS (08:30 - 12:30)
(MEQ Committee Topic Session: S6)
Co-convenors: Steve C. Samis (Canada) & Dong-Beom Yang (Korea)

Peter C. Grevatt. (invited) Trends in the development of scientific remediation standards for contaminated sediments (S6-010)

Peter M. Chapman. The utility and use of Sediment Quality Values (SQVs) (S6-049)

Mike MacFarlane and Don MacDonald. Development of sediment quality criteria for contaminated sites in British Columbia (S6-285)

Poster introduction

Connie Gaudet, Kathie Adare and Doug Spry. Canadian sediment quality assessment tools (S6-072)

James Meador. Tissue and sediment concentrations of TBT and PCBs to protect juvenile salmonids under the Endangered Species Act (S6-018)

Evgueni Shumilin, G. Rodríguez-Figueroa, O. Morton Bermea, D.Yu. Sapozhnikov, E. Lounejeva Baturina and E. Hernández. Heavy metals and metalloids from mining operations in coastal marine sediments of the peninsula of Baja California (S6-080)

Vladimir Shulkin, B.J. Presley and V.Ya. Kavun. Metal concentrations in mussels and oysters in relation to contamination of ambient sediments (S6-054)

COASTAL OCEAN PHYSICAL PROCESSES RESPONSIBLE FOR BIOLOGICAL PRODUCTIVITY AND BIOLOGICAL RESOURCE DISTRIBUTION (08:30 - 15:10)
(POC Committee Topic Session: S4)
Co-convenors: Susan E. Allen (Canada) & Yuri I. Zuenko (Russia)

A. Edward Hill, J. Brown, K.J. Horsburgh, L. Carillo and L. Fernand. (invited) Baroclinic processes on continental shelves: Cold pool systems and their impacts on shelf biology (S4-013)

Sarah Hinckley, A. Hermann, E.L. Dobbins and G. Blamey. Use of a biophysical NPZ model to investigate the effect of alongshore vs. cross-shelf transport in the coastal Gulf of Alaska on quality of habitat for migrating juvenile salmon (S4-267)

Chen-Tung Arthur Chen, A. Snidvongs, N. Saadon and T.M. Tengku Rozaina. Monsoon and typhoon rains also nurture oceanic productivity (S4-005)

Debby Ianson, S.E. Allen, K. Orians, S. Harris, D. Varela and C.S. Wong. Variations in biological carbon and nitrogen uptake during coastal up- and downwelling (S4-237)

Vadim V. Navrotsky, V.L. Izergin and E.P. Pavlova. Internal wave generation and their role in bioproductivity of the coastal ocean (S4-354)

Tetsuo Yanagi. (invited) Mixing processes along the shelf edge (S4-041)

Oleg Zaytsev, F. Salinas-González, R. Cervantes-Duarte and C. Turrent Thompson. Coastal dynamics influence on nutrient transport at the area of Magdalena-Almejas lagoon system, Baja California Sur, Mexico (S4-317)

Akihide Kasai, T. Fujiwara,T. Kimura and H. Yamada. Fortnight shifts of intrusion depth of oceanic water into Ise Bay and its effect on the biological productivity (S4-098)

Evelyn Brown, K. Coyle, J. Thedinga, L. Haldorson, L. Hulbert, R. Foy and T. Shirley. Environmental factors affecting forage fish distribution and their availability as prey for sea birds (S4-086)

David G. Ainley, L.B. Spear, C.T. Tynan and Jack Barth. Seabird response to ocean structure during upwelling and downwelling events off the Oregon-California coast: A GLOBEC study (S4-370)

Craig Lewis. Biology and physics in the coastal ocean: A decade of Georges Bank GLOBEC models (S4-326)

Chuanlan Lin and J. Su. The variation tendency of the property of seawater in the central and southern parts of the Bohai Sea during 1960-1996 and its influence on marine ecosystem (S4-358)

Jan A. Newton, W. Ehinger, E. Siegel, J. Bos, K. Nakata and B. Hickey. Control of northwest coast estuarine primary production by the supply of oceanic nitrogen (S4-239)

Silvio Guido Marinone. The mean and seasonal circulation in a three dimensional model of the Gulf of California (S4-245)

Poster introduction

PLANKTON SIZE CLASSES, FUNCTIONAL GROUPS AND ECOSYSTEM DYNAMICS: CAUSES AND CONSEQUENCES (08:30 - 17:30)

(BIO Topic Session co-sponsored by JGOFS: S2)

Co-Convenors: Angelica Peña (Canada), Toshiro Saino (Japan) & Patricia A. Wheeler (U.S.A.)

M.M. Mullin, M.P. Thimgan and **David Checkley**. Temporal and spatial variation in the sizes of California Current macrozooplankton - analysis by optical plankton counter (S2-082)

Peter Burkill. (invited) Dimethyl sulphide biogeochemistry in a coccolithophore bloom (DISCO): The role of the microbes (S2-003)

Hiroaki Saito and A. Tsuda. Physiological responses of diatoms to irradiance declining (S2-196)

Douglas G. Capone. (invited) N2 fixation in the worlds oceans (S2-004)

Tawnya Peterson, E.A. Bornhold, F.A. Whitney and P.J. Harrison. Temporal changes in size-fractionated photosynthetic biomass distribution in a warm-core mesoscale eddy in the NE Pacific (S2-244)

Isao Kudo, S. Ban, T. Yoshimura, C.W. Lee, Y. Sakagami and Y. Isoda. The fate of primary production during spring diatom bloom in Funka Bay, Japan (S2-195)

Sanae Chiba and T. Saino. Plankton community study: A better way to understand ecosystem dynamics in the Japan Sea (S2-115)

Masaya Toyokawa, T. Toda, T. Kikuchi, H. Miyake and J. Hashimoto. Dense occurrence of *Bolinopsis infundibulum* (Ctenophora) near the sea floor (1,260 m) under Oyashio Current (S2-123)

Poster introduction

Akira Taniguchi. (invited) Effect of environmental changes on microzooplankton assemblages and implications for ecosystem dynamics (S2-034)

David Checkley. Zooplankton size and type inferred from physical volume and optical transparency, and implications for ecosystem function (S2-081)

Mark Ohman and B.E. Lavaniegos. Zooplankton shifts in the California Current System (S2-141)

Atsushi Tsuda, T. Kobari and A. Shinada. Functional roles of mesozooplankton in the western subarctic Pacific (S2-193)

Poster introduction

Kenneth L. Denman. Modelling the planktonic ecosystem: How much complexity is too much? (S2-401)

Georgina A. Blamey, D.L. Musgrave and E. Bueler. Fundamental dynamics of an ecosystem model for the coastal Gulf of Alaska (S2-315)

Angelica Peña. The influence of plankton composition on export production (S2-309)

Susan E. Allen and N. Jeffrey. The impact of copepod life cycle dynamics on the planktonic ecosystem of Ocean Station Papa (OSP): A modelling approach (S2-290)

Michio Kishi and T. Okunishi. Lower trophic model in the Sea of Okhotsk (S2-231)

Anatoly Smirnoff and E.V. Smirnova. Variations of northern part Sea of Okhotsk plankton community and their influence for the abundance of walleye pollock year classes (S2-197)

MIGRATIONS OF KEY ECOLOGICAL SPECIES IN THE NORTH PACIFIC OCEAN (08:30 - 17:30)

(FIS Committee Topic Session: S3)

Co-Convenors: Vladimir A. Belayev (Russia), George W. Boehlert (U.S.A.), James Irvine (Canada) & Akihiko Yatsu (Japan)

George Rose. (invited) Migrations of fish, mammals and seabirds in the northwest Atlantic: Making large ecosystems work (S3-029)

Robert Campbell and J.F. Dower. Lipids, buoyancy and life history: The depth distribution of overwintering *Neocalanus* spp. in the eastern North Pacific (S3-071)

Michael Healey. (invited) Migratory patterns of salmon in the North Pacific (S3-011)

George W. Boehlert and P. Wilzbach. Habitat utilization and movement by maturing chinook salmon off the coast of California and Oregon (S3-046)

Jin Yeong Kim, K.B. Seong, C.S. Park and Y.S. Kang. Yearly variation of chum salmon (*Oncorhynchus keta*) migration, sex ratio, length composition and environmental factors in the eastern area of Korea (S3-252)

David W. Welch and G.W. Boehlert. "POST" - The Census of Marine Life initiative to develop a Pacific Ocean Salmon Tracking Program (S3-052)

Katsumi Tsukamoto. (invited) Migration of Japanese eels (S3-036)

Shingo Kimura, T. Inoue and T. Sugimoto. Fluctuation in larval transport of the Japanese eel associated with global oceanic - climatic changes (S3-121)

Jackie King and G.A. McFarlane. Migration dynamics of spiny dogfish (*Squalus acanthias*) (S3-172)

Ruben Rodríguez-Sánchez, D. Lluch-Belda, H. Villalobos and S. Ortega-García. Dynamic geography of small pelagic fish populations in the California Current System on regimen-scale (1931-1997) (S3-174)

Ashleen J. Benson, G.A. McFarlane, S.E. Allen and J.F. Dower. The response of Pacific hake (*Merluccius productus*) to recent ecosystem change (S3-083)

Takashi Kitagawa, H. Nakata, S. Kimura, T. Sugimoto and H. Yamada. Diving behavior and performance of Pacific bluefin tuna (*Thunnus thynnus orientalis*) recorded by an archival tag (S3-100)

Vadim F. Savinykh and V.A. Shelekhov. Pacific pomfret (*Brama japonica*) migrations: Onthogenetic and regional changes (S3-234)

Michael P. Seki and A. Yatsu. The distribution and migration of Pacific pomfret, *Brama japonica*, in the North Pacific (S3-110)

David Hyrenbach and D.J. Anderson. Oceanographic habitats of two sympatric North Pacific albatrosses: Scale-dependent patterns (S3-118)

Jeffrey J. Polovina, E. Howell, D. Parker and G. Balazs. (invited) Migration patterns and forage habitats of juvenile loggerhead and olive ridley turtles in the central North Pacific (S3-025)

Bruce R. Mate. (invited) Movements of blue whales in the eastern North Pacific (S3-017)

Alexander V. Vasilenko (presented by **Vladimir A. Belyaev**). (invited) Dynamic processes in the fish community of the Kuroshio Current Region (S3-037)

Victor V. Lapko. Migrations of common pelagic fishes and squids as a determinative for the nekton communities forming in the southern Okhotsk Sea in fall (S3-382)

Daniel P. Costa, B. Block, G.W. Boehlert and R. Kochevar. Tagging of Pacific pelagics: A CoML pilot project (S3-142)

PHYSICAL, CHEMICAL AND BIOLOGICAL INTERACTIONS DURING HARMFUL ALGAL BLOOMS (13:30 - 17:30)

(MEQ/BIO/POC Committees' Joint Topic Session: S9) (See also titles presented at Working Group 15 Meeting on October 7)

Co-Convenors: Hak-Gyoon Kim (Korea), F.J.R. (Max) Taylor (Canada) & Vera L. Trainer (U.S.A.)

Barbara M. Hickey. (invited) Biological/physical connections of harmful algal blooms in the eastern Pacific Ocean (S9-012)

Hee-Dong Jeong, H.G. Kim, B.K. Kim, K.D. Cho and J.D. Hwang. (invited) The prediction and movement of the harmful algal blooms in Korean waters (S9-015)

Juliette Fauchot, M. Levasseur, F.J. Saucier, S. Roy and A. Vézina. Study of *Alexandrium tamarense* bloom dynamics in the St. Lawrence Estuary (Canada): A modeling approach (S9-411)

Adrian Marchetti, P.J. Harrison and V.L. Trainer. Evidence of toxin production by the oceanic diatom, *Pseudo-nitzschia* during Fe stimulated growth in an HNLC Region (S9-221)

Ming-Yuan Zhu, F. Qiao, R. Li and S. Chen. Study on the HAB biological model in China (S9-064)

Mark Wells, C.G. Trick, M.T. Maldonado and E.L. Rue. Iron regulation of domoic acid production by toxigenic *Pseudo-nitzschia* spp. (S9-412)

PAPERS FOR THE PHYSICAL OCEANOGRAPHY AND CLIMATE COMMITTEE (15:25 - 17:30)

Convenor: Vyacheslav B. Lobanov (Russia)

Igor Belkin, R. Krishfield and S. Honjo. Decadal variability of the North Pacific Polar Front (POC-367)

Howard J. Freeland. The heat flux across Line-P in 1996-1999 (POC-165)

Tsuneo Ono, K. Tadokoro, T. Midorikawa and T. Saino. Linear decrease of nutrient consumption in the spring Oyashio mixed layer from 1968 to 1998 (POC-213)

Thomas C. Royer and C.E. Grosch. Long period signals in the Alaskan salmon catch, Northeast Pacific coastal freshwater discharge, salinity, temperature, Northern Oscillation Index (NOIx) and Pacific Decadal Oscillation (PDO) (POC-215)

Hiroshi Ishizaki and I. Ishikawa. Simulation of NPIW circulation by high-resolution North Pacific Ocean model (POC-161)

Valery Sosnin, P. Tishchenko, N. Biebow, G. Winckler, S. Lammers, A. Obzhirov, A. Salyuk, O. Vereshchagina, R. Shakirov and E. Dmitrieva. Renewal of Okhotsk Sea waters at intermediate depths near the Sakhalin continental slope (POC-068)

Closing Session (17:30 - 18:30)

12th October, 2001 (Friday)

Science Board Meeting* (08:30-17:30)

Governing Council Meeting* (13:30 - 17:30)

13th October, 2001 (Saturday)

Governing Council Meeting* (08:30-12:30)

Poster Session (displayed from Oct. 9-11 (noon) with designated Wine & Cheese Reception on October 10 at 17:30-20:30)

S1: SB PICES X Anniversary Symposium

Daniel L. Bottom, J.D. Rodgers and X. Augerot. A classification of salmon biogeographic zones of the North Pacific Ocean (S1-312)

Svetlana V. Davidova and Y.I. Zuenko. Changes of the mass subtropical fishes in the Japan Sea under the match/mismatch control (S1-419)

Charles W. Fowler and S.M. McCluskey. Sustainability, ecosystems and fishery management (S1-310)

Salvador Lluch-Cota, Y.M. Tourre, W.B. White, A. Bakun, D. Lluch-Belda, J. Alheit, D.B. Lluch-Cota, C. Colin and F.P. Chavez. Exploring mechanisms underlying global climate and fisheries variations in the PICES region (S1-219)

S2: BIO/JGOFS Joint Topic Session (Poster introduction at oral session: October 11, 12:15 & 14:55)

Valentina V. Andreeva. Seasonal alternations of plankton community in the nearshore areas of the Kievka Bay (the Sea of Japan) (S2-319)

David U. Hernández-Becerril, J.A. Aké-Castillo and E. Bravo-Sierra. The phytoplankton from Baja California, Mexico, in December, 1998: Communities dominated by two diatom species of the genus *Pseudo-nitzschia* (S2-320)

Naoki Iguchi and H. Morimoto. The growth and distribution pattern of the euphausiid, *Thysanoessa longieps*, in the Sea of Japan (S2-192)

Hideki Kaeriyama and T. Ikeda. Seasonal variations in vertical distribution and population structure of the three dominant oceanic ostracods (*Conchoecia pseudodiscophora*, *C. haddoni* and *C. skogsbergii*) in the Oyashio region (Site H), western North Pacific Ocean (S2-096)

Michael Lipsen and P.J. Harrison. Variation of primary productivity along Line P in the NE subarctic Pacific during the 1998 El Niño and the 1999 La Niña as well as 2000 with some reference to biogenic silica (S2-194)

Maeve Lohan. Dissolved zinc in the waters of the subarctic North Pacific water column (S2-294)

Joseph A. Needoba, T. Wagey and P.J. Harrison. Stable nitrogen isotope fractionation by phytoplankton in an HNLC region (S2-295)

Kyoungsoon Shin, M.C. Jang, P.K. Jang, T.K. Lee, M. Chang. Influence of food quality on feeding and egg production of the marine planktonic copepod *Acartia omorii* (S2-075)

Yuichiro Yamada, T. Ikeda and A. Tsuda. Seasonal variability in the abundance and biomass of four pelagic amphipods in the Oyashio region, western subarctic Pacific (S2-327)

Vladimir Zvalinsky. Including higher trophic levels and microbial food web in the ecosystem model (S2-076)

Vladimir Zvalinsky. The description of co-limitation of primary production by several substrate factors (S2-246)

S3: FIS Topic Session

Tomonori Azumaya, Y. Ishida, M. Fukuwaka and Y. Ueno. Swimming pattern of homing adult chum salmon (*Oncorhynchus keta*) (S3-137)

Troy W. Buckley, A. Greig, J. Ianelli, P. Livingston and G. Walters. Spatial distribution and ontogenetic movement of walleye pollock in the eastern Bering Sea (S3-214)

Alexander Figurkin. Seasonal variability of temperature and salinity in the intermediate water in the northern part of the Sea of Okhotsk (Okhotsk Sea Mode Water) (S3-132)

Tadanori Fujino, R. Uji, K. Miyashita, K. Tetsumura, J. Yamamoto, S. Masuda, K. Iida and T. Mukai. Fish species identification using a quantitative echo sounder (S3-173)

Douglas E. Hay and S.M. McKinnell. Association of individuals within migrating herring schools as determined by tagging: Implications for analysis of schooling, population biology and fishing (S3-407)

David Hyrenbach and R.C. Dotson. Overlap between satellite-tracked female black-footed albatrosses and the Japanese Eastern Pacific longline fishery (S3-119)

Masayuki Iwahashi, Y. Isoda, S. Ito, Y. Oozeki and S. Suyama. Seasonal changes in the location of spawning ground and the experienced temperature of water during the early life stages of Pacific saury (*Cololabis saira*) in the western North Pacific (S3-093)

Masahide Kaeriyama, M. Nakamura, J.R. Bower, S. Yamaguchi, R.V. Walker and K.W. Myers. Recent change in summer feeding ecology and trophic dynamics of Pacific salmon in the offshore waters of the Gulf of Alaska (S3-175)

Alexander Kaev. Different strategies in pink and chum salmon migrations from Pacific Ocean into the Okhotsk Sea (S3-057)

Sukyung Kang, R.H.J. Lu, J. Wiggert and S. Kim. Relationship between chub mackerel (*Scomber japonicus*) population and climate variability in the East China Sea (S3-060)

Jin Yeong Kim, K.B. Seong, C.S. Park, D.W. Lee and S.S. Kim. Biological characteristics of chum salmon (*Oncorhynchus keta*) in the Namdae River of Korea (S3-253)

M.Y. Kuznetsov and L.A. Boretz. Interannual dynamics of walleye pollock (*Theragra chalcogramma*) abundance and distribution in the northwestern Bering Sea in 1997-2000 (S3-360)

Tae Won Lee, H.T. Moon, S.D. Hwang and W.S. Kim. Fluctuation of elver catch of Japanese eel (*Anguilla japonica*) in Korean water (S3-178)

Arturo Muhlia-Melo, P. Klimbley, S. Gonzalez-Armas, R. Jorgensen, A. Trasviña-Castro, J. Rodriguez-Romero and A. Amador Buenrostro. Studies of fish assemblages and oceanography of seamounts at the southern Gulf of California (S3-338)

Svetlana V. Naydenko. Consumption of the food hydrobionts by the Pacific salmons in the epipelagial in the south Kuril Region (S3-102)

Yury Novikov, E. Slobodskoy and Y. Nakamura. Interannual variability of squid distribution in relation to oceanological conditions of the south Kuril Islands Region (S3-251)

Michael J. Schirripa and R. Methot. Aspects of spatial distribution of sablefish (S3-305)

Satohi Suyama, Y. Ueno and Y. Kurita. The basic structure and operation method of the mid-water trawl for quantitative collection of typical surface pelagic fish, Pacific saury (*Cololabis saira*) (S3-233)

Olga S. Temnykh. Interannual and long-term dynamics of epipelagic fish communities in the southern Okhotsk Sea in connection with migrations of common nekton species (S3-342)

Orio Yamamura, P. Livingston and J. Napp. Habitat heterogeneity affects walleye pollock trophodynamics: Comparative analysis using an age-structured model in the Eastern Bering Sea and Oyashio area (S3-303)

Michio Yoneda, S. Yamasaki, Y. Mukuno, H. Horikawa, K. Yamamoto, M. Yoda and M. Matsuyama. Reproductive cycle, spawning frequency and spawning grounds of the john dory, *Zeus faber*, in the East China Sea (S3-059)

S4: POC Topic Session (Poster introduction at oral session: October 11, 15:00)

Vladimir V. Anikiev, O.V. Dudarev and E.N. Shumilin. Scales and factors of spatial and temporal variability of the biogeochemical barrier characteristics in marine part of the Yangtze River Estuary in the East China Sea (S4-369)

Harold Batchelder. Spatial and temporal distributions of mesozooplankton in idealized models of coastal upwelling ecosystems (S4-229)

Steven J. Bograd, R.J. Lynn and J.A. McGowan. A climate-driven physical mechanism for plankton decline in the California Current (S4-296)

Jaime Färber-Lorda, A. Trasviña and P. Cortes-Verdin. Trophic conditions in the mouth of the Sea of Cortes, during summer (S4-055)

Jaime Jahncke, D. Checkley and G.L. Hunt, Jr. Long-term trends in carbon flux in the Peruvian upwelling system and its effect on guano-producing seabirds (S4-094)

Gennady A. Kantakov, A.K. Klitin, G.V. Shevchenko and L.S. Shirmankina. Tsushima and West-Sakhalin Currents driving role on the red king crab early ontogenetic stages in the Sea of Japan (S4-077)

Vyacheslav B. Lobanov, S.P. Zakharkov, O.V. Kopelevich, T.Y. Orlova, M.A. Evdoshenko, A.N. Salyuk, V.I. Zvalinskiy, E.A. Streihert, S.Y. Mosyagina and A.I. Aleksanin. Variations of phytoplankton productivity characteristics in the coastal zone of Primorye, Japan Sea, as a result of mesoscale eddies formation (S4-238)

Skip McKinnell and W.R. Crawford. The curious abundance of evidence of the 18.6-year lunar nodal cycle in NE Pacific air and sea surface temperatures, and its association with major ENSO events (S4-124)

Shigeru Montani and P. Magni. An inter annual survey on intertidal macro-zoobenthic communities and environmental variability, the Seto Inland Sea (S4-101)

David L. Musgrave, H. Statscewich, T. Whitledge, S. Danielson, T. Weingartner and T.C. Royer. Recent results from a biophysical mooring on the Gulf of Alaska Shelf (S4-307)

Anatoly Salyuk, B. Li, A. Obzhirov, V.P. Shevtsov and E. Zuess. Current structure in the Northern Sakhalin shelf and slope gas venting areas in the Okhotsk Sea derived from standard shipboard echosounder survey (S4-235)

Robert Schabetsberger, C.A. Morgan, R.D. Brodeur, C.L. Potts and W.T. Peterson. Diel feeding chronology, prey selectivity and daily ration of juvenile chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Columbia River plume (S4-269)

Igor P. Semiletov. Biogeochemical consequences of coastal erosion in the North Asian marginal seas (S4-325)

George V. Shevchenko and G.A. Kantakov. Autonomous measurements of water characteristics during petroleum drilling on the northeastern shelf of Sakhalin Island in August - September 2000 (S4-113)

S.P. Zakharkov. Influence of hydrological conditions on distribution of Chlorophyll *a* concentration in Peter the Great Bay in autumn of 1999 (S4-332)

Oleg Zaytsev, E. Romero-Vadillo and R. Morales-Pérez. Numerical simulation of tropical cyclone impact on coastal circulation in the southern Baja California peninsula (S4-318)

S5: POC/BIO/FIS Joint Topic Session (Poster introduction at oral session: October 9, 08:30 & 13:00)

Vladimir B. Darnitsky. Topographical and mid-ocean eddies near Hawaiian and Imperial Ridges (S5-282)

Vladimir B. Darnitsky, M.A. Stepanenko and V.N. Vologdin. TINRO investigations of underwater mountains of the Northeast Pacific (S5-361)

Vladimir B. Darnitsky. Inside and interdaily water dynamics above of Hawaiian and Imperial Seamounts (S5-281)

Emanuele Di Lorenzo. Sensitivity of a California Current System ecosystem model to changes in mean flows versus changes in eddy statistics (S5-156)

John F. Dower, W.R. Crawford and D.R. Yelland. Physical and biological interactions between Haida eddies and shallow seamounts in the NE Pacific (S5-131)

Sachihiko Itoh and T. Sugimoto. Numerical experiments on the movement of the warm-core rings in the Kuroshio-Oyashio transition zone (S5-092)

Viatcheslav Makarov. Quasi-geostrophic two-layer model of background currents in the Gulf of California (S5-248)

Yuji Okazaki, H. Nakata, S. Kimura and A. Kasai. A Lagrangian approach to temporal changes in the abundance of larval fish and their prey organisms in the Kuroshio frontal eddy (S5-053)

Tawnya Peterson, E.A. Bornhold, F.A. Whitney and P.J. Harrison. Seasonal changes in photosynthetic biomass and primary productivity in a mesoscale eddy in the Gulf of Alaska (S5-243)

Alexander B. Rabinovich, R.E. Thomson and S.J. Bograd. Drifter observations of anticyclonic eddies seaward of Bussol' Strait, Kuril Islands (S5-065)

Young Jae Ro and E. Kim. Inter-comparison of current vector estimates and meso-scale eddy characteristics between models and altimeter datasets in the East Sea (S5-048)

Katsuyuki Sasaki and Y. Hiroe. The mechanism of nutrient supply to warm core ring off Sanriku, Japan (S5-099)

C.S. Wong, W.K. Johnson, N. Sutherland and M. Chierici. Iron distribution and transport by Haida eddies in the Northeast Pacific Ocean (S5-155)

Douglas R. Yelland and W.R. Crawford. Current structure of a Haida eddy (S5-073)

Takafumi Yoshida and T. Sugimoto. Effect of Kuroshio frontal wave and coastal topography upon coastal environment (S5-127)

S6: MEQ Topic Session (Poster introduction at oral session: October 11, 10:25)

Tatiana Konovalova, J. Robinson, J. Coil and V. Andreeva. Result of environmental monitoring of the Piltun-Astokh Oil & Gas Field (Northeast shelf of Sakhalin Island) (S6-254)

Galina Moiseychenko and U.G. Blinov. Heavy metals environmental contamination during offshore oil and gas deposits development (S6-256)

Galina Moiseychenko, L.V. Nigmatulina and U.G. Blinov. Methodical aspects and evaluation of bottom sediments contamination level (S6-257)

Galina Moiseychenko and G.S. Borisenko. The contents of radionuclides in offshore bottom sediments of northeast Sakhalin in the area of oil and gas deposits (S6-255)

S7: MEQ Topic Session

Amy B. Borde, R.M. Thom and S. Rumrill. Geospatial habitat analysis in Pacific Northwest coastal estuaries (S7-410)

Christopher Farley and R. Johnson. Coastal residents' attitudes regarding estuarine environments and resource management (S7-276)

Bridget Ferriss and T. Leschine. The role of indicators in the management of PNCERS estuaries (S7-274)

Kirstin K. Holsman, D. Beauchamp and D. Armstrong. A spatially explicit bioenergetic model for *Cancer magister* (S7-272)

Daniel Huppert and K. Bell. Potential local economic support for Coho local enhancement programs (S7-273)

Rebecca Johnson, K. Bell and D. Huppert. Importance of biophysical attributes on coastal residents' location decisions (S7-277)

Sarah MacWilliams and D. Huppert. Styles of collaborative resource management in Pacific Northwest coastal estuaries (S7-275)

Jessica A. Miller, A.L. Shanks and C.A. Roegner. Ocean-estuary coupling in the Coos Bay estuary: Nearshore and estuarine delivery of larval and juvenile fish and invertebrates (S7-278)

Julia K. Parrish, E. Logerwell, D. Hyrenbach and W.J. Sydeman. Community interactions between seabirds and coastal pelagics: Starvation or satiation? (S7-390)

Curtis Roegner, D. Armstrong and A. Shanks. Measuring variation in larval supply to estuarine sites with light traps (S7-270)

Chris Rooper, D.R. Gunderson and B.M. Hickey. English sole egg and larval transport on the Oregon/Washington shelf in 1997-2000 (S7-271)

S8: MEQ Topic Session

Alexander Bogdanovsky, I.E. Kochergin, V.D. Budaeva, V.G. Makarov, V.F. Mishukov, V.F. Putov, S.I. Rybalko and E.P. Uraevsky. On-line oil spill model for Sakhalin shelf (VOS-RT 2) (S8-129)

María Verónica Morales Zátare and S.E. Lluch-Cota. Exploring low frequency variability of mariculture production (S8-300)

Leonid Muratov, V.F. Mishukov and A.A. Tkalin. Numerical modeling of the oil spill spreading (S8-062)

Leonid Muratov, V.F. Mishukov, A.S. Pavlov and A.A. Tkalin. Oil drilling faults analysis: Insight from amcad (S8-061)

Jihui Yan and J. Li. Marine ecosystem protection in China (S8-040)

Dong-Beom Yang, J. Yu, Y.H. Jin, K.T. Kim, S.H. Kim, D.S. Moon and G.H. Hong. Atmospheric flux of PAHs and organochlorines to the southeastern Yellow Sea: Results based on shipboard aerosol collection during 2000-2001 (S8-417)

S9: MEQ/BIO/POC Joint Topic Session

T.N. Krupnova. Influence of hydrological conditions on product of *Laminaria japonica arech.* in northwestern part of the Sea of Japan (S9-387)

T.N. Krupnova. A way of sporiferous tissue disposition on thalluses of *Laminaria japonica* as a feature of growth conditions (S9-385)

S10: CCCC Topic Session (Poster introduction at oral session: October 9, 13:30)

Kenneth O. Coyle and A.I. Pinchuk. Variations in zooplankton distribution and abundance on the inner shelf of the southeast Bering Sea relative to climate extremes (S10-323)

Nancy D. Davis, Y. Ishida, M. Kaeriyama, K. Tadokoro, Y. Ueno and M. Fukuwaka. Food habits of sockeye, chum, and pink salmon from the central Bering Sea, 1991-2000 (S10-130)

O.V. Dudarev, N.I. Savelieva and I.P. Semiletov. Interdecadal and mesoscale time-spatial variability in the physical and biogeochemical components of the Bering Sea ecosystem: The Anadyr Gulf (S10-265)

David Hyrenbach, J. Jahncke, C.L. Baduini and G.L. Hunt, Jr. Spatial and temporal patterns of shearwater use of the southeastern Bering Sea (S10-117)

Keiri Imai, A. Shiomoto, T. Odate, S. Saitoh and Y. Nojiri. Primary productivity and phytoplankton biomass in the southeastern Bering Sea in summer 2000 (S10-321)

Jaime Jahncke, D. Hyrenbach, C.L. Baduini, K.O. Coyle and G.L. Hunt, Jr. Distribution of foraging shearwaters with respect to the inner front of the southeastern Bering Sea (S10-210)

Nancy Kachel, A.J. Hermann, S.A. Salo and P.J. Stabeno. Currents near the Inner Front of the southeastern Bering Sea (S10-095)

Young Shil Kang, J. Napp and S. Kim. Seasonal succession in zooplankton community in the Bering Sea in 1994 (S10-298)

Gordon H. Kruse and J. Zheng. Stock-recruitment relationships for Alaskan crab stocks (S10-389)

C. Peter McRoy, S. Nakanishi, K. Mizobata and S. Saitoh. Trends in ocean conditions and new production on the shelf of the southeast Bering Sea over the past 20 years (S10-418)

Kohei Mizobata, S. Saitoh, T. Miyamura, N. Shiga, K. Imai, M. Toratani, Y. Kajiwara and K. Sasaoka. Bering Sea eddy in the "Green Belt" (S10-284)

Valentina V. Moroz. Analysis of the water circulation in the Komandor-Kamchatka region by the types of the atmospheric circulation (S10-230)

Victor Nadtochy and E.E. Borisovets. Composition, structure and present state of buccinidae molluscs of Olyutorsky Bay, Bering Sea (S10-085)

Jeffrey M. Napp and C.T. Baier. The rise and fall of zooplankton populations in recent decades on the SE Bering Sea shelf - Bottom-up and top-down control of two copepod genera (S10-140)

Wonsun Park and I.S. Oh. Surface heat fluxes and sea ice variations of the Bering Sea in the 1990s (S10-262)

Tae Keun Rho, T.E. Whitledge, D.A. Stockwell and J.J. Goering. Effects of high ammonium concentrations on nitrate uptake rates and its implications in the southeastern Bering Sea shelf ecosystem (S10-208)

Sigrid Salo, S. Zeeman and P.J. Stabeno. An enduring coccolithophore bloom in the Bering Sea (S10-107)

Vladimir Sevostianov. Some significant changes in the Bering ecosystem (S10-111)

Naonobu Shiga, C. Sassa and M. Mochizuki. Summer characteristics of zooplankton community south of St. Lawrence Island, northern Bering Sea shelf (S10-264)

Kyung-Hoon Shin and N. Tanaka. Organic carbon cycles in the Bering Sea and western Arctic Ocean (S10-363)

Stacy Smith and S. Henrichs. Temporal and spatial variability in lipid fluxes over the southeastern Bering Sea Shelf, 1997-2000 (S10-216)

Gordon Swartzman, L. Ciannelli, A. Winter and K. Coyle. When push comes to shove: Contrast in zooplankton depletion in high and low juvenile pollock abundance years based on acoustic and modeling evidence near the Pribilof Islands Alaska (S10-405)

Albert V. Tyler, G.E. Rosenkranz and G.H. Kruse. Effects of water temperature and wind recruitment of tanner crabs in Bristol Bay, Alaska (S10-414)

L.N. Vasilevskaya, V.V. Plotnikov and N.I. Savelieva. Assessment of macroscale connection in the atmosphere - sea ice cover system (S10-364)

Lucy S. Vlietstra and G.L. Hunt, Jr. Temporal patterns in the at-sea abundance and distribution of marine birds around the Pribilof Islands, 1975-1999 (S10-133)

N.M. Wakulskay and A.G. Petrov. Analysis of the reasons of abnormal dissemination of ice in the Bering Sea (S10-380)

Thomas K. Wilderbuer, A.B. Hollowed and G. Walters. Flatfish recruitment response to decadal climatic variability and ocean conditions in the Eastern Bering Sea (S10-259)

Stephan Zeeman. Coccolithophores in the Bering Sea (S10-171)

S11: CCCC/GLOBEC Joint Topic Session

Douglas F. Bertram, A. Harfenist and A. Hedd. Comparative reproductive performance and nestling diet of Cassin's Auklet breeding in two distinct oceanographic domains off British Columbia (S11-395)

Larisa N. Bokhan. Year-to-year dynamics of Copepoda: Calanoida in epipelagic layer of the Okhotsk Sea and the Kuril region of the Pacific Ocean (S11-374)

Richard D. Brodeur, E. Casillas, R.L. Emmett, J.P. Fisher, J. Popp-Noskov and D. Teel. Mesoscale and fine-scale distribution of juvenile salmon and associated biota off Oregon and northern California (S11-139)

Victor F. Bugayev. On pink salmon (*Oncorhynchus gorbuscha*) number influence on Asian sockeye (*Oncorhynchus nerka*) (S11-228)

Steve H. Coombs *et al.* Bio-physical transport modelling of the growth and survival of the planktonic stages of mackerel (*Scomber scombrus*) in the eastern North Atlantic (S11-116)

Patrick Cummins and G. Lagerloef. Low frequency pycnocline depth variability at Station P in the Northeast Pacific (S11-006)

Natalia T. Dolganova. Year-to-year variability of plankton in the northwestern part of the Japan Sea (S11-351)

Robert Emmett, P. Bentley and G. Krutzikowski. The recent northwest baitfish boom and increased salmon ocean survival (S11-146)

Leah Feinberg and W.T. Peterson. Variability in length and intensity of euphausiid spawning off central Oregon, 1996-2001 (S11-153)

Jaime Gómez-Gutiérrez and W.T. Peterson. Zonal distribution and community structure of euphausiid on the coastal shelf off central Oregon, during 1970-1972: A multivariate approach (S11-306)

Tomonori Hamatsu and K. Yabuki. Decadal variability of the stomach contents and the growth rate of walleye pollock off the Pacific coast of eastern Hokkaido, Japan (S11-079)

Masahide Kaeriyama, Y. Ishida and S. Urawa. Increase in body size with decrease in population size of chum salmon returning to Hokkaido, Japan, since the late 1990s (S11-322)

Young Shil Kang, Y.H. Lee and H.G. Kim. Interannual and seasonal variations in oceanographic condition and zooplankton community in the eastern area of the Yellow Sea (S11-299)

Natalia Klovatch, O. Gritsenko and M. Bogdanov. New era of Pacific salmon existence in the Northwest Pacific (S11-279)

Lydia B. Ladah and J.A. Zertuche-González. Global warming and ENSO in the kelp forest ecosystems of Baja California, Mexico: Biological indicators of climate change in biogeographic transition zones (S11-346)

Carol Ladd and L. Thompson. Decadal variability of North Pacific central mode water (S11-074)

Nathan Mantua and S.R. Hare. Empirical evidence for a late 1990s North Pacific regime shift (S11-201)

Arthur J. Miller and Niklas Schneider. Predicting climate changes of the western North Pacific Ocean (S11-198)

Franz J. Mueter, B.J. Pyper and R.M. Peterman. Effects of coastal sea surface temperatures on survival rates of sockeye, pink, and chum salmon stocks from Washington, British Columbia, and Alaska (S11-203)

L.S. Muktepavel, A.A. Nikitin and T.A. Shatilina. Reasons for abnormal ice cover in the Okhotsk Sea (S11-356)

Victoria V. Nadtochy and Y.I. Zuenko. Coastal upwelling in the Japan Sea: Estimation of wind-driven transport of zooplankton (S11-331)

Kaoru Nakata, M. Tomiyama, H. Yamada and Y. Matsukawa. A large shift in the survival rate of Japanese sand eel (*Ammodytes personatus*) in Ise Bay, between 1998 and 1999, in relation to copepod composition (S11-205)

Manuel O. Nevárez Martínez, D. Lluch Belda and M.A. Cisneros Mata. Environmental conditions, spawning stock, and Pacific sardine recruitment in the Gulf of California (S11-347)

Yasunori Sakurai, J. Yamamoto, R. Uji, T. Shimura and S. Masuda. Observations on possible egg masses of the squid, *Todarodes pacificus*, in the Sea of Japan (S11-287)

Robert L. Smith, A. Huyer and J. Fleischbein. Ocean climate change off Oregon? (S11-393)

Gary L. Thomas and R.E. Thorne. Collapse of Pacific herring stock in Prince William Sound, Alaska (S11-067)

Richard Thorne and G.L. Thomas. NOWCAST-forecasting in Prince William Sound, Alaska: A multi-frequency approach to synoptically assessing spring copepod prey and fish predator densities (S11-066)

Cynthia T. Tynan, D.G. Ainley and J. Barth. Cetacean distributions and oceanographic features of the Northern California Current: GLOBEC Northeast Pacific process studies during 2000 (S11-249)

Thomas C. Wainwright. Time scales of top-down and bottom-up processes in a coastal upwelling system (S11-261)

C.S. Wong and L. Xie. Inter-annual variation of nutrients and carbon in subarctic NE Pacific: Influence of wind-induced upwelling and ENSO events (S11-329)

Jen Zamon, F.A. Whitney, D.W. Welch, M. Robert, J.F.T. Morris, M. Trudel and M.E. Thiess. Changes in water mass, nutrient, chlorophyll, and zooplankton distributions across juvenile salmon habitat on the continental shelf during the 1998/1999 shift from warm-ocean to cool-ocean conditions (S11-212)

Lidiya O. Zavarina. Biological and age-specific changes of the mature part of the Kamchatka River chum salmon - *Oncorhynchus keta* (Walbaum) (S11-376)

Yongping Zhao, A. Wu and D. Hu. The climatic jump of the western Pacific warm pool and its climatic effects (S11-042)

Janne Zorbidi. On the influence of some environmental parameters on the Kamchatka silver coho salmon productivity (S11-377)

S12: TCODE E-Poster Session

Lynn deWitt and R. Mendelssohn. PFEL Data holdings and data products (S12-392)

Sonia Hamilton. The Bering Sea and North Pacific Ocean Theme Page: A web-based ocean information system (S12-396)

Hee-Dong Jeong, B.K. Kim, K.K. Jung and S. Heo. Oceanographic observation and data management activities in Korea (S12-416)

Sung-Dae Kim, K.S. Park, S.K. Kang, S.Y. Park and J.K. Lee. Development of real-time data service system for the Korean coastal waters (S12-409)

Taiyo Kobayashi, Y. Takatsuki, Y. Ichikawa, T. Suga, K. Mizuno, N. Shikama and K. Takeuchi. Japan ARGO delayed-mode data base in JAMSTEC (S12-349)

Alexander Kozyr. Electronic tour through the Carbon Dioxide Information Analysis Center's Ocean web page (S12-084)

Savithri Narayanan. Data management in DFO (S12-394)

Sachiko Oguma and T. Suzuki. Activities of Marine Information Research Center. II: A contribution to the construction of inventory of CO_2 related data (S12-167)

Igor Rostov, M.V. Zhayvoronok and V.I. Rostov. Integrated base of information resources on the N.W. Pacific oceanography and marine environment: New version of POI web-site (S12-106)

Nikolay A. Rykov, I.E. Kochergin, A.N. Man'ko, S.I. Rybalko, E.P. Uraevsky and Yu.N. Volkov. Regional Oceanographic Data Center (S12-388)

Toru Suzuki, A. Asada, S. Oguma and Y. Nagata. Activities of Marine Information Research Center. I: Three-dimensional panoramic animations for bottom topography near Japan (S12-168)

Michelle Tomlinson and V.L. Trainer. Access to the Pacific Region Harmful Algal Bloom (PACHAB) data through the National Harmful Algal Bloom Data Management System (S12-166)

Shigeru Toyoshima, S. Sato and N. Baba. Recent activities of the Japan Oceanographic Data Center (JODC) (S12-350)

BIO Committee posters

Irina Bragina. Copepods structure reply on the Sea of Okhotsk advection in the Sea of Japan (GP-191)

Irina Bragina and G.V. Shevchenko. Influence of water exchanging through the La Perouse (Soya) Strait on the intrusion of Okhotsk Sea zooplankton endemics in the Sea of Japan (GP-089)

Donghyun Lim, J.Y. Yang, W.D. Yoon and W.R. Kim. Biological evidence on introduction of the Kuroshio to the Yellow Sea (GP-122)

Chul Park, and P.G. Lee. Characteristics of zooplankton distribution in the northern East China Sea (GP-044)

Marina Shebanova. Vertical distribution of copepods: *Neocalanus cristatus*, *Neocalanus plumchrus/flemingeri* and *Eucalanus bungii* in the south part of the Okhotsk Sea, in summer 1989, 1994 (GP-373)

Zaholi Xu, Y. Wang, Y. Jiangmei and Y. Chen. Study of ecological characteristics of copepods in the East China Sea (GP-335)

CCCC Program posters

Vera N. Agostini, R.C. Francis, A.B. Hollowed, P.J. Stabeno, P. Sullivan. Pelagic ocean habitats in the Bering Sea (GP-143)

Vadim V. Navrotsky. Physical factors defining climate and ocean ecosystem variations (GP-355)

Koji Ozaki, S. Uye, T. Kusumoto and T. Hagino. Inshore and offshore fluctuation of the Kuroshio path may affect the environment and zooplankton in Kii Channel, a shelf water on the Pacific side of southwestern Japan (GP-104)

Yun-Long Wang and Yuan Qi. Species composition and distribution characteristics of key species of chaetognaths in the East China Sea (GP-334)

FIS Committee posters

Natalya Bessmertnaya and Y. Reznik. Fecundity of females *Todarodes pacificus* (Ommastrophidae, Cephalopoda) in the Japan Sea (GP-314)

Evelyn Brown, R.L. Collins, J.H. Churnside, J. Wilson and T. Veenstra. Pilot study of new near-field remote sensing methods for assessing fish: Light detecting and ranging (lidar) using lasers and imagers (GP-088)

Natalia T. Dolganova and Y.A. Fedorets. Feeding of the squid, *Berryteuthis magister*, in the area of Kuril Islands (GP-090)

Yang Jae Im, H.J. Hwang, J.B. Lee, S.H. Hong, S.Y. Park, T.S. Ko and Y.C. Park. Based on diving survey, stock assessment and management implications of pen shell (*Atrina pectinata*) in the Korean adjacent waters of the Yellow Sea (GP-240)

Atsushi Kawabata. A new trial for acoustic abundance estimation of Japanese common squid (GP-313)

Natalia A. Kuznetsova. Trophic relationship of fishes in pelagial in northern part of the Sea of Okhotsk (GP-352)

Juana López-Martínez, S. Hernández-Vázquez, F. Arreguín-Sánchez and A.R. García-Juárez. Environmental influence in the definition of the recruitment magnitude of the brown shrimp (*Farfantepenaeus californiensis*) in the Gulf of California, Mexico (GP-343)

Yuri Mitrofanov, O.V. Demenok, G.R. Gasanova and V.V. Kalinin. The difference of biological indicators in chum (*Oncorhynchus keta*) fry of some natural and fish-farm populations (GP-247)

Alexei M. Orlov. Feeding habits of shortraker *Sebastes borealis* and rougheye *S. aleutianus* rockfishes (Scorpaeindae) in the western Bering Sea (GP-371)

V.A. Pavlyuchkov and T.N. Krupnova. Factors influencing stock increase of the grey sea urchin (*Strongylocentrotus intermedius*) in the northwestern part of the Japan Sea (GP-386)

Igor V. Tiller. On the population structure and number dynamics of the Bolshaya River *Salvelinus malma* (GP-378)

Marc Trudel, S. Tucker and D.W. Welch. Are Pacific salmon starving in the ocean? (GP-289)

Mari Yoda, K. Mizuta and M. Matsuyama. Final oocyte maturation and ovulation of the jack mackerel, *Trachurus japonicus*, induced by HCG (GP-128)

Shijie Zhou. Salmon escapement forecasts using artificial neural networks (GP-348)

MEQ Committee posters

Tatyana A. Belan. Peculiarity of benthos abundance and species composition in conditions of pollution (the Sea of Japan) (GP-372)

Shang Chen, M. Zhu and R. Li. Long-term changes in Bohai Sea ecosystem (GP-051)

L.S. Dolmatova, V.V. Romashina and A.L. Kovaleva. Comparative studies on the antioxidant enzyme activities in coelomoctyes of Far Eastern holothurians *A. japonicus* and *E. fraudatrix*, and Sea Star *A. amurensis* (GP-366)

Ruixiang Li, M. Zhu, S. Chen, R. Lu and B. Li. Responses of phytoplankton on phosphate enrichment in mesocosm (GP-063)

POC Paper Session (Poster introduction at oral session: October 11, 15:25)

Andrew Bobkov, D.K. Staritsin and V.R. Foux. Coastal tidal fronts in the Okhotsk Sea (GP-058)

Pavel V. Boubnov. Particulate organic carbon variability in the subarctic Pacific based on transmissiometer data (GP-291)

Fedor Khrapchenkov and E.V. Dmitrieva. The analysis of the seasonal variability of upper mixed layer depth of the Japan and Okhotsk Sea (GP-268)

Eung Kim and Y.J. Ro. Horizontal structure of sea surface height anomaly estimated from Topex/Poseidon in the East (Japan) Sea (GP-162)

Sergey B. Kozitskiy. Linear stability problem for a system with thermohaline convection in a limit of high Hopf frequency (GP-345)

Akira Kusaka and Y. Kawasaki. Mooring observation of Oyashio current southeast of Hokkaido, Japan (GP-047)

Victor I. Kuzin and V.M. Moiseev. Variability of the North Pacific circulation model under the surface forcing from re-analysis data (GP-398)

Victor I. Kuzin, A.D. Nelezin and A.D. Man'ko. Diagnosis of Kuroshio states (GP-399)

M. Lucila Lares. The mussel, *Mytilus californianus*, as indicator of Cd in upwelling regimes (GP-316)

Ehecatl Manuel Muñoz Mejía. Dynamic characterization of the Northeast Pacific transition zone (GP-337)

A.A. Nikitin. Typification of thermal structures in the Japan Sea based on satellite information (GP-357)

A. Obzhirov, A. Salyuk, E. Suess and N. Biebow. Shallow water methane anomaly in the western part of the Okhotsk Sea (GP-368)

Alexander G. Petrov. Surface phenomena of frontal character in the North Pacific (GP-381)

Eugene Samko and Y. Novikov. Water dynamics in the Sakhalin-Kuril region (GP-108)

Igor P. Semiletov, J.P. Christensen, I.I. Pipko and P.Ya. Tishchenko. Carbonate chemistry dynamics in the Bering Strait and Chukchi Sea (GP-365)

Pavel Ya. Tishchenko, L.D. Talley and V.I. Zvalinsky. Temporal variability of hydrochemical properties in the Japan Sea (GP-136)

Nikolay Vanin, G.I. Yurasov and S.S. Ermolenko. Climatic characteristic of currents in the Japan (East) Sea (GP-280)

Galina Vlasova and A.M. Polyakova. An energy-active zone in the ocean and atmosphere of the northwestern Pacific (GP-038)

Hiroshi Yoshinari, I. Yasuda, M. Ikeda, S. Ito, E. Firing, Y. Matsuo, O. Katoh and Y. Shimizu. Meridional transport of the North Pacific intermediate water across 37N line based on the objective analysis of lowered acoustic doppler current profiler data (GP-126)

W1: REX Workshop

P.A. Balykin and A.V. Buslov. Long-term changes in size-at-age of walleye pollock in the western Bering Sea and Pacific waters off Kamchatka Peninsula (W1-225)

A.A. Bonk. Herring distribution in the western Bering Sea in the conditions of the number raising (W1-227)

Elsa R. Ivshina. Influence of some factors on the growth of Sakhalin-Hokkaido herring (Sea of Japan) (W1-145)

Vladimir A. Shelekhov and A.A. Baitaluk. Microstructure of otoliths and feature of growth of the Pacific saury in the Northwest Pacific Ocean and Japan Sea (W1-112)

Sergey Tarasyuck. Yellow-fin flounder (*Limanda aspera*, Pallas) generations survive dynamics in the Tartar Strait, northern part of the Sea of Japan, in the second half of the 20th century (W1-150)

I.K. Trofinov and A.A. Smirnov. The peculiarities of the linear growth in the Pacific herring from the northeast part of the Sea of Okhotsk (W1-224)

PICES X

Abstracts

Abstracts are sorted first by session and then alphabetically by the main author's last name. Presenter's names are in bold 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 the abstracts in this collection have not been edited and have been printed in the condition that they were received.

Keynote Address

10AM2001 KA-039

PICES - THE FIRST DECADE, AND BEYOND

Warren S. Wooster
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While PICES celebrates its tenth anniversary, its origins can be traced back more than 25 years. Early informal discussions of the need for such an organization took place at an FAO Technical Conference on Fishery Management in Vancouver in 1973. More active consideration began at the University of Washington in 1976, and the first informal meeting on the subject occurred in 1978. Between then and March 1992 when the PICES Convention was signed, there were 8 other informal and formal reunions, involving participants from most of the present member countries. While some time was required to develop mutual understanding of what such an organization could accomplish, the long gestation period was mostly due to the shifting political relations among the countries concerned.

Early in the discussions, it became clear that interests of the proposed organization would not overlap with those of international organizations operating in the region. These were either global and broad in scope, or regional and specialized, in most cases for fishery management. PICES was envisioned as a regional organization, similar in many ways to the International Council for the Exploration of the Sea, ICES, in the North Atlantic, and was to be devoted to marine science in its broad aspects, and particularly to the interactions between the physical ocean environment and the ecosystems that function therein. This focus became particularly relevant as the impact of climate variations and the threat of climate change became apparent.

In its first decade, PICES considered a wide array of problems, including those of specific regions, such as the Okhotsk Sea and Oyashio region, the Bering Sea, the subarctic gyre, and the Japan/East Sea; circulation modeling, carbon dioxide, and the iron fertilization experiment; monitoring, data exchange and quality control; pollution assessment methodology; coastal pelagic fisheries, marine birds and mammals, crabs and shrimps, and harmful algal blooms. The major program on Climate Change and Carrying Capacity incorporates an interdisciplinary, integrative, and comparative approach, encompasses estimations of ecosystem carrying capacity and will shed light on the implications of climate changes for fisheries management. These efforts continue as the problems evolve and new ones arise.

The coming decade may include more cooperative operational efforts, for example in establishing an effective ecosystem monitoring system, and in data and information exchange and analysis in order to generate regular and timely ecosystem status reports and to provide scientific assessment and advice to its members and to interested regional organizations. The goal of PICES should be to continue and enhance its services to its members and to their scientists.

S1 PICES X Anniversary Symposium
Ten Years of PICES Science: Decadal-Scale Scientific Progress and Prognosis for a Regime Shift in Scientific Approach

Convenors: Patricia Livingston (Science Board, U.S.A.), Tsutomu Ikeda (BIO, Japan), Douglas E. Hay (FIS, Canada), John E. Stein (MEQ, U.S.A.), Susan E. Allen (POC, Canada), Thomas C. Royer (TCODE, U.S.A.) and David W. Welch (CCCC, Canada)
Monday, October 8, 2001 10:30-17:30

This Science Board Symposium is a celebration and reflection on the first ten years of scientific progress by PICES. In-depth overviews of the scientific activities and results of PICES committees and scientific programs will be given by invited speakers on topics related to climate variability, ocean impacts at lower and top trophic levels, factors influencing fish stock fluctuations, human activities and marine environmental quality, and North Pacific ecosystem structure and function.

A look to the future of marine science in the North Pacific will be provided through thought-provoking invited talks, given by distinguished scientists with connections outside PICES, on various topics, which could range from the future of ocean sensing technologies and our predictive capabilities; human perspectives on ocean uses and appreciation of the geography and cultures of the North Pacific; broadening our scientific disciplinary focus; and improving the links between marine science and policy. Contributed papers on the historical perspective and the future scientific direction of PICES will be presented as posters.

Publication of papers will be in the PICES Scientific Report Series scheduled for early spring 2002.

Invited speakers:

D.E. Harrison (Pacific Marine Environmental Laboratory, U.S.A.) – Ocean observing systems and prediction: The next ten years

Robie W. Macdonald (Institute of Ocean Sciences, Canada) - Marine environmental issues in the North Pacific: What are the dangers and how do we identify them?

Berrien Moore III (IGBP) - Marine science-IGBP: Partners in the 21st century

Steven A. Murawski (Northeast Fisheries Science Center, NMFS, U.S.A.) - Ecosystem considerations in fisheries management: the future of science and policy

Timothy R. Parsons (Institute of Ocean Sciences, Canada) - Future needs for biological oceanographic studies in the Pacific Ocean

10AM2001 S1-403 invited

PICES MARINE ENVIRONMENTAL QUALITY COMMITTEE - THE FIRST TEN YEARS

Richard F. **Addison**[1], John E. Stein[2], Alexander V. Tkalin[3], Jia-Yi Zhou[4] and Usha Varanasi[2]

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Marine environmental quality (MEQ) is a subject of concern in all PICES member countries. It affects all sectors of society -- governments, users of renewable and non-renewable resources, resource and environmental managers, and the public in general, particularly as recreational users of the coastal zone or as environmental activists. It is therefore natural that MEQ should be one of the main interests of PICES. Nevertheless, there is a sense in which MEQ is a somewhat artificial or contrived subject for PICES: MEQ is essentially a local or regional concern, which is perceived as being of most significance in the coastal zone or on continental shelves (because that is where most marine resources are used) rather than an inter-continental or hemispheric issue. During the first few years of its existence, the PICES MEQ Committee has had to consider MEQ issues both from a national or bi-lateral perspective (reflecting local or regional concerns) and from the larger, inter-continental perspective. The common ground in these issues, whether local, regional or intercontinental, has been the approaches used in assessing MEQ. A recurrent theme in PICES MEQ meetings over the last decade has been "common assessment methodology".

The PICES MEQ Committee's approach to "common assessment methodology" has taken two directions. Through its annual scientific meetings it has tried to identify issues of common interest. These have included (for example, and in no particular order of priority) coastal eutrophication and (possibly) associated harmful algal blooms, transport of non-indigenous species (ballast water exchange), the impact of large scale freshwater management schemes (such as the Three Gorges project), local contamination issues, oil and gas exploration, and long range transport of pollutants. This last issue is perhaps the one supra-regional scale issue for PICES MEQ. Additionally, the committee has taken an initial step to harmonise approaches to assessing MEQ, particularly by organising the Vancouver Harbour Workshop, in which participants from all member countries worked together on a common pollution gradient. In the course of this practical study, participants were able to exchange information about methods and techniques and to gain a better understanding of each others' approaches to MEQ issues. Harmonization of approaches is continuing in an assessment of the extent and occurrence of HABs in all PICES countries.

From the perspective of marine environmental quality there are a limited number of issues that truly connect countries on the western and eastern sides of the North Pacific. Nonetheless, there has been significant progress by the MEQ Committee in identifying common concerns, and the prospect of global climate change and increased population growth on coastal regions suggests that in the next ten years trans-Pacific MEQ issues will likely increase.

10AM2001 S1-312 poster

A CLASSIFICATION OF SALMON BIOGEOGRAPHIC ZONES OF THE NORTH PACIFIC OCEAN

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Many Pacific salmon populations, particularly at the southern portion of each species' range, have been reported in serious decline and at risk of extinction due to a variety of factors affecting their stream, estuarine, and ocean habitats. While widespread decline may indicate important systemic rather than isolated causes, no comprehensive assessments have been made to interpret the status of salmonid species across their entire North

Pacific distributions. To facilitate such an assessment, we classified the entire North Pacific region into a series of salmon "biogeographic zones" for compiling and comparing stock status information. The zones define 62 salmonid "catchments," comprising networks of distinct stream-estuarine-coastal habitat that support the juvenile phases of salmon life history where year-class strength is largely determined. Until more quantitative and population-specific data become available, the zones offer a standardized and ecologically-based system for compiling stock status and habitat information at a Pacific-Rim scale. Differences in jurisdictional and biogeographic boundaries for salmon, the spatial resolution and definition of "stocks" in various regions, and the lack of data for many smaller (noncommercially exploited) populations restrict some applications of the zone approach. Nonetheless, our results show that the biogeographic zones offer a useful and systematic method for analyzing patterns of salmonid risk at a Pacific-Rim scale.

10AM2001 S1-419 poster

CHANGES OF THE MASS SUBTROPICAL FISHES IN THE JAPAN SEA UNDER THE MATCH/MISMATCH CONTROL

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Changes of abundance of sardine, saury, scomber, and anchovy in the Japan Sea in XX Century are considered on the base of catch dynamics and compared with environments changes for testing the match/mismatch hypothesis. Different sensitivity of certain species to the match/mismatch of terms of their spawn with periods of high abundance of zooplankton in dependence on their ecology are discussed and explained for last decades. Sardine, scomber and anchovy need the similar conditions for the success of their spawn. In general, cool winters or low intensity of Kuroshio were favourable for them in the second half of the Century, but sardine is sensitive to low temperature in embryonic period. Saury needs opposite conditions, and warm winters or intensive Kuroshio were favourable for it in these times. As a result, sardine had the well-known large fluctuations, abundance of scomber and anchovy fluctuated with 17-19 years periodicity, and saury changed inversely to all other species.

On the basement of concluded regularities, an increasing of sardine stock is expected in the first decade of the XXI Century.

10AM2001 S1-310 poster

SUSTAINABILITY, ECOSYSTEMS AND FISHERY MANAGEMENT

Charles W. **Fowler** and Shannon M. McCluskey

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Fisheries management is experiencing a trend in which harvest rates are being reduced through increasing consideration of complexity. As recently as the late 1960s there was acceptance of fishing mortality equivalent to natural mortality (F = M). From this extreme, reductions in fishing mortality have been based on a variety of arguments, not the least of which is consideration of other species and ecosystems, especially those of the target resource species. In 1999, a National Research Council committee recommended further reductions as a means of dealing with ecosystem issues. Reductions in fishing mortality are the common element in the options being considered for the management of Bering Sea fisheries in view of potential effects of fishing on the endangered northern sea lion. Similar patterns are seen in the management of other fisheries such as the salmon of the Pacific Northwest, now protected under the Endangered Species Act.

One of the tenets of management requires that the complexity of nature be accounted for as a matter of principle. What is the end point of the declining trends in acceptable fishing mortality as more and more complexity is considered? In this paper we present empirical information for estimating such endpoints. More specifically, we present the central tendencies within limits to natural variation in predation/consumption rates observed for various marine mammal species as standards and reference points for fisheries management. Systemic management would apply this information to manage fisheries with harvests from individual resources species, groups of species, ecosystems, or the entire marine environment.

10AM2001 S1-032 invited

OCEAN OBSERVING SYSTEMS AND PREDICTION: THE NEXT TEN YEARS

D.E. Harrison[1] and Neville Smith[2]

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The oceanographic community is moving into a new era where routine applications and research operate together, supported by a robust, international network of observations. Some people term this the era of operational oceanography, with the ability to predict future states of the ocean and climate being the overriding paradigm. This point has not been reached with an *ad hoc* approach but rather through a careful and systematic approach to observing system design and implementation, and appropriate consideration of cost and effectiveness. This paper reviews this process, focussing principally on physics and dynamics and provides a vision for the observing system. The future promises a near-revolution in our ability to measure and predict based on thoughtful and insightful exploitation of knowledge gleaned over the past decades. Initiatives such as *Argo* and GODAE, and targeted investment in other key areas, particularly remote sensing, are providing certainty and a long-term view. One of the more exciting aspects relates to innovation in data and information management. Emerging initiatives promise greater flexibility and generality and, through the exploitation of modern information technology, a more open and accessible system. In all respects, we are experiencing a regime shift and, perhaps, a paradigm shift in our approach to oceanography. Organizations such as PICES will play a pivotal role in this shift and provide an important regional mechanism for implementing and/or testing these new methods.

10AM2001 S1-344 invited

TEN YEARS OF PICES: AN INTROSPECTIVE, RETROSPECTIVE, CRITICAL AND CONSTRUCTIVE REVIEW OF FISHERIES SCIENCE IN PICES

Douglas E. Hay, R.J. Beamish, G.W. Boehlert, V.I. Radchenko, Q.S. Tang, T. Wada, D.M. Ware and C.I. Zhang

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In the ten years since PICES was formed, many fisheries throughout the world have entered into turmoil, with some stocks collapsing and others, unexpectedly, reaching historically high levels of abundance. Both situations have led to severe difficulty for fisheries management agencies, which have been subjected to intense criticism. This turmoil has also occurred in the North Pacific, of which PICES is the foremost marine scientific organization. So, we ask rhetorically, what has PICES done to help clarify or assist with solutions to these problems? Specifically, has the Fisheries Science Committee (FIS) done anything that that will make a difference? Certainly, as we point out in this paper, we have held some excellent scientific sessions, set up capable working groups that wrote comprehensive reports and published a few papers. Further, PICES has had some terrific parties and kindled some excellent collaboration and friendships - even between fisheries biologists and oceanographers! But, as we ask in this paper, have we done enough? Have we met the objectives that were originally set for PICES? Were those original objectives adequate to address the issues we see today? In this paper we review these original objectives that were defined for fisheries activities in PICES and compare these to our performance and contributions in the last 10 years. Our conclusion is that, in many respects, we did a good job, but overall, it was not enough. We have not fulfilled all of the key objectives and visions of the founders of PICES. Given these shortcomings, do we have now a clear vision of what we want FIS and PICES to do, and do we know the scientific directions in which it should go? Indeed, is PICES an organization that sponsors an annual scientific meeting, but little more relative to fisheries issues? Should PICES be more than an annual science meeting, and if so, what should it be? Is there more we could and should do? Has there been adequate support and recognition by member counties? To address these issues, key participants in the FIS Committee, and working groups and symposia organizers provide constructive and critical comments on FIS, PICES, and provide visions of the next decade of PICES.

10AM2001 S1-263 invited

OCEAN IMPACTS FROM THE BOTTOM OF THE FOOD WEB TO THE TOP: BIOLOGICAL OCEANOGRAPHY COMMITTEE RETROSPECTIVE

Tsutomu **Ikeda**[1] and Patricia A. Wheeler[2]

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The major responsibilities of the biological oceanography committee (BIO) are to promote and coordinate biological oceanography and interdisciplinary research in the northern North Pacific. This work proceeded under the leadership of Mike Mullin (1992-1995), Pat Wheeler (1996-1998) and Tom Ikeda (1999-2001). Over the last decade, BIO has sponsored or co-sponsored symposia and special topics covering the entire spectrum of trophic levels and food web processes. Highlights include: factors controlling phytoplankton stocks, physical, chemical and biological interactions during harmful algal blooms, the carbon cycle in the North Pacific, progress in zooplankton ecology, plankton size classes, functional groups and ecosystem dynamics, micronekton distributions and trophic linkages, consumption of marine resources by marine birds and mammals, and contaminants in higher trophic level biota. BIO sponsored the working groups on Marine Birds and Mammals (WG11) and Micronekton (WG14).

A major theme through these activities has been interdisciplinary aspects, regional comparisons, and ecosystem analyses. BIO has also worked with other international programs including ICES and GLOBEC to plan an international symposium on comparative zooplankton ecology. We feel that a major success of BIO within PICES has been the increase in co-sponsored special topics and symposia to highlight the importance and contributions achieved through interdisciplinary approaches and contributions to understanding the oceanography of the North Pacific Ocean.

10AM2001 S1-105 invited

THE PHYSICAL OCEANOGRAPHY AND CLIMATE COMMITTEE: THE FIRST DECADE

Paul H. **LeBlond**, Yutaka Nagata and Vyacheslav B. Lobanov

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At its first meeting, on October 15, 1992, the Physical Oceanography and Climate Committee (POC) of PICES elected Y. Nagata as its first chairman, agreed that one of its roles should be to facilitate collaboration in international scientific programs, and identified four important topics to be addressed through the formation of Working Groups: Ocean Circulation and Climate Variability in the Subarctic Pacific; the Okhotsk Sea and the Oyashio Region; New Technologies and Observing Strategies; Data Collection and Quality Control. This first meeting set the tone for POC's work in the years to come: a fruitful and friendly forum, where ideas were welcome and debated, and where exploration and understanding of the ocean was always the primary goal. This presentation will review the activities of POC and its role in the scientific life of PICES in its first decade, under the leadership of Y. Nagata, P.H. LeBlond and V.B. Lobanov. Major accomplishments as well as future prospects will be discussed.

10AM2001 S1-219 poster

EXPLORING MECHANISMS UNDERLYING GLOBAL CLIMATE AND FISHERIES VARIATIONS IN THE PICES REGION

Salvador E. Lluch-Cota, Y.M. Tourre, W.B. White, A. Bakun, D. Lluch-Belda, J. Alheit, D.B. Lluch-Cota, C. Colin and F.P. Chavez

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Abundance of small pelagic fish populations from different regions (Northeast Pacific, Northwest Pacific, Southeast Pacific and Southeast Atlantic) fluctuate with a high degree of synchrony on a $\pm$ 40 to 60-year period. Because of the global nature, the fisheries being developed under different management schemes, and because these type of variations have been also recognized in non-exploited populations, we suggest a global environmental forcing source. Recently, several climate diagnostic, modeling, and proxy studies, have revealed fluctuations in the climate system at mostly the same multi decadal time-scale. In a previous paper we showed a conspicuous synchrony between spatio-temporal evolution of reconstructed multi-decadal climate fluctuation during the 20th century and a global standardized index of anchovy and sardine landings, or Regime Indicator Series (RIS). In this contribution, we extend our analysis by exploring mechanisms underlying the above relationship. We suggest that changes in sardine abundance are a result of environmentally modulated reproductive habitat availability in two PICES regions: the Oyashio-Kuroshio extension and the California Current.

10AM2001 S1-020 invited

MARINE ENVIRONMENTAL ISSUES IN THE NORTH PACIFIC: WHAT ARE THE DANGERS AND HOW DO WE IDENTIFY THEM?

Robie W. Macdonald[1], Brian Morton[2] and Richard F. Addison[1]

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Oceanographic research in the North Pacific has focused on temperature and other sea surface anomalies to understand the role of the sea as a sink for CO_2 emissions and the relationships between El Niño and La Niña events, coastal water properties, and weather. Sea surface air and water temperatures are believed to be rising, and this together with the melting of terrestrial ice is leading to sea-level rise projected at 30-100 cm within the next 100 years. The inundation of coastal areas in the Bohai Sea, China, alone has been estimated at 10,000-11,500 km^2. Translated to the entire coastline of the Northwest Pacific, effects will thus be huge.

Fish stocks in the North Pacific are under pressure from change in watermass distribution (so-called regime shifts), from fishing pressure and, in the case of anadromous fish, from alteration of temperature, hydrology and habitat in rivers and lakes. The confounding of the effects of climate change, human predation, contaminants and habitat disruption makes it exceptionally difficult to determine what causes variation in fish populations and, therefore, what action to take to curtail harmful human activities.

Waldichuk (1990) last reviewed marine pollution in the North Pacific. The situation along the northern Pacific Rim was considered poor then and more recent studies have re-emphasized the risks posed to the Pacific both by coastal contamination and by long-range transport. Taking a Northwest Pacific southern cut-off point as 30°N, which approximates Shanghai and the Yangtze River, the coastal waters of East and Northeast Asia encompass four seas including the East China Sea, the Yellow Sea (including the Bohai Sea), the Sea of Japan and the Sea of Okhotsk. It is claimed that the remote sea of Okhotsk is not polluted, but the other three certainly are and those coastal areas of China, in particular, have been studied extensively in this respect to reveal a problem huge in scale and poor in recovery potential. On the eastern side of the North Pacific, the southern cut-off of 30°N includes the large coastal centers of Los Angeles and San Francisco and the coastal basin incorporating the Strait of Georgia, Puget Sound and Juan de Fuca Strait. The latter region is particularly at risk due to the enclosed nature of the waterways and the large and increasing human population. Contamination of coastal waters from local sources is clearly a leading issue, but recent studies identify risks from long-range transport of contaminants to the entire Northeast Pacific Ocean.

In addition to the threats posed by climate change and contaminants, coastal oceans are stressed by development, noise, loss of biodiversity and introduction of exotic species. The conjunction of coastal pollution, loss of habitat and change in oceanographic climate witnessed during the past 50 years means that very real threats are now being felt in the North Pacific. In this paper, we review these issues with the intention of proposing the types of research and monitoring required to identify change, to assign cause, to priorize our response and to mobilize society to action.

10AM2001 S1-019 invited

MARINE SCIENCE - IGBP: PARTNERS IN THE 21ST CENTURY

Berrien Moore III

Chair, Scientific Committee, IGBP

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The core of the International Geosphere-Biosphere Programme (IGBP) for the next decade will be built around three interlocking and complementary structures:

- Core projects that focus on key processes will continue to be the foundation for the IGBP;
- A formal integrated study of the Earth System as a whole, in its full functional and geographical complexity over time, and
- A focus on three cross-cutting issues where advances in our scientific understanding are required to help human societies develop in ways that sustain the global life support system: Carbon, Water, and Food.

The research will be undertaken in the context of an expanding and strengthening collaboration with the International Human Dimensions Programme on Global Environmental Change (IHDP) and the World Climate Research Programme (WCRP). The new challenge is to build an international programme of Earth System Science on our collective scientific foundation. This effort will be driven by a common mission and common questions, employing visionary and creative scientific approaches, and based on an ever-closer collaboration across disciplines, research themes, programmes, nations, and regions.

Global biogeochemical cycling will remain at the core of IGBP research, but the Programme will evolve towards a more systematic structure with major activities located in the three compartments – atmosphere, oceans, and land – and in the three interfaces between them. These six domains will more formally guide the emerging Core Projects for the next decade. This theme is already apparent within the IGBP. For instance, Land - Ocean Interactions in the Coastal Zone (LOICZ) is positioned well at the Land-Ocean interface, and the emerging Surface Ocean Lower Atmosphere Study (SOLAS) is clearly headed in this direction.

We are asking, in this formulation, hard and challenging questions. The ocean is particularly important. How can we better integrate the science that has emerged (and will emerge) from the Joint Global Ocean Flux Study (JGOFS) with the science in the Global Ocean Ecosystem Dynamics (GLOBEC)? What should follow JGOFS and how do we insure continuity of critical scientific efforts including key observations? How do the crosscutting studies of carbon, water, and food play into the ocean research program for the next decade? Finally and importantly, setting aside programmes and acronyms, what are the principal challenges in oceanic research in the context of global environmental change and how will they be achieved?

This paper seeks to contribute to these questions.

The continuing evolution of the IGBP in concert with the WCRP and IHDP is important and merits the thoughts of all. We continue to welcome input and need insights on directions, processes, objectives, and goals and the processes by which they may be realized. The challenges of global environmental change are not going to vanish.

10AM2001 S1-021 invited

ECOSYSTEM CONSIDERATIONS IN FISHERIES MANAGEMENT: THE FUTURE OF SCIENCE AND POLICY

Steven A. **Murawski**

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It is often speculated that if only we had a true ecosystems approach to fisheries management, that problems of overfishing, bycatch, habitat alterations caused by fishing, and interspecies relationships could be more effectively addressed by our governance institutions. If this is the case, then it is productive to consider what a formal ecosystems management approach could offer that is not explicitly addressed under the current rubric of fishery management as practiced in the PICES area and elsewhere world-wide. The machinery of (nearly?) all fishery management institutions is based on evaluating exploitation rates relative to pre-defined biologically-based reference points that have been determined to result in a set of optimal societal benefits. These benefits are usually expressed as fishery yields (and their variation through time), but also may include maintaining populations of non-consumptive or ecological value (e.g. marine mammals). Thus, most energy in fishery science and management is centered on strategies for achieving, to the greatest degree feasible, the vector of optimal exploitation rates for each of the system's components. Fishery science and management, as currently practiced, can thus be characterized as based on achievement of pre-defined rules determined in a decision-theoretic context, and primarily focused on conservation of the ecosystem by parts. In order to achieve these goals, science and management have invoked strategies to contend with bycatch interactions, effects of changes in vital rates induced by variations in the environment, and key predator-prey interrelationships.

An alternative to the current paradigm is to redefine management based on goals of conserving ecosystem function. Momentum for such an approach stems from problems mostly found in areas where good single-species management is not practiced - sequential depletion of economic resources, trophic imbalances caused by concentrating fisheries on high trophic levels, progressive losses in the diversity of animals represented in the catch and the ecosystem, and alterations to the productivity of habitats wrought by the use of various fishing gears. If such concerns are deemed to have precedence over traditional goals of fishery management, then new reference points, pre-defined control strategies and scientific monitoring consistent with such will be required.

Can current approaches be extended to consider ecosystem functions in developing optimal harvest policies, or is an alternative approach necessary? In this paper I consider alternatives to the current fishery science-management paradigm, consequences of managing to ecosystem-based metrics of fishing, and the research, policy and governance issues consequent embodied in such an approach.

10AM2001 S1-024 invited

FUTURE NEEDS FOR BIOLOGICAL OCEANOGRAPHIC STUDIES IN THE NORTH PACIFIC OCEAN

Timothy R. **Parsons**

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Biological studies of natural marine ecosystems have generally lagged behind physical and chemical studies due to the difficulty of quantifying biological parameters. There can be little progress in science without reliable data. Biological oceanography has begun to enter an age when we are able to measure some parameters in the ocean with a good degree of accuracy and precision. Collection methods must now be applied on a routine basis, using the least expensive means possible, in order to build a data bank of biological observations in the North Pacific, over time and space. These data can then be used in the many ecosystem models that have been developed. In some cases, more sophisticated models incorporating genetic variation due to fishing or climate change, may be necessary; however, relatively simple size-selective models may be effective for other purposes, such as estimating the ocean's carrying capacity.

During the past decade, biological oceanographic observations have developed on two scales: large-scale data sets have been compiled from the use of satellites and commercial vessels; other data have accumulated from relatively small-scale studies of environmental and physiological interactions. These two data sets must be integrated to provide information useful to the management of ocean resources.

Historically, attempts to link climate directly with fish abundance through probability relationships have failed. The only pathway to understanding is through the ecosystem:

Climate => Ecosystem => Fish abundance

Future studies should yield information on many aspects of ocean life including the carrying capacity of the oceans, regime shifts and species interactions. These can only be realistic if ecosystem research includes **all** of the major components of life in the oceans, many of which have been previously neglected (e.g. gelatinous zooplankton, meso- and bathyplegic species and non-commercially exploited fishes).

10AM2001 S1-301

A REVIEW OF THE PICES CLIMATE CHANGE AND CARRYING CAPACITY PROGRAM

R. Ian **Perry**[1] and Anne B. Hollowed[2]

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The Climate Change and Carrying Capacity (CCCC) program of PICES was the first major initiative of the new organisation, starting (in 1993) only 2 years after the establishment of PICES itself. In the intervening 8 years, the CCCC program has remained the flagship initiative of PICES, and has been adopted as a Regional Program by the Global Ocean Ecosystem Dynamics (GLOBEC) program of IGBP. The objectives of the CCCC are to address how climate change affects ecosystem structure, and the productivity of key biological species at all trophic levels in the open ocean and coastal North Pacific ecosystems. The program was based on the marked physical environmental changes that occurred during the 20th Century, which were viewed as providing a natural experiment to study climate change questions. In this presentation we review the original goals for the CCCC programs and the structure established to achieve these goals. We examine the activities of the CCCC program during the past 8 years and assess its progress towards these goals. The 1990s have seen a huge increase in interest in global change issues and activities, and we assess the role of the CCCC program in instigating and benefiting from this larger interest, i.e. we examine whether increases in understanding of North Pacific marine systems and their responses to global changes would have occurred without the CCCC program. We conclude by offering suggestions for the future of the CCCC program.

S2 BIO/JGOFS Topic Session
Plankton size classes, functional groups and ecosystem dynamics: Causes and consequences

Co-sponsored by JGOFS
Convenors: Angelica Peña (Canada), Toshiro Saino (Japan) and Patricia A. Wheeler (U.S.A.)
Thursday, October 11, 2001 08:30-17:30

This session and the subsequent publication will be dedicated to the memory of the late Prof. Michael M. Mullin. The plankton are composed of different functional groups. The phytoplankton, for example, are comprised of mostly small organisms ($< \sim 5\mu m$ equivalent diameter) that are supported largely by recycled nutrients and contribute little to the biological CO_2 pump. The diatoms ($> \sim 5\mu m$) use nitrate, silica and the trace element, iron. They are the usual bloom organisms and contribute to much of the sinking flux of organic carbon. Other organisms, such as calcifying coccolithophorids, use calcium carbonate rather than silica in their skeletal structures: when they take up carbon as carbonate and sink out of the surface layer, they raise the surface pCO_2 thereby retarding the oceanic uptake of CO_2. These different groups in turn support different functional groups of zooplankton - such as microzooplankton and mesozooplankton, through differential grazing. The relative abundance of these functional groups depends strongly on physical and chemical processes - which themselves are modified in a changing climate. We invite talks on the dynamics governing planktonic functional groups, and on the causes and consequences of their changing on various timescales.

Invited speakers:

Peter H. Burkill (CCMS Plymouth Marine Laboratory, UK) - Dimethyl sulphide biogeochemistry in a coccolithophore bloom (DISCO): the role of the microbes

Douglas G. Capone (USC Wrigley Institute, U.S.A.) - N2 fixation in the world's oceans

Paul Falkowski (Rutgers University, U.S.A.) - The Pacific Ocean and earth's carbon cycle

Akira Taniguchi (Tohoku University, Japan) - Effect of environmental changes on microzooplankton assemblages and implications for ecosystem dynamics

Selected papers from this session (oral and posters) will be published in a special issue of *Progress in Oceanography*. If the review and final revision are completed by March 1, 2002, publication might be scheduled before PICES XI, in October 2002.

10AM2001 S2-290 oral

THE IMPACT OF COPEPOD LIFE CYCLE DYNAMICS ON THE PLANKTONIC ECOSYSTEM OF OCEAN STATION PAPA (OSP): A MODELLING APPROACH

Susan E. Allen and N. Jeffery

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The biomass of mesozooplankton at OSP changes by a factor of 20 due to the octogenic migration of large copepods. We have developed a vertically resolved, dynamic ecosystem model of OSP consisting of a copepod life cycle model and the following nitrogen pools: two phytoplankton (< 5 μm phytoplankton and >10 μm diatoms), two zooplankton (microzooplankton flagellates and mesozooplankton copepods), two particulate organic (suspended and sinking), and two inorganic (nitrate and ammonium+urea). Vertical mixing of the biological pools is modelled by the KPP oceanic boundary layer scheme. Phytoplankton groups are differentiated by their light, nutrient and micronutrient (iron) affinities, sinking rates and their predators, while zooplankton pools have distinct predation roles: microzooplankton heterotrophs versus copepod omnivores. In addition, we consider a more fundamental difference in zooplankton; for unicellular flagellates, growth and reproduction are, to good approximation, indistinguishable, however, this is certainly not the case for copepods, the primary mesozooplankton at OSP. We model copepod dynamics, which include migration of early stage copepodites to the upper ocean, weight dependent growth, molting, maturation and emigration to the deep ocean, based on the life cycles of *Neoclanus plumchrus* and *N. flemingeri*. Incorporating knowledge of stage duration, weight, individual growth and excretion rates, number density, and migratory behaviour is an important next step in assessing the grazing impact of copepods on microzooplankton, diatoms and sinking particulates. We discuss the ecosystem response to the copepod life cycle with particular emphasis on phytoplankton productivity, f-ratio, and export particulate flux.

10AM2001 S2-319 poster

SEASONAL ALTERNATIONS OF PLANKTON COMMUNITY IN THE NEARSHORE AREAS OF THE KIEVKA BAY (THE SEA OF JAPAN)

Valentina V. Andreeva[1] and E.N. Selivanova[2]

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Seasonal alternations of the composition and abundance of plankton were surveyed in the nearshore areas of the Kievka Bay, in the areas of fattening of juvenile salmons, smelts, redfin and other fish species. Samples were being taken from March through October in open areas with the depth of 10 m and shallow water areas with the depth not exceeding 1.0 m covered by macrophytic flora.

The plankton was of great variety and included ocean and neritic plankton species, as well as plankton-benthic species, larvae of seafloor invertebrates and fishes. The plankton of both areas mainly consisted of neritic forms of Copepoda, but their composition and alternation regularities were different.

Over the whole survey period, various Harpacticoida had prevailed in the areas covered by macrophytic flora, with their amount reaching up to 80% of the total numerosity and biomass of animals. In the summertime, an increase of the share of *Oithona similis* and *Pseudocalanus newmani*, brackish-water species of *Sinocalanus, Schmackeria* and *Eurytemora* genus had been observed. Other groups of animals, which were numerous in certain periods, were represented by Gammaridea, Nematoda, Ostracoda, Hydromedusa and larvae of seabed Bivalvia, Gastropoda, Echinodermata.

The major part of plankton inhabiting the open areas was represented by *O. similis*, *P. newmani* and *P. parvus*, with *Acartia, Centropages, Eurytemora, Tortanus,* larvae of seabed invertebrates, fish eggs and larvae being observed in certain periods. Numerous Harpacticoida were observed only in spring.

Seasonal alternations of both the composition and number of animals were observed in all the areas. Some species were encountered only in spring, while others were seen only after the water temperature had risen above 20°C. Breeding periods of mass species were determined on the basis of the age and sex composition ratio change, and availability of females with egg bags.

10AM2001 S2-315 oral

FUNDAMENTAL DYNAMICS OF AN ECOSYSTEM MODEL FOR THE COASTAL GULF OF ALASKA

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The ability to accurately model the influence of physical forcing on primary and secondary production in the Coastal Gulf of Alaska (CGOA) is thought to be critical in understanding the regions overall productivity under different forcing regimes. Several Nutrient, Phytoplankton, Zooplankton (NPZ) models have been developed and applied to the open Gulf of Alaska. However, even when these biophysical models are subject to various physical circumstances a fundamental understanding of their underlying dynamics remains incomplete because individual simulations are incapable of characterizing the whole system (Edwards *et al.*, 2000). Edwards *et al.* performed stability analysis on a simple second order NPZ model subject to realistic levels of mixing and explored the effects of vertical diffusion on its dynamics. The model considered the exchange of nitrogen between single phytoplankton and zooplankton species and a nutrient pool. In the Gulf of Alaska, due to the importance of microzooplankton grazers, a model of the lower trophic levels must include both small and large phytoplankton, macro and micro zooplankton, nitrate and ammonium. We have extended the stability analysis by Edwards *et al.*, to a more realistic model with the above components developed for the CGOA as part of the GLOBEC program.

10AM2001 S2-003 invited

DIMETHYL SULPHIDE BIOGEOCHEMISTRY IN A COCCOLITHOPHORE BLOOM (DISCO): THE ROLE OF THE MICROBES

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Dimethyl sulphide (DMS), produced naturally in marine surface waters, has been proposed as a significant agent in climate change. While we recognise that DMS is produced from its precursor, dimethyl sulphoniopropionate (DMSP) and that DMSP is found in some algae, the routes, rates and controls on the DMSP to DMS transformation are poorly understood. A multiplicity of pathways, many involving microbes, have been suggested. We recently carried out a Lagrangian study, using the tracer SF_6, of the dynamics of a young, evolving bloom of the DMSP-rich coccolithophore, *Emiliania huxleyi*, in the northern North Sea. The bloom was sampled daily in an integrated, interdisciplinary study of the dynamics of viruses, bacteria, algae, protists and larger grazers as well as measurements made of the ambient levels of DMS and DMSP in the evolving bloom. Many results are surprising and suggest, for instance, that *E. huxleyi* was not necessarily the main source of DMSP, and that the some parts of the microbial community were closely tuned to DMSP production. The paper will present an overview of the study including pre- and post-cruise modelling of DISCO biogeochemistry and shipboard results.

10AM2001 S2-004 invited

N_2 FIXATION IN THE WORLDS OCEANS

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Recent observations in biological oceanography, geochemistry and molecular ecology have prompted us to review and radically revise our view of the quantitative importance of N_2 fixation in the marine N cycle, particularly in the oligotrophic tropics and sub-tropics. It has been generally held that the main source of nitrogen supporting new production by phytoplankton in surface waters through much of the world's upper ocean is the reserves of nitrate in the deep ocean, and that microbial N_2 fixation is of relatively minor importance in the global marine N balance. However, geochemical indices point to substantial inputs of recently fixed nitrogen in several major ocean basins. Direct estimates of depth integrated N_2 fixation by the most conspicuous planktonic N_2 fixer, the

cyanobacteria *Trichodesmium* spp., similarly suggest that oceanic N_2 fixation is far greater than earlier projected. Intense inputs of fixed nitrogen can occur during episodic surface aggregations of *Trichodesmium* although this is only poorly quantified at present; remote sensing may provide the means to resolve the spatial and temporal dimensions of such phenomenon. The simple view that there are only a few key N_2 fixers in the sea is also being reevaluated as new studies unveil a much broader suite of potential diazotrophs resident in the oceans. Quantifying their input is a current challenge.

Because it can affect the oceanic inventories of fixed nitrogen and thereby the ocean's capacity to sequester carbon, N_2 fixation has been proposed as a key components in a suite of interactions and a possible feedback system among the oceans, atmospheric CO_2 and climate. Nitrogen fixers have a greater demand for iron than do non-diazotrophs and the delivery of iron to the upper ocean through aeolian dust deposition is hypothesized to be a critical control on this process. Phosphate availability may also place a constraint on the extent of N_2 fixation in particular ecosystems. Current investigations are focusing on the interplay of these limiting nutrients in different ocean regimes and the role of nitrogen fixers in ocean carbon sequestration.

10AM2001 S2-081 oral

ZOOPLANKTON SIZE AND TYPE INFERRED FROM PHYSICAL VOLUME AND OPTICAL TRANSPARENCY, AND IMPLICATIONS FOR ECOSYSTEM FUNCTION

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Mucous-web and crustacean particle grazers differ in ways that affect their role in marine ecosystems. Differences include size, transparency, feeding, and reproduction. Effects include relative abundance of these groups and their impact on grazing and recycling. Since January 1998, an *in situ* Optical Plankton Counter (OPC, minimal opaque particle size 250 μm equivalent spherical diameter) has been deployed on oblique (to 210m) tows of a bongo net (500 μm-mesh) at standard stations (normally 66) on 14 CalCOFI cruises. The depth-integrated biovolume (OBV) of particles sensed optically by the OPC has been analyzed and compared with volume displaced (DV) by plankton collected simultaneously. For all cruises combined, OBV and DV are significantly correlated but with little explanatory power. Stronger correlations of OBV and DV exist within cruises. Spatial patterns of OBV and DV are similar within cruises. However, large, spatially-consistent differences in the ratio of OBV/BB exist between cruises. These results are consistent with the hypothesis that large, clear particles (e.g. doliolids and salps) were relatively rare in comparison to smaller, less-transparent particles (e.g. copepods and euphausiids) at most times but, on occasion, the reverse was true. The implications of such an ecosystem-wide change are discussed.

10AM2001 S2-082 oral

TEMPORAL AND SPATIAL VARIATION IN THE SIZES OF CALIFORNIA CURRENT MACROZOOPLANKTON - ANALYSIS BY OPTICAL PLANKTON COUNTER

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Macrozooplankton in the southern California sector of the California Current had been reported to decrease from 1951 through 1998. We analyzed some of the same preserved samples of macrozooplankton taken in non-El Niño years 1955, '56, '66, '81, '84, '91, '95, and '96, and also '99, with an optical plankton counter to determine whether all size categories changed similarly over time. The results from '55 through '96 could be interpreted either as a linearly decreasing trend (total biovolume decreased by 29-43%) or as a regime shift (decrease of 36-64% from pre- to post-'75 regimes). The largest zooplankters (> 2.7 mm equivalent circular diameter - ECD) were relatively more important at night than by day, and offshore than onshore. Their biovolume decreased by the greatest relative amount, and biovolume of the smallest zooplankters (0.75-0.8 mm ECD) decreased hardly at all. The decrease in relative importance of large zooplankters was most evident in Winter and Spring, and was qualitatively similar by day and at night and in nearshore and offshore regions.

Mike Mullin died 19 December 2000. The manuscript containing this abstract was nearly complete at the time of his death and was completed by Dave Checkley.

10AM2001 S2-115 oral

PLANKTON COMMUNITY STUDY: A BETTER WAY TO UNDERSTAND ECOSYSTEM DYNAMICS IN THE JAPAN SEA

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Lower trophic level ecosystem in the offshore Tsushima Current area of the Japan Sea was studied for these decades in relation to temporal variability of the upper water environment, using data on community structure of diatoms for 1970s-90s and zooplankton for 1990s. We observed a distinct change of diatom community structure in spring during 80s, the periods when the climate/ecosystem regime shifts have been reported to occur in the vast areas of the North Pacific. In spring during 80s, Chlorophyll *a* concentration and Chl *a* to cell ratio were markedly low, and summer-adapted species, that were abundant not only in spring but also in summer, dominated the diatom community. Water density profile between the surface and 300 m showed the thickness of the surface Tsushima Current water and the cold sub-surface water decreasing and increasing, respectively, from the late 70s to the late 80s, resulting in intensified stratification of the upper water column. Increase in phosphate gradient between the surface and sub-surface layers suggested that the intensified stratification might reduce nutrients supply to the surface. This condition might subsequently cause the shift of the dominant diatom species from those adapted to eutrophic conditions to oligotrophic conditions. The observed change in diatom community was expected to alter zooplankton community, and consequently food web structure and function of biological carbon pump of the region. This study demonstrated that community structure study was a useful clue to understand processes and ecological consequences of climate - ecosystem interactions compared to the conventional time-series analysis based merely on the total biomass data.

10AM2001 S2-401 oral

MODELLING THE PLANKTONIC ECOSYSTEM: HOW MUCH COMPLEXITY IS TOO MUCH?

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There is a growing awareness that ecological "texture" must be included in models of the marine planktonic ecosystem - for both foodweb and biogeochemical studies. Different groups of plankton play different roles, both in the foodweb supporting harvestable species and in the cycles of carbon and other radiatively-active gases influencing the climate. Smaller phytoplankton, microzooplankton and bacteria comprise the "background steady state" planktonic ecosystem, where most of the primary production is recycled within the euphotic zone. Larger phytoplankton, primarily diatoms, form the blooms and contribute to most of the export flux out of the euphotic zone. Diatoms require silica for their skeletal structures and also iron, whereas other phytoplankton species, especially coccolithophorids, both require calcium carbonate, thereby increasing pCO_2, and produce DMS, which has been shown to increase cloud condensation nucleii. In the subtropics, yet other species, can fix elemental nitrogen, and can change the nutrient that limits primary production from nitrogen to phosphorus.

There is increasing pressure from observationalists, and it is relatively straightforward, to formulate a model with more compartments to include these different functional groups. However, the number of parameters that must be specified from observations increases as the square of the number of compartments and quickly surpasses our ability to constrain them properly from observations. It may be that we need to find alternative formulations for ecosystem models rather than increasing the number of compartments. I present several examples of ecosystem formulations that try to represent complexity in other ways.

10AM2001 S2-007 invited

THE PACIFIC OCEAN AND EARTH'S CARBON CYCLE

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On geological time scales, the inventory of inorganic carbon in the ocean and atmosphere is dictated by outgassing of CO_2 from vulcanos and the silicate weathering cycle. The net effect of these two processes can be described by the reaction sequence:

$$Ca(Mg)\,SiO_3 + CO_2 \xleftarrow[\text{vulcanism}]{\text{weathering}} Ca(Mg)CO_3 + SiO_2$$

Throughout the Phanaerozoic (the past ca. 550 Ma), the difference between the $\delta^{13}C$ of carbonates and organic matter (the so called ε_{toc}; (Rothman 2001)) has decreased, suggesting a long term depletion in CO_2 in the two mobile pools. Simultaneously, the rapid evolution and ecological success of calcifying nanoplankton, especially coccolithophorids, rapidly accelerated the deposition of carbonates in marine sediments. With the formation of the Atlantic Basin, ca. 180 Ma, shallow neritic seaways provided an alternative source of cell wall material for phytoplankton, silica, leading to the emergence of diatoms in the Cenozoic (Falkowski and Rosenthal 2001). While calcification proceeded in the Pacific however, the deep basin topography prevented significant accumulation of carbonates; simply the basin is below the carbon compensation depth. The Atlantic became a sedimentary respository of carbonates. However, in contrast to the Atlantic, the Pacific Rim is the largest subduction zone on Earth, and hence fuels the subsequent vulcanic outgassing. I will examine how the Pacific Ocean basin topography, in combination with the evolutionary competition and subsequent dominance of mineral export by diatoms in the Cenozoic and modern oceans, has determined the trajectory of global carbon pools in the atmosphere and the ocean, and will continue to do so for the next 200 Ma.

Falkowski, P. and Y. Rosenthal (2001). Biological diversity and resource plunder in the geological record: Casual correlations or causal relationships? Proc. Natl Acad. Sci, USA **98**: 4290-4292.

Rothman, D. (2001). Global biodiversity and the ancient carbon cycle. Proc. Natl Acad. Sci, USA **98**(4305-4310).

10AM2001 S2-320 poster

THE PHYTOPLANKTON FROM BAJA CALIFORNIA, MEXICO, IN DECEMBER, 1998: COMMUNITIES DOMINATED BY TWO DIATOM SPECIES OF THE GENUS *Pseudo-nitzschia*

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The El Niño (1997-1998) event had relaxed considerably by the middle of 1998, and its impact in waters of Baja California, Mexico, in the Pacific Ocean, practically disappeared. Phytoplankton samples collected from a cruise along coasts off Baja California, in December, 1998, were studied to know the basic structure of the community, and make direct comparisons to the phytoplankton obtained by March-April, 1998 (still the presence of El Niño) in the region. Despite the different methodologies used for collection and analysis of the samples (e.g. samples of December, 1998, were collected by bottle, fixed with lugol's solution, and counted by the inverted microscope technique), the results showed somewhat homogeneous communities dominated by diatoms, in terms of diversity and abundance. Only very few large, thecate dinoflagellates and "phytoflagellates" (such as coccolithophorids and their relatives) were present. Two diatom species: *Pseudo-nitzschia delicatissima* and *P. pungens* were widely spread and were numerical dominants, especially in the southern area. The highest diversity and abundance of the phytoplankton were observed in the southern area (Bahia Magdalena and surroundings): of the 139 species recorded, 99 were present in that area, whereas cell densities reached up to 1.4×10^6 cells/L, in surface waters in front of Bahia Magdalena. In the northern and central areas the abundances varied from 7×10^2 to 9.6×10^4 cells/L, with a rather homogeneous or decreasing with depth vertical distribution. Small centric diatoms were rather scarce, whereas large or chain-forming pennate diatoms cleary dominated the communities,

possibly indicating a post-upwelling condition, situation also reported for California and Oregon, U.S.A., for May and June 1998.

10AM2001 S2-192 poster

THE GROWTH AND DISTRIBUTION PATTERN OF THE EUPHAUSIID, *Thysanoessa longipes*, IN THE SEA OF JAPAN

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The growth, horizontal distribution and vertical migration pattern of *Thysanoessa longipes*, a euphausiiid abundant in the subarctic Pacific Ocean and the marginal seas were studied using specimens from the Sea of Japan. Collections were made with vertical hauls (0-500 or 200m depth) of NORPAC nets and oblique hauls (0-500m depth) of BONGO nets in January, June 1997 and October 1999. MOCNESS were also towed from 1000m depth to the surface to evaluate their vertical migration patterns in January 1997 and October 1999. The populations of *T. longipes* were dense in north of about 40°N. The magnitude of the vertical migration was 100m in January, occurring between 200 and 400m depth, while non-migratory was observed in October, dwelling in 400-500m layer. The range of temperature that *T. longi*pes encounter during the vertical migration was estimated to be 0-10°C. The female attained a larger body size than the male. Judging from size-distribution patterns and maturity conditions, the sexual difference in growth rates was analyzed and the estimated life span was less than 4 years. The present results are compared with those for other regions of the North Pacific.

10AM2001 S2-096 poster

SEASONAL VARIATIONS IN VERTICAL DISTRIBUTION AND POPULATION STRUCTURE OF THE THREE DOMINANT OCEANIC OSTRACODS (*Conchoecia pseudodiscophora*, *C. haddoni* AND *C. skogsbergii*) IN THE OYASHIO REGION (SITE H), WESTERN NORTH PACIFIC OCEAN

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Seasonal variations in vertical distribution and population structure of the three dominant oceanic ostracods were investigated at Site H in the Oyashio region during September 1996 through October 1997. Near-monthly samples were collected with a closing net (0.10 mm mesh) from five discrete depths between the surface and 2000 m depth.

On the basis of annual mean abundance, *C. pseudodiscophora* was most numerous, followed by *C. skogsbergi* and *C. haddoni*. The three ostracods all together contributed 95% of the total ostracods. The vertical distribution of these three species became shallower with the progress of the development. The depth where the major population resided was 300-400 m for *C. pseudodiscophora*, 450-800 m for *C. haddoni* and 650-900 m for *C. skogsbergii*.

Juvenile/pre-adult instars (II-VII) of *C. pseudodiscophora* were abundant in autumn-spring, and adults were numerous in summer. By tracing the sequential changes in abundance peaks of each instar, *C. pseudodiscophora* was considered to produce one generation per year. The main reproduction of this species was estimated to occur in autumn. Developmental sequences of *C. haddoni* and *C. skogsbergii* were not possible to analyze from their seasonal data of population structure. *C. haddoni* exhibited abundance peaks of juvenile / pre-adult instars (II-IIV) and adult instar in autumn-winter. Moderate abundance peaks of adults were observed in summer. The abundance of instar III-VIII of *C. skogsbergii* did not change markedly with season, thereby maintained rather stable population structure throughout the year.

10AM2001 S2-231 oral

LOWER TROPHIC MODEL IN THE SEA OF OKHOTSK

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The lower trophic ecosystem model in The Sea of Okhotsk is constructed and embedded into MOM. The ecosystem models are (1) KKYS and (2) NEMURO. The physical model was run under the fall forcing in 1998. The model can reproduce an enhanced primary production along Kuril Islands due to wind induced upwelling together with high mixing around the islands. This high productive region will decrease within two weeks by grazing.

10AM2001 S2-195 oral

THE FATE OF PRIMARY PRODUCTION DURING SPRING DIATOM BLOOM IN FUNKA BAY, JAPAN

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The primary production during a diatom spring bloom and its fate in Funka Bay was investigated. The amount of organic carbon production measured at the peak of the bloom was several times higher than the previously reported values in this bay and estimated to be 52-74 gCm^{-2} during the bloom season, which accounted for almost a half of the annual production. This bloom occurred in March, but the timing of this bloom was affected by the inflow of Oyashio Water, which contributes water column stratification. The grazing by mesozooplankton during the bloom, however, was much lower than in summer due to low biomass and temperatures. This indicates that the grazing food chain is less important for the flow of the produced organic carbon. We measured primary and bacterial production as well as nutrients, dissolved organic carbon for two years. Meso and micro-zooplankton grazing was also estimated by the dilution culture experiments. Two possible energy flows from the primary production during the spring bloom to the secondary production of mesozooplankton in Funka Bay were (1) indirect flow through settling removal and subsequent regeneration near bottom and upwelling, and (2) fueling organic carbon to bacterial production and subsequent grazing by microzooplankton (i.e. microbial food web).

10AM2001 S2-194 poster

VARIATION OF PRIMARY PRODUCTIVITY ALONG LINE P IN THE NE SUBARCTIC PACIFIC DURING THE 1998 EL NIÑO AND THE 1999 LA NIÑA AS WELL AS 2000 WITH SOME REFERENCE TO BIOGENIC SILICA

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Several decades of measurements of primary productivity have been taken at Ocean Station Papa (OSP) in the NE subarctic Pacific. During the 1990s, the Canadian JGOFS program extended the data set to include five stations (line P) that spanned from the productive British Columbian coast to the high nitrate low chlorophyll (HNLC) region of OSP (Boyd and Harrison, 1999). Our study continued the data set and measured size fractionated chlorophyll *a* and primary productivity along line P for the winter, spring, and late summer for the years 1998 to 2000. Our results agree with the earlier findings that show the inshore stations to follow the classical seasonal cycle of spring and late summer blooms controlled by macronutrient concentrations with varying algal cells dominating depending on the season. The offshore stations (including OSP) exhibited low seasonality in biomass with a moderate seasonality in primary production. These stations were always dominated small algal cells. The 1998 year displayed a strong El Niño signal with a shallowing of the mixed layer and low coastal biomass followed by higher biomass at the offshore stations. Conversely, 1999 showed a strong La Niña signal and followed a somewhat opposite pattern from 1998 (Whitney, 2000). We will attempt to explain the effects of the El Niño and La Niña on the phytoplankton population along Line P in terms of size fractionated primary productivity and chlorophyll. We will further correlate this with biogenic silica data from 1999 and 2000.

10AM2001 S2-294 poster

DISSOLVED ZINC IN THE WATERS OF THE SUBARCTIC NORTH PACIFIC WATER COLUMN

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Total dissolved Zn measurements were made using adsorptive cathodic stripping voltammetry and in order to lower detection limits a new UV system was built in-house. The detection limit obtained is 0.02nM. Total dissolved Zn concentrations are reported for winter and summer along the E-W line P transect and for summer along S-N line Z transect extending from Ocean Station Papa (OSP; 50°N 145°W) to the respective shelf waters. Surface water (10m) concentrations ranged from 0.04 nM in the open ocean to 0.9 nM at the Canadian shelf station. A clear gradient is evident, with Zn concentrations decreasing with increasing distance from shore along the E-W transect. Low concentrations of Zn (0.05-0.07 nM) were observed in near surface water at OSP in winter. The vertical distribution of dissolved Zn is oceanographically consistent, showing a silicon-like vertical profile. Dissolved Zn/Si ratios in the upper 200m indicate a trend of decreasing with distance from shore, which infers a decoupling between Zn and Si in the upper ocean. We hypothesise that the silicon-like profile of Zn is a result of recycling from relatively biologically resistant organic particulate phases, that leads to profiles very similar to those of dissolved silicon.

10AM2001 S2-295 poster

STABLE NITROGEN ISOTOPE FRACTIONATION BY PHYTOPLANKTON IN AN HNLC REGION

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The stable nitrogen isotope fractionation that occurs during uptake and assimilation of nitrate was directly measured at Ocean Station Papa in the Eastern North Pacific during late summer in onboard iron addition incubations. The stimulation of phytoplankton growth after iron addition caused the nitrate in the system to be completely utilized after 144 hours. This drawdown of nitrate allowed us to directly measure the change in $\delta^{15}N$ in the nitrate and the particulate nitrogen pool. The change over the course of the experiment followed Rayleigh type kinetics, and allowed us to directly measure the isotope fractionation factor of phytoplankton growing on nitrate, as has been done in laboratory settings. The fractionation value that we measured supports recent estimates of isotope fractionation by phytoplankton from the Southern Ocean and the North Pacific. This is the first study to directly measure isotope fractionation of natural community in onboard bottle incubations and provides important information for interpretation of $\delta^{15}N$ in food webs, suspended particulate matter, and ocean sediments.

10AM2001 S2-141 oral

ZOOPLANKTON SHIFTS IN THE CALIFORNIA CURRENT SYSTEM

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Analysis of the CalCOFI zooplankton samples dating from 1951 through 2001 has revealed important structural changes in the composition of the California Current zooplankton, which are not resolvable at the level of bulk properties such as total zooplankton biomass. We will present results focusing on annual and longer time scales of perturbation to upper ocean zooplankton assemblages, in the context of low frequency physical changes in the atmosphere and upper ocean. We will present evidence bearing on the issue of whether 1999 represented a state transition for epipelagic zooplankton of the CCS.

10AM2001 S2-309 oral

THE INFLUENCE OF PLANKTON COMPOSITION ON EXPORT PRODUCTION

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The export of carbon from the surface waters is constrained in principle by the rate of delivery of limiting nutrients and can be substantially influenced by the composition of the plankton community, which can shift dramatically seasonally and from year to year. In addition to natural variability, evidences exist that climate change could significantly alter the structure and function of marine ecosystems. A better understanding of the links between phytoplankton type, food web structure, and export efficiency is required to estimate global export production and to predict potential future responses of the carbon cycle to climate change. In this study, a coupled 1-D mixed layer / plankton ecosystem model is used to explore the effect of changes in the composition of the planktonic community on export production. Model results indicate that changes in the size composition of phytoplankton and the type of dominant zooplankton (copepods vs. gelatinous zooplankton) have the strongest effect on export production. However, to improve model predictions, substantial increases in field work and laboratory experiments are required.

10AM2001 S2-244 oral

TEMPORAL CHANGES IN SIZE-FRACTIONATED PHOTOSYNTHETIC BIOMASS DISTRIBUTION IN A WARM-CORE MESOSCALE EDDY IN THE NE PACIFIC

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Anticyclonic mesoscale eddies spawned off the Queen Charlotte Islands transport nutrient-rich coastal waters to the open Gulf of Alaska. Over time, utilization of these nutrients by phytoplankton lead to changes in nutrient availability and nutrient ratios present within a quasi-closed system, influencing the nature of the phytoplankton community. Three major stations were chosen in the vicinity of the Haida-2000 eddy (centre, edge, and reference station outside) in June and September, 2000, to examine temporal changes in size class distribution of the phytoplankton community. Water samples were fractionated to give chlorophyll *a* concentration and primary productivity estimates in the >20, 5-20, and 0.2-5μm size ranges.

In June, the distribution of photosynthetic biomass in different size classes among the three stations was similar. The bulk of photosynthetic biomass was found in the >0.2-5μm size fraction, while the lowest concentration of chlorophyll *a* was observed in the >20 μm range. This relationship was uniform over the water column and similar for all stations. In September, size class distribution over the water column was less uniform at the outside and centre stations, where larger cells represented a greater proportion of total photosynthetic biomass. The concentration of chlorophyll *a* in the different size fractions was uniform over depth at the edge station. Changes in size class distribution over time reflect changes in chemical and physical properties of the water column.

10AM2001 S2-196 oral

PHYSIOLOGICAL RESPONSES OF DIATOMS TO IRRADIANCE DECLINING

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In the western subarctic Pacific, diatoms outburst in spring. Diatom production during the spring bloom is quite high, consuming most new nutrients supplied by winter mixing, decreasing ΔpCO_2 (Seawater-Air) from

+20-90 µatm in winter to <-200 µatm at the end of spring. Understanding the fate of diatom production is a key process of the biogeochemical cycle in this region. Through the spring bloom, the consumption ratio of silicic acid to nitrate increased, i.e., low in the early phase of the bloom and high at the later phase. This result indicates change in diatoms physiology responding to environmental change through the period, e.g., nutrient depletion, decline in irradiance by self-shading, etc. In the present study, we examined physiological responses of diatoms to the declining of irradiance assuming *in situ* environmental change at mid-bloom period. Diatoms were isolated from Oyashio region and incubated at 3°C under the irradiance of 450 µE m^{-2} s^{-1}. After the acclimation, irradiance was decreased and incubated for 4-10 days. Irradiance were controlled by neutral density filters and 6 light levels were prepared. Cell specific contents of C, N, Si and Chl.*a*, chlorophyll *a* specific absorption, cell size were examined before and after the irradiance control. By decreasing irradiance, C:Chl, cell specific C and N contents and C:N of diatoms decreased but Si:N increased. The influences of these physiological changes in diatoms on biogeochemical cycles in the western subarctic Pacific will be discussed.

10AM2001 S2-075 poster

INFLUENCE OF FOOD QUALITY ON FEEDING AND EGG PRODUCTION OF THE MARINE PLANKTONIC COPEPOD *Acartia omorii*

Kyoungsoon **Shin**, Min Chul Jang, Pung Kuk Jang, Tae Kyun Lee and Man Chang

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S2

Growth and production of copepods are influenced by a number of factors, the principal one being the availability of food. Quality as well as quantity of available food is important and the high quality food encourages successive production of egg masses and clutches. Egg production rates, egg viability and fecal pellet production rates in the copepod *Acartia omorii* were examined using two diatoms (*Phaeodactylum tricornutum* and *Skeletonema costatum*) and three dinoflagellates (*Heterocapsa triquetra*, *Scrippsiella trochoidea*, and *Cocchlodinium polykrikoides*). Particularly, *C. polykrikoides* has been devastating to local fisheries since its appearance as large-scale red tides in 1995 along the Korean coastal waters. Depending on the diets, egg production of *A. omorii* varied with time. It diminished with time in some diets (*S. trochoidea*, *C. polykrikoides*, *P. tricornutum*). This diminution was much more rapid for *C. polykrikoides* with egg production decreasing to ca. 2.4 eggs/female/d in only 4 d. Egg production showed a maximum value (41.7±13.9 eggs/female/d) in dinoflagellate, *H. triquetra* and a minimum value (5.2±6.0 eggs/female/d) in dinoflagellate, *C. polykrikoides*.

Egg viability also varied with the food types ranging from 62.7% to 96.0%. Egg viability was initially high but decreased rapidly with time in *C. polykrikoides* and *P. tricornutum* diet. In contrast, egg viability was high and stable over time in *H. triquetra*, *S. trochoidea* and *S. costatum* diet. Fecal pellet production of *A. omorii* showed the range from 4.4 ±3.5 (*C. polykrikoides*) to 32.1 ±9.4 fecal pellet/ind./d (*S. trochoidea*). The pellet type was closely related to ingested food shape by *A. omorii*. Egg production showed positive correlation to fecal pellet production, and the correlation became clearer in smaller size diets than larger size diets. We analyzed intracellular compositions (protein, carbohydrate, lipid) and fatty acid of the feed organisms to explain the differences in fecundity of *A. omorii* in relation to feed types, and discussed food quality on feeding and egg production of *A. omorii*.

10AM2001 S2-197 oral

VARIATIONS OF NORTHERN PART SEA OF OKHOTSK PLANKTON COMMUNITY AND THEIR INFLUENCE FOR THE ABUNDANCE OF WALLEYE POLLOCK YEAR CLASSES

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Stocks of pollock in the northern part of Sea of Okhotsk were reduced up to historically minimum level by the end of the 1990s. The spawning biomass decreased from 5-6 million t in the middle of the decade to 1.4 - 1.8 million t in early next century. The 1988-1989 strong year classes supported high biomass level until 1996, but most year classes that appeared in the 1990s were poor. The comparative analysis of larvae and juvenile survival

has shown, that its average values in the 1990s were on 10^2-10^3 less compare to the 1980s. The significant changes of Sea of Okhotsk ecosystem were observed by the TINRO-Centre investigations during 17 years. Total zooplankton stock reduction was observed in the 1990s in comparison with 80s at the same proportion of predatory species had increased. Biomass of large copepods off Western Kamchatka reduced almost twice during last decade. The scale of reduction of small zooplankton fraction (copepod and euphausiidae eggs and nauplii, the smallest copepod species) which is basis of walleye pollock larvae food was much bigger. Density of it has decreased off Western Kamchatka from 401 to 197 mg/m^3, in the northwest of the sea - from 185 to 65 mg/m^3. The ratio "feeding zooplankton-nekton biomass" in the middle of 1980s was about 20, but in 1996-1998 only 6.9-7.5. Nevertheless, two numerous year classes (1995 and 1997) has appeared despite bad survival conditions in the 1990s. The 1995 year class has appeared off Western Kamchatka, the 1997 - in the northwest of the sea. The success of reproduction obviously determined by high density of the smallest zooplankton fraction as well as low chaetognath density. The *Sagitta* biomass was in 8-10 times less, but the biomass of small copepods was higher in 2-3 times in the reproduction area at Western Kamchatka shelf. Therefore survival of pollock eggs and larvae was in 10^6 higher compare with 1994 and 1996. Biomass of small zooplankton in 1997 off Western Kamchatka has minimum, but chaetognath biomass was only a little higher, compare with adjacent years and areas of the Sea of Okhotsk. The pollock survival was close to average. Chaetognath biomass was less in 3-10 times in northwest of the sea, and eggs and nauplii copepods biomass was much higher than average during the entire 1990s. The survival of pollock eggs, larvae and juveniles was in 10 times higher in 1997, than in other years. Therefore, the main facts, determining northern part Sea of Okhotsk pollock year classes abundance is structure of plankton community.

10AM2001 S2-034 invited

EFFECT OF ENVIRONMENTAL CHANGES ON MICROZOOPLANKTON ASSEMBLAGES AND IMPLICATIONS FOR ECOSYSTEM DYNAMICS

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Since the ocean is filled with water, its surface layer becomes severely oligotrophic, compared to the terrestrial environment. Consequently, most pelagic organisms have evolved to be small in body size to possess higher metabolic rates and shorter longevity that accelerate repeated use of the limiting amount of resources. In this context, microzooplankton must be recognized as the typical organisms that dominate pelagic ecosystems. Aim of this review is to speculate how do such microzooplankton respond to changing environment, though our present knowledge is not enough to predict quantitatively their responses.

Highly probable change which would occur in oceanic environment in nature is warming, and that generated by human is iron enrichment or artificial eutrophication. The former will intensify oligotrophy in surface layer by establishing a deeper and longer-lasting thermocline. The latter will enhance productivity of phytoplankton assemblages with modification of their taxonomic/size structure: mostly increase dominancy of diatoms and average cell size. Although absolute production of microzooplankton will be suppressed, relative importance of their role should be extended in the former case, and the reverse is the case in the latter case. What is interesting is that the both cases could happen within the northern North Pacific or the PICES region in future.

10AM2001 S2-123 oral

DENSE OCCURRENCE OF *Bolinopsis infundibulum* (CTENOPHORA) NEAR THE SEA FLOOR (1260 M) UNDER OYASHIO CURRENT

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In October 1997, dense occurrence of ctenophores was for the first time observed by using video camera attached to the Deep Tow system of the Japan Marine Science and Technology Center (JAMSTEC) near the sea floor (800-1200 m) off Kushiro, Hokkaido, Japan. As the ctenophores could not be collected, dives by manned submersible *SHINKAI 2000* of JAMSTEC were carried out from 1998 through 2000 to survey the ctenophores.

Nine ctenophores collected in these dives were identified to *Bolinopsis infundibulum*. The total body length was 6.5-16.5 cm. Horizontal surveys by submersible showed that the ctenophores occurred exclusively at 1200 and 1250 m depths. They were most abundant from 8 m to 30 m above the seafloor, and then decreased gradually to 80 m. Abundance of the ctenophores was estimated to ca 0.9 individual m^{-3} at 10 m to 20 m above the seafloor. They seemed to be foraging actively by extending their oral lobes widely. Carbon and nitrogen stable isotope ratio suggests that the ctenophores rely on surface photosynthetic products and their nutrient stage is low. Previous knowledge on the feeding habit of *Bolinopsis infundibulum* show that the ctenophores' main food resource is copepods. It is well known that large copepods e.g. *Neocalanus* spp. and *Eucalanus bunngii* grow in surface layer and sink to the deep layer as diapausing C5 and adult. It is possible that the deep ctenophore population is responsible for the mortality of these epipelagic copepods during the diapausing stage.

10AM2001 S2-193 oral

FUNCTIONAL ROLES OF MESOZOOPLANKTON IN THE WESTERN SUBARCTIC PACIFIC

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The subarctic Pacific is characterized by seasonal occurrence of a large amount of large sized copepods by ontogenetic vertical migration. These copepods are *Neocalanus cristatus*, *N. plumchrus*, *N. flemingeri* and *Eucalanus bungii*. We investigated their biomass, vertical distribution and life histories in the Oyashio area, western subarctic Pacific. We also carried out feeding experiments and gut-pigment analysis during their growing period. Among *Neocalanus* copepods, *N. cristatus* showed highest biomass and *N. plumchrus* showed highest P/B ratio. Annual secondary production of *Neocalanus* copepods was estimated as 29 gC m^{-2}, which is 19% of annual primary production in the Oyashio area. They mainly graze on diatoms during a spring bloom (by *N. cristatus* and *N. flemingeri*), and on microzooplankton after the blooming (by *N. plumchrus*). *Neocalanus* grazing is estimated to exceed half of the primary production. If we consider other copepods such as *Eucalanus bungii* and *Metridia* spp., importance of mesozooplankton as grazers should increase. Feeding experiments suggest that *Neocalanus* and *Eucalanus* directly utilize the primary producers during spring bloom, and became a secondary consumer after the bloom. These facts suggest that mesozooplankton is one of the key organisms which shape the ecosystem of the western subarctic Pacific. We will also estimate the export flux by their faecal pellets and by the ontogenetic vertical migration, and discuss their importance in the material flow of a deeper layer.

10AM2001 S2-327 poster

SEASONAL VARIABILITY IN THE ABUNDANCE AND BIOMASS OF FOUR PELAGIC AMPHIPODS IN THE OYASHIO REGION, WESTERN SUBARCTIC PACIFIC

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Abundance and biomass of four pelagic amphipods *Themisto pacifica*, *T. japonica*, *Primno abyssalis* and *Cyphocaris challengeri* were investigated based on seasonal Bongo-net samples collected in the Oyashio region, western subarctic Pacific, over the period of July 1996 to July 1998. As a common feature, both abundance and biomass of all the four amphipods were high in summer and low in winter. The annual mean biomass of all amphipods was 2.3 mg/m^3, which was 1.1% of the total zooplankton biomass. Among the four species, *C. challengeri* was most abundant (annual mean: 0.94 mg/m^3), followed by *T. pacifica* (0.50), *P. abyssalis* (0.37), *T. japonica* (0.27) and others (0.24). In terms of the number, *T. pacifica* was most numerous (0.2 inds/m^3) followed by *C. challengeri* (0.12), *P. abyssalis* (0.06), *T. japonica* (0.05) and others (0.03). Mature females and males of *C. challengeri*, *T. pacifica* and *P. abyssalis* occurred throughout the year, indicating that the reproduction of those species took place throughout the year. On the other hand, mature females of *T. japonica*

was observed only in early spring. More details about life cycle characteristics of the four amphipods will be discussed in our presentation at the symposium

10AM2001 S2-075 poster

INCLUDING HIGHER TROPHIC LEVELS AND MICROBIAL FOOD WEB IN THE ECOSYSTEM MODEL

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The approach we proposed to describe each biological processes as a system of chains of coupling cyclical interactions make it possible (by natural way) for including of higher trophic levels (HTL) and microbial food web in the ecosystem model. The HTL can have several type of food with different preferences in such model. It is possible to split HTL in several age groups which have different types of food, different growth rates and different another parameters too. By analogy with HTL microbial link can have different types of detritus as a substrate and different mineral forms of nitrogen with different uptake affinity. The bacteria are not only as a way of organic matter mineralization but as a source of food for different protozoan organisms. The including of HTL and microbial food web in the ecosystem model makes closed the matter fluxes of ecosystem. The including of these two links in the PICES NEMURO model increases the compartment number up to 15 and its dynamics is described by the system of more then 60 equations.

10AM2001 S2-246 poster

THE DESCRIPTION OF CO-LIMITATION OF PRIMARY PRODUCTION BY SEVERAL SUBSTRATE FACTORS

Vladimir I. Zvalinsky
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In PICES NEMURO MODEL the dependence of primary production on several environmental substrate factors (light intensity, concentrations of nitrogen, silicon, phosphorus) describes by the interexcluding functions. In accordance with this model the process rate is determine by one of functions having minimal value: by light-dependence function, or by dependence function on one of nutrients. But there are data that co-limitation by two substrate factors exists. Primary production models in the PICES NEMURO MODEL and in other ecosystem models known in the literature cannot describe such co-limitation of primary production by several substrate factors.

Our developing approach (the description of each biological process as a chain of coupling cyclical interactions) opens the possibility to describe the primary production process as function of several substrate factors. In addition such approach opens the possibility to construct conceptual model and correspondence mathematical model, which describe the light adaptation of primary production rate at different values of another substrate factor (such as carbon, nitrogen, silicon and so on). Light intensity is the energy factor, which determines the rate of organic matter biosynthesis, on the one hand, and is the factor, which determines the rate of destruction of the key components of biosynthesis process, on the other hand. This approach can be used as a model for description co-limitation of primary production rate by several factors.

S3 FIS Topic Session
Migrations of key ecological species in the North Pacific Ocean

Convenors: Vladimir A. Belayev (Russia), George W. Boehlert (U.S.A.), James Irvine (Canada) & Akihiko Yatsu (Japan)
Thursday, October 11, 2001 08:30-17:30

Migrations of marine organisms in the North Pacific occur on a variety of spatial and temporal scales, from diel vertical migrations to annual (or longer) foraging or reproductive migrations. Over the past decade, a great deal of new information has come to light on the dynamics of migration, in part due to new technologies such as electronic tags. This session will examine migrations of key ecological species important to fisheries in the North Pacific. Migrations of exploited species -- for example tunas, salmon, groundfish, crustaceans, squid, saury, mackerel and pomfret -- may be compared with movements of the lower trophic level organisms on which they prey. What role do migrations of protected species such as turtles, marine mammals, and seabirds play in the interactions with fisheries? Papers and posters in this full-day session will cover the most recent information on what is known about these migrations -- their pathways, seasonal and interannual dynamics, and relationship to physical forcing -- as well as new tools available to study migrations.

Invited speakers:

George Rose (Memorial University of Newfoundland, Canada) - Migrations of fish, mammals and seabirds in the northwest Atlantic: making large ecosystems work

Michael Healey (UBC, Canada) - Migratory patterns of salmon in the North Pacific

Bruce R. Mate (Oregon State University, U.S.A.) - Movements of blue whales in the eastern North Pacific

Jeffrey J. Polovina (NMFS, U.S.A.) - Migration patterns and forage habitats of juvenile loggerhead and olive ridley turtles in the central North Pacific

Katsumi Tsukamoto (University of Tokyo Ocean Research Institute, Japan) - Migration of Japanese eels

Alexander V. Vasilenko (TINRO-Center, Russia) - Dynamic processes in the fish community of the Kuroshio Current region

Selected papers from this session (oral and posters) will be considered for publication in the *Canadian Journal of Fisheries and Aquatic Sciences* (if the paper conforms to the journal's editorial policies http://www.uoguelph.ca/~cjfas/WEditorial-Jan98.html and receives a favourable review by peers).

10AM2001 S3-137 poster

SWIMMING PATTERN OF HOMING ADULT CHUM SALMON (*Oncorhynchus keta*)

Tomonori **Azumaya**[1], Yukimasa Ishida[1], Masa-aki Fukuwaka[1] and Yasuhiro Ueno[2]

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To investigate the swimming pattern of homing adult chum salmon (*Oncorhynchus keta*), archival tagging surveys were conducted in July 1998 in the Bering Sea. An archival tag was inserted into the abdominal cavity of fish on board, and a total of 20 homing adult chum salmon were released with archival tag. Three archival tags were recovered in the coast of Hokkaido, Japan after release in the Bering Sea. From these archival tags retrieved, time-series data of the swimming depth, ambient water temperature, internal temperature, and ambient light levels were obtained. We examined the power spectra of the swimming depth of the time series of 3 individuals. These individuals had the spectrum peaks in the period of about 24 and 12 hour. The homing adult chum salmon migrated at 60 m depth in the daytime and stayed at near the sea surface in the nighttime. The vertical movement was predominant in the daytime. The 25-hour running averaged swimming depth was deeper in the waters where the gradient of sea surface temperature was large spatially. These results indicate the common characteristics of the swimming pattern of the homing adult chum salmon.

10AM2001 S3-083 oral

THE RESPONSE OF PACIFIC HAKE (*Merluccius productus*) TO RECENT ECOSYSTEM CHANGE

Ashleen J. **Benson**[1], Gordon A. McFarlane[2], Susan E. Allen[1] and John F. Dower[1]

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Climate-ocean variability has been shown to have a profound effect on the biology, distribution and abundance of fish populations. The response of Pacific hake (*Merluccius productus*) to recent changes in ocean conditions has been dramatic. Traditionally the offshore stock migrated north to feeding grounds off British Columbia in summer and south to winter spawning grounds off Baja, California in winter. This changed in the 1990s, when a much larger proportion of the stock moved north, resulting in a higher than normal abundance of hake off Canada's west coast. Additionally, since 1994 hake have been spawning in Canadian waters and a portion of the stock has remained year round. These changes all occurred after the 1989 regime shift.

In order to determine whether the change in distribution also yielded a physiological response, hake growth rates and size at maturity were examined. Changes in length and weight at age have been documented for a separate stock of the same species in response to the 1977 and 1989 regime shifts, it therefore seems reasonable to expect a similar growth response in the offshore stock. Preliminary results indicate that the length at age decreased slightly between the 1980s and 1990s, and a decline in the weight at age was observed for fish in the southern part of the range over the same period. These results will be discussed in light of the effects of the 1989 regime shift on the relative productivity of the northern and southern areas of the California Current ecosystem.

10AM2001 S3-046 oral

HABITAT UTILIZATION AND MOVEMENT BY MATURING CHINOOK SALMON OFF THE COAST OF CALIFORNIA AND OREGON

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Archival tags recording temperature and depth were placed on 25 subadult and maturing chinook salmon in waters off Trinidad Head, northern California, during August and September, 2000. A total of five tags was recovered between October 2000 and January 2001, four from rivers or estuaries (Sacramento, Klamath (2), and

Rogue), and one off the Oregon coast. Temperature and depth data were recorded for a total of 96 days in the ocean and 59 days in estuaries and rivers.

In the marine environment, chinook occupied temperatures between 7.4-20.6°C (mean 10.6°C) and depths from the surface to 218 m (mean 42 m). Estuarine and freshwater values were 11.1-22.9°C (mean 19.3°C) and 0-21 m (mean 1.9 m). Contrasting with several other species of salmonids in the open North Pacific, chinook in coastal waters did not demonstrate clear day-night differences. Fish generally move to shallower water near dawn and dusk, likely associated with feeding behavior. Diel temperature variations during residence in the rivers appears to be related to river temperatures rather than to behavior of the fish. Migration patterns between the points of tagging and recapture were approximated by comparing *in situ* environmental data to that from the tags.

These data provide the first longer term information on behavior and habitat of chinook salmon in coastal waters. Further tagging will be required to discern the roles of season, age, and sex; tagging near the extremes of the species' range may help elaborate habitat preferences.

10AM2001 S3-214 poster

SPATIAL DISTRIBUTION AND ONTOGENETIC MOVEMENT OF WALLEYE POLLOCK IN THE EASTERN BERING SEA

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The age-specific spatial and density distribution of walleye pollock (*Theragra chalcogramma*) encountered during the 1982-2000 summer groundfish bottom-trawl surveys of the eastern Bering Sea shelf were examined. The size-specific catch-per-unit-effort (CPUE) was converted to age-specific CPUE at each station for ages 0 through 8 using each year's age-length data. For each year, the centroid of abundance of each age was calculated based on the CPUE at each station in the main survey area. These centroids are used to illustrate differences in the average location of pollock age-groups among years. Results indicate that walleye pollock disperse further onto the shelf during warm years than in cold and intermediate years. For all years combined, there is an ontogenetic shift in the average location from age-1 to age-2 toward the outer shelf which gradually shifts southeastward with age-3, 4 and 5, then progresses toward the middle shelf with age-6, 7 and 8. However, this overall average pattern is driven mostly by a few yearclasses that display a very large southeastward shift. The implications of these observations are discussed.

10AM2001 S3-071 oral

LIPIDS, BUOYANCY AND LIFE HISTORY: THE DEPTH DISTRIBUTION OF OVERWINTERING *Neocalanus* spp. IN THE EASTERN NORTH PACIFIC

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The large calanoid copepods that dominate the mesozooplankton of the North Pacific (and other high-latitude pelagic ecosystems) undergo considerable annual ontogenetic vertical migrations. A large proportion of the life history of these copepods is spent overwintering in a quiescent state, at depths of hundreds to thousands of metres. In general, vertical distributions are poorly described in these copepods, and it is unknown by what mechanisms species-specific vertical distributions are regulated. Since overwintering copepods do not swim, it has been proposed that they overwinter by settling to a depth of neutral buoyancy, that is determined partially by their species-specific lipid profile. However, the lipids utilized by these copepods (primarily wax ester) are more compressible than seawater and thus the depth of neutral buoyancy for an animal is not stable: if displaced up (or down) from that depth, a copepod will continue to ascend (or sink). We will present overwintering depth distributions of *Neocalanus* spp., as mapped by an optical plankton counter, at two sites in the northeast Pacific (the Strait of Georgia and Station P) in comparison to depth-stratified measurements of lipid composition. The results, presented in the framework of a model for the buoyancy of a copepod, will be used to illustrate the relative importance of lipid composition and buoyancy in determining overwintering depth distributions.

10AM2001 S3-142 oral

TAGGING OF PACIFIC PELAGICS: A CoML PILOT PROJECT

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Tagging of Pacific Pelagics (TOPP) is a pilot program of the Census of Marine Life (CoML) that will use electronic tags to examine the distribution and behavior of organisms relative to the ocean environment. TOPP will describe patterns of movement and behavior of marine vertebrates and large squid in the North Pacific. This project will use the tag-bearing animals as autonomous ocean profilers to define the oceanographic regions of critical interest. The temporal and spatial data generated by our project will provide an "organism-eye" view of several interactive oceanic regimes. The aim of the program is to generate a detailed understanding of how marine animals from several trophic levels use distinct oceanic regions: the Continental Shelf System stretching from Baja California to the Aleutians; the pelagic realm of the Subarctic and the Subtropical Transition Zones and Central and Alaska Gyres; and complex current systems including the California Current and the Alaska Coastal Current.

Fifteen to twenty species of pelagic organisms from several trophic levels, many with similar patterns of spatial and temporal distributions, will be monitored throughout the North Pacific. The aim is to understand animal movements and aggregations in the context of the complex and varying North Pacific environment. Results from TOPP will provide a framework for future management and conservation of these economically and ecologically valuable resources while simultaneously capturing the imagination of the public. TOPP will develop the tools and the conceptual framework necessary for using electronic tags by other CoML programs in other ocean basins.

10AM2001 S3-132 poster

SEASONAL VARIABILITY OF TEMPERATURE AND SALINITY IN THE INTERMEDIATE WATER IN THE NORTHERN PART OF THE SEA OF OKHOTSK (OKHOTSK SEA MODE WATER)

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In the Okhotsk Sea, OSMW occupies a layer between the depth of 100–150 m (the lower boundary of winter convection) and the depth of 400-700 m. OSMW is the environment of an adult pollock. The data of more than 80000 oceanographic stations, obtained by TINRO-DVNIGMI surveys from 1932 to 2000, were used to calculate monthly-averaged temperature and salinity at the depth of 100, 200, 300, 400, 500, 600, 800 meters and area-averaged for the 30 regions of the Sea of Okhotsk.

The seasonal maximum of temperature at the depth of 100 m is observed in November–December, when the maximum destruction of the dichothermal water is occurred and the temperature minimum follows maximum winter cooling in February-April. The maximum of temperature and salinity at horizons of 200-700 m is observed in November-January in most of regions, except the Kruzenshtern Strait and West-Kamchatka Current areas. Maximum of temperature and salinity is observed in February-March from Kruzenshtern Strait to Lebed Trench, in February-May – in TINRO Basin, in May-June – in the eastern part of Derugin Basin (49-54°N, 146-150°E). These regions are the main area of Pollock spawning grounds and there is a good correlation between the periods of temperature maximum and the peaks of spawning intensity for each region. Prolonged conservation of high values of temperature and salinity is caused by winter intensity of the Pacific Ocean water transport into the Sea of Okhotsk. Temperature, salinity and density of the Okhotsk Sea Mode Water are lowered until July-August in the most areas after winter monsoon is stopped and specific heat of ocean waters is wasted. The earliest increasing of temperature and salinity in OSMW is observed in June in the Kuril Islands area. The discovered features of seasonal variability in OSMW show that winter intensity of the Pacific Ocean water transport into the Sea of Okhotsk is much more than its summer value.

10AM2001 S3-173 poster

FISH SPECIES IDENTIFICATION USING A QUANTITATIVE ECHO SOUNDER

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In the Sea of Japan off Tottori Prefecture, the Tsushima Current creates a good fishing area for mackerel, squid, and flatfish. However the stock sizes of these species change dramatically as environmental conditions change. Quantitative echo sounders can be useful when monitoring large areas, however information is needed so that individual species can be identified. Hydroacoustic observations were made using a quantitative echo sounder during May, August, and October 2000 along a sampling transect positioned across the shelf edge. Along the transect, temperature and salinity were also measured. Acoustic data was recorded at two frequencies: 38khz and 70khz. Several characteristic echo patterns were observed in the echogram. During each observation period, layer like echoes that underwent diurnal vertical migration were observed. The echoes in this layer resembled those of Japanese pearlsides, which is the only microneckton in the Sea of Japan. Other species identified in October included several larvae crustaceans, zooplankton, and leptocephalus larvae. Echoes from the seabed were presumably from sailfin sandfish based on the result of the bottom trawl sampling. Middle range patch-like echoes were presumably anchovy and yellowfin horse mackerel based on the results of surface trawl sampling. To identify fish species from echograms, information on the ecology of species, such as the timing of migration, predator-prey relationships and habitat temperature, is important in addition to the acoustic data.

10AM2001 S3-407 poster

ASSOCIATION OF INDIVIDUALS WITHIN MIGRATING HERRING SCHOOLS AS DETERMINED BY TAGGING: IMPLICATIONS FOR ANALYSIS OF SCHOOLING, POPULATION BIOLOGY AND FISHING

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Pacific herring in British Columbia were tagged with external anchor tags between 1979 and 1992. A total of 572 378 herring were tagged and released from 429 different tagging sessions. For each session herring were captured by purse seine, and 1000-2000 herring were tagged and released of over a period of several hours. Most tags were recovered after periods of <1 to 60 months from commercial fisheries. Each tag had a unique number so the exact date and location was known for most recoveries. A total of 5654 tags were recovered from 1771 recovery 'events', where an event consisted of the recovery of a single tag ($\sim$1147 events) or 'multiple' (2 or more) tags (624 events). A total of 4507 tags were recovered from 'multiple events' so most recovered tags ($\sim$80%) were recovered with other tagged herring. The question of biological interest is whether these instances of multiple tag recaptures represent examples of post-tagging association of individuals from the same schools (or origins) or whether such multiple recoveries would be expected by chance. From analyses of acoustic records we know that herring frequently occur in small schools but sometimes they also occur in large, aggregations, particularly during the over-wintering period and before spawning when often they are subjected to fisheries. Is it possible that two or more herring could associate over periods of months or years as they move into, and out of large aggregations and as they migrate to and from feeding, over-wintering and spawning areas - distances of up to hundreds of km away from their tagging site? Alternately, do herring mix randomly? We tested this using a statistical method (from McKinnell, Pella & Dahlberg 1997) developed to determine the probability that an observed frequency of matching tag recoveries (animals tagged at the same time and location and subsequently recaptured together) occurred by chance. Tag recoveries were considered to be matched if two or more tags from the same release event were caught on the same calendar date in the same location. This analysis was done for 5 major areas on the BC coast, each corresponding to areas supporting large migratory stocks. We conclude that the probability of the observed association occurring by chance is extremely unlikely. The results indicate that herring have the ability to retain associations with other individuals, even after travelling considerable distances and that there may be considerable non-random associations of herring within aggregations. This has implications for the interpretation of biological samples from large aggregations.

10AM2001 S3-011 invited

SALMON MIGRATIONS IN A DYNAMIC OCEAN

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Migration over long distances in both fresh and salt water is one of the defining characteristics of Pacific salmon (*Oncorhynchus* spp.). Salmon possess remarkable capabilities for finding and maintaining a compass direction from celestial or geophysical clues and for distinguishing between water masses on the basis of their smell, salinity, and temperature. In recent years, research on salmon migrations has been focussed on relationships between ocean conditions and migratory behaviour. This has led to a strong bond between physical and biological modeling that has permitted investigators to explore, in realistic computer simulations, plausible relationships between oceanic water properties and circulation and salmon migrations. The results of these models have led to a set of behavioural rules that account for the oceanic migrations of salmon as a component of the fish's strategy for satisfying the ecological imperatives of growth, survival and reproduction. These rules help to put the migration behaviour of salmon into the context of evolutionary ecology and suggest new avenues for productive interdisciplinary research on salmon migrations.

10AM2001 S3-118 oral

OCEANOGRAPHIC HABITATS OF TWO SYMPATRIC NORTH PACIFIC ALBATROSSES: SCALE-DEPENDENT PATTERNS

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We characterized the habitats exploited by black-footed (*Phoebastria nigripes)* and Laysan (*P. immutabilis*) albatrosses breeding sympatrically at Tern Island, Hawaii. Analyses of ARGOS telemetry data in conjunction with satellite-derived sea surface temperature (AVHRR) and chlorophyll concentrations (SeaWiFS) suggest that albatross habitat selection is scale-dependent. Over macro-mega scales (1000's km) albatross dispersion is influenced by water mass distributions and constrained by breeding duties at the colony. During the brooding period (< 19 days after chicks hatched), black-footed albatrosses restricted their movements to tropical waters (>20°C), while Laysan albatrosses ventured into the cooler waters of the Transition Domain (15-12°C) and the Subarctic Frontal Zone (12-10°C). Albatross foraging ranges expanded during the rearing period (19–140 days post-hatching), when both species foraged in cooler and more productive water masses. Black-footed albatrosses commuted to the California Current, and Laysan albatrosses ventured into subarctic waters (<10°C) of the Gulf of Alaska, the Aleutians, and the Northwest Pacific. Within these large-scale water masses, albatrosses focused their foraging activities within smaller coarse-meso scale (10's – 100's km) features characterized by elevated productivity. Foraging birds engaged in area-restricted searching behavior along continental shelves (California – British Columbia, Aleutians), and water mass boundaries (North Pacific Transition Domain, California Current). Conversely, albatrosses commuted rapidly over tropical and subtropical waters between highly-productive foraging areas and Tern Island. An understanding of the physical processes that stimulate ocean productivity and prey aggregation is essential to delineate important foraging grounds exploited by highly-mobile pelagic species.

10AM2001 S3-119 poster

OVERLAP BETWEEN SATELLITE-TRACKED FEMALE BLACK-FOOTED ALBATROSSES AND THE JAPANESE EASTERN PACIFIC LONGLINE FISHERY

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Black-footed albatrosses (*Phoebastria nigripes*) sustain substantial mortality in the Hawaiian longline fishery, where an estimated 1-2% of the world population (58,500 breeding pairs) was taken yearly during 1990-1994. Pelagic longline fleets not currently monitored by observer programs are a likely source of additional mortality in the central and eastern north Pacific. In particular, determining the overlap between longline fishing effort and albatross foraging zones is an important first step to identify potential sources of additional bycatch. We tracked four female albatrosses for a total of 99 days during their summer (July–September, 1997-99) non-breeding dispersal, and compared their movements to seasonal summaries of fishing effort from the Japanese Eastern Pacific Ocean (EPO) longline fishery. The satellite-tracked birds ranged across national boundaries, and spent 22%, 26% and 52% of the time in U.S., Mexican and international waters respectively. Determining the overlap between this fishery and albatross distributions was hindered by the inherent spatial and temporal variability of fishing effort. While the analysis of summertime longline effort between 1981-87 revealed potential overlap with albatross distributions, the pattern was not as clear when data from 1991-97 were analyzed. At present, this research cannot directly evaluate whether black-footed albatross bycatch occurs in the Japanese Eastern Pacific longline fishery. However, the available data highlight the need for international observer programs in longline fisheries operating within the Eastern Pacific Ocean. These results underscore the value of satellite telemetry to assess national conservation responsibilities and potential threats to far-ranging pelagic species.

10AM2001 S3-093 poster

SEASONAL CHANGES IN THE LOCATION OF SPAWNING GROUND AND THE EXPERIENCED TEMPERATURE OF WATER DURING THE EARLY LIFE STAGES OF PACIFIC SAURY (*Cololabis saira*) IN THE WESTERN NORTH PACIFIC

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It is known that the spawning of Pacific saury occurs almost year-round in the western North Pacific. Since we have no effectual method for estimating its egg abundance, the location of spawning grounds (SGs) had been speculated from the distribution of larvae. However, the SGs and the larval habitats are not exactly in the same location, because as eggs they drift for more than a week in the area with prevailing oceanic currents such as the Kuroshio and the Kuroshio Extension. In order to deduce more accurate location of SGs, larvae and juveniles collected in 1993-1996 were backtracked using the Euler-Lagrange method. We assumed the larvae and juveniles, with poor swimming ability, were passively advected by a combined flow of geostrophic and wind-driven currents, since the time they were laid as eggs. The drifting period for each individual was estimated based on known growth rates from egg to juvenile. While drifting, daily experienced temperatures of water (TWs) for each individual were examined by 1°×1° grid sea surface temperature dataset. The advantage of our analysis is not only in the consideration of egg stage duration, but also in the deduction from juveniles that helped extending the analyzed region both in time and space. Thus, the seasonal changes were clearly observed as follows. In autumn, the SGs were located south of the offshore Oyashio front (OF) and expanded southward to the Kuroshio Extension (KE) area. In winter, the SGs moved further southward into the Kuroshio area. In spring, the SGs shifted northward into the KE area and its north. In summer, small SGs occurred south of the

inshore OF. The TWs during the egg stage ranged 18-26°C in autumn, 16-22°C in winter, and 10-18°C in spring. However, the TWs during the juvenile stage (about two months after they were laid as eggs) ranged 14-20°C without significant differences between those three seasons.

10AM2001 S3-175 poster

RECENT CHANGE IN SUMMER FEEDING ECOLOGY AND TROPHIC DYNAMICS OF PACIFIC SALMON IN THE OFFSHORE WATERS OF THE GULF OF ALASKA

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Analysis of $\delta^{13}C$ and $\delta^{15}N$ isotope values and stomach contents of Pacific salmon indicate that their summer feeding ecology and trophic dynamics have changed in the offshore waters of the Gulf of Alaska since the late 1990s. Micronektonic squid (mainly *Berryteuthis anonychus*) were the dominant prey of Pacific salmon at stations sampled in early July along the 145°W transect line by the *Oshoro-maru*, except for chum salmon which primarily fed on gelatinous zooplankton by 1996. There was a reduction in the percentage of squid in the diets of sockeye, pink, and coho salmon in 1997 and 1999. At southern transect stations there was a large reduction in squid in the diets of sockeye and pink salmon in 1999-2000 and coho salmon in 2000. The mean percentage of squid increased in diets of all species at northern transect stations in 2000. Prey composition of chum salmon has recently changed from dominant gelatinous zooplankton to more diverse zooplankton. The overlap of food niche among 6 salmonid species has increased since 1999. Scatter plots in the $\delta^{13}C$ -$\delta^{15}N$ plane of Pacific salmon in 1999-2000 showed that the difference in isotope values was generally consistent with stomach content analyses, i.e., chinook salmon, steelhead trout, coho salmon, sockeye salmon, pink salmon, and chum salmon in order of trophic level. All species including chum salmon occupied each trophic position at the same branch of the food chain in 1999-2000, although chum salmon feeding on gelatinous zooplankton was reported as a unique trophic position at a different branch of the food chain in 1991. Our results suggest that sockeye, pink, and chum salmon show a high plasticity in their feeding strategy such as switching diets from micronecton or jellyfish to zooplankton according to changes in the ecosystem.

10AM2001 S3-057 poster

DIFFERENT STRATEGIES IN PINK AND CHUM SALMON MIGRATIONS FROM PACIFIC OCEAN INTO THE OKHOTSK SEA

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During several years Pacific salmon have been studied in the Pacific Ocean along Kuril Islands: catch-per-unit-effort (CPUE), body length, sex composition, gonad state (stage of maturity, gonad somatic index - GSI), age, and scale structure. The following peculiarities are determined for chum salmon: specimens with "southern" type of scale occur in catches since May-June; body weight is rather smaller than for fish migrating to rivers; variability in maturity indices is the greatest comparing to other salmon species; unlike the other species with variable duration of a sea life period (sockeye salmon, chinook salmon), immature chum salmon group is not isolated from other ages either by the date of migration into the Okhotsk Sea or by the age composition and GSI (uniform field of values). These peculiarities prove the continuous feeding and growing of some portion of chum salmon in the Okhotsk Sea before their entering the rivers for spawning. As a result, it is difficult to distinguish spatial or temporal disconnection in individual chum salmon groups of different origin.

As regards to pink salmon, their greatest increment in length and weight during the last year of life is observed in the ocean before entering the Okhotsk Sea, and their migrating flow is well-structured. In particular, spatial divergence is caused by the fact that in the southern part of the flow between 45° and 48°N, pink salmon are mainly represented by populations whose fry after downstream migration from rivers begin their sea life in the western and southwestern parts of the Okhotsk Sea. A temporal divergence is caused by migration of pink salmon from various seasonal groups. These temporal groups occurring in the southern part of migrating flow in the ocean correspond to fish groups of early and late running into the rivers of eastern Sakhalin and southern Kuril Islands by their dates of migration and scale structure.

10AM2001 S3-060 poster

RELATIONSHIP BETWEEN CHUB MACKEREL (*Scomber japonicus*) POPULATION AND CLIMATE VARIABILITY IN THE EAST CHINA SEA

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To detect decadal and interannual climate signals and the variability of chub mackerel population, we examined total landing of chub mackerel and environmental data (such as SST, wind speed, and chlorophyll *a*) along the East China Sea. Fishery data were collected from FAO catch statistics by nation (China, Japan, Korea, Philippine, and Taiwan) during 1959-1998. SST data were extracted from ClimLab 2000, wind from IRI data center, and chlorophyll a from SeaWiFs and CZCS data. For environmental data, two meridional lines, 123°E (S1) and 130°E (S2) and 1°x1° 4 subareas (33-34°N, 29-30°N, 25.5-26.5°N, 21.5-22.5°N) by latitude were selected. A quasi-decadal signal is observed within SST anomalies. There is an evidence for inverse phase relationships in SST anomalies between coastal area (S1) and Northern Pacific Gyre (S2). From the statistical test, it was revealed that SST anomaly was a good factor to explain the catch fluctuations of chub mackerel in the East China Sea. Catch fluctuations track the quasi-decadal variability in the SST anomaly and ENSO signals. The fishery location in Taiwan seems to be concentrated in boundary between high and low chlorophyll *a* distributions. Also, there was a shift in fishing location to the north during the warm phase, so that the catch between Japan and Taiwan showed a negative correlation.

10AM2001 S3-252 oral

YEARLY VARIATION OF CHUM SALMON (*Oncorhynchus keta*) MIGRATION, SEX RATIO, LENGTH COMPOSITION AND ENVIRONMENTAL FACTORS IN THE EASTERN AREA OF KOREA

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Migration of chum salmon (*Oncorhynchus keta*) was investigated with concerning environmental condition in the eastern area of Korea during 1984-1997. Additionally, sex ratio and length composition was studied to figure out biological characteristics in associated with environmental condition.

Harvest of chum salmon showed increasing trend after increasing release of juvenile fish in the Namdae River, eastern area of Korea. Chum salmon catch revealed positive relationship with coastal sea temperature and zooplankton biomass.

They strongly migrated after mid November in 1980s and before early November in 1990s. Coastal sea temperature and zooplankton biomass exhibited the increasing trend in 1990s compared with 1980s. Of zooplankton, macrozooplankton such as euphausiids and amphipods sharply increased after early 1990s. Monthly migration is positively related with coastal temperature and zooplankton biomass.

The proportion of female chum salmon showed the yearly variation, 34-38% in the late 1980s with increasing to 45-54% after early 1990s. Mean body length revealed the increasing trend from 60-65 cm in the late 1980s to 64-72 cm in 1990s. Mean body length is positively correlated with sex ratio and zooplankton biomass and negatively associated with coastal temperature.

10AM2001 S3-253 poster

BIOLOGICAL CHARACTERISTICS OF CHUM SALMON (*Oncorhynchus keta*) IN THE NAMDAE RIVER OF KOREA

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Artificial propagation of the chum salmon *Oncorhynchus keta* in Korea was first conducted in 1913. Since then, fish biologist have learned more about the life cycle of chum salmon and adopted their knowledge to gain more control for the juvenile production, resulting in continued increase of releasing and harvesting of chum salmon.

In this study, we estimated biological characteristics and their density dependent growth of chum salmon population in the Namdae River of Korea, based on the result of artificial propagation project of NFRDI during 1984-1989. We investigated fish age to determine yearly growth by scales. Monthly gonad-somatic index, fecundity, egg diameter and weight by age group were used to estimate spawning season during 1987-1989.

Artificial propagation induced increasing trend of releasing of chum salmon juvenile and adult catch since 1984. Body length and body weight were decreasing trend in adult chum salmon during 1984-1989; 72-82cm of mean body length during mid 1980s and 68-73cm during late 1980s in 5- year old chum salmon. Spawning occurred during late September-early December with peak in October-November. Fecundity showed 2,402-4,710 mean egg numbers during September-October and 1,750-3,347 during November-December.

10AM2001 S3-121 oral

FLUCTUATION IN LARVAL TRANSPORT OF THE JAPANESE EEL ASSOCIATED WITH GLOBAL OCEANIC - CLIMATIC CHANGES

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In 1991 an expedition of a Japanese research vessel discovered that the spawning ground of the Japanese eel is located in the North Equatorial Current (NEC) in the Pacific Ocean. Several unanswered questions about the distribution of the eel and their larvae downstream of the NEC, however, remain and are unlikely to be resolved by the observations alone. Numerical simulation is one of the possible ways to settle them and we demonstrated that answers to these questions can be explained by the water circulation in the North Pacific.

For the successful completion of 3000 km larval migration from the spawning ground in the NEC to their growth habitat in east Asia, a complicated strategy including effects of the trade winds and salinity front in the NEC is necessary. The trade wind generates efficient northward Ekman transport of the larvae and the salinity front works as a landmark of spawning ground for the adult eel. Associated with occurrence of El Niño / Southern Oscillation (ENSO), the salinity front moves southward largely. It means that the spawning ground during ENSO is located in the southern region of the NEC where current circulation is not so appropriate for the larval migration to the nursery ground in the East Asia. Catch of the Japanese eel larvae in Japan was well corresponded to fluctuation of Southern Oscillation Index (El Niño index) and it verifies that ENSO controls abundance of larval migration from the NEC to the Kuroshio.

10AM2001 S3-172 oral

MIGRATION DYNAMICS OF SPINY DOGFISH (*Squalus acanthias*)

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From 1978 to 1988, approximately 71,000 spiny dogfish (*Squalus acanthias*) were tagged off the west coast of Canada. This program is the most extensive tagging study conducted for shark species. Twelve years after the last year of tagging, recaptured tagged dogfish are still being reported. As of December 2000, 2940 tagged fish (4.1%) have been recaptured. Dogfish were tagged in three major regions: Strait of Georgia, west coast Vancouver Island, and Queen Charlotte Sound up through Hecate Strait. Generally, dogfish were recaptured close to their release site, however extensive migrations (up to 7,000 km) did occur. Migration rates varied

across release areas. Dogfish tagged in the Strait of Georgia underwent the least extensive movement, with only approximately 20% of the recaptures occurring outside the strait. Dogfish tagged off the west coast of Vancouver Island or in Hecate Strait underwent more extensive movement with approximately 50-70% of the tagged dogfish recaptured outside of the release region. Dogfish from all three release regions were recaptured off west coast of the United States and Alaska. Most impressive are the recaptures of tagged dogfish off the coast of Japan. Over 30 spiny dogfish were recaptured near Japan, most of which originated from Hecate Strait or off the west coast of Vancouver Island. The movement of spiny dogfish throughout their distribution range is an important aspect of their biology. We discuss differences in rates of movement that are attributed to size, sex and ecosystem changes.

10AM2001 S3-100 oral

DIVING BEHAVIOR AND PERFORMANCE OF PACIFIC BLUEFIN TUNA (*Thunnus thynnus orientalis*) RECORDED BY AN ARCHIVAL TAG

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Immature Pacific bluefin tuna marked with archival tags were released off Tsushima Island in the East China Sea. Using time-series data on swimming depth, ambient temperature and peritoneal cavity temperature recorded by the tags retrieved, we examined the effect of ambient temperature on their dives in relation to the occurrence of feeding events. The development of their diving performance with growth was also discussed. In the East China Sea, the bluefin swam within the surface mixed layer in winter, while as the thermocline developed in summer the bluefin spent most of the time at the surface and made in daytime repeated dives to depths through the thermocline. Further, feeding events were mostly recognized in accordance with the diving performance, suggesting that their diving is for feeding.

In summer, some bluefin migrated to the Pacific, where they made few dives in the daytime despite a deeper surface mixed layer, and they mainly made dives at dusk and dawn. This suggests that their diving patterns may possibly be affected by vertical prey distribution. The dives at dusk and dawn were supposed to be a behavioral response to temporal change in illumination since few feeding events were recognized in accordance with these dives. Additionally, diving depth and vertical swimming speed increased with growth.

In conclusion, seasonal and spatial changes in the vertical thermal structure and vertical food distribution may have a great influence on the diving behavior. It is also evident that their diving performance develops with growth.

10AM2001 S3-360 poster

INTERANNUAL DYNAMICS OF WALLEYE POLLOCK (*Theragra chalcogramma*) ABUNDANCE AND DISTRIBUTION IN THE NORTHWESTERN BERING SEA IN 1997-2000

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Mixed aggregations of feeding pollock are formed in the northwestern Bering Sea in summer-autumn period. They usually consist of fishes of local origin and migrants from the eastern part of the sea. Their quantitative proportion varies annually and depends on extent of seasonal migrations of the eastern Bering Sea pollock population in the northwestern direction.

In 1997-2000 the TINRO-Centre applying the same methods conducted echo integration and bottom trawl surveys in the northwestern Bering Sea (Russian EEZ) that has allowed annually determining the stocks state and structure of walleye pollock aggregations in this part of the sea. Basing on surveys data the graphs and maps of density distribution, illustrating interannual dynamics of length-age structure and spatial distribution of various age groups of pollock in Navarin-Anadyr region in 1997-2000 have been constructed.

In 1997, which can be defined as the warmest among the last four years, all age groups of pollock were much wider distributed comparing to consequent years. 1-2 year old fishes of 1996-1995 year-classes predominated in

abundance, forming the densest concentration in survey area. In 1998 there was observed almost double reduction of total number and decrease total biomass on 120 thousand tons due to young fishes 1996-1997 year-classes while abundance of both 3-year old fishes and mature fishes stayed stable. In anomalous cold 1999 the number of 3-year old pollock of 1996 year-class was sharply reduced in 3.5 times and mature fishes - in 2.2 times due to mainly middle-aged pollock of 40-50 cm length. According to results of echo integration survey conducted in Navarin-Anadyr region in 2000, tendency of abundance decrease of 3-year old and older fishes, forming a base of stock exploited in Russian zone, was confirmed. 1-year old pollock of 1999 year-class (68%) remained the most numerous age group in 2000. The distribution of this age group was broader and pelagic aggregations were noticeably denser than in other years. Regarding other age groups, there has been clearly observed gradual reduction of extent of the 2-year old and 3-year old pollock migrations to the northwestern part of the Bering Sea. Square occupied by mature fish stayed stable, however density of the recorded aggregations reduced sequentially year by year.

Thus, during the last years the appreciable decrease of pollock abundance was registered in the northwestern Bering Sea reflecting the reduction of feeding migrations extent of the eastern Bering Sea pollock population to Russian zone. That could be caused by both general changes of oceanological conditions to cold growing in Navarin region and favorable for feeding conditions taken place in the eastern Bering Sea shelf. Besides, the decrease of migrations activity in northwestern direction can be caused by intense pollock fishery conducted along the both sides of the Conventional line.

10AM2001 S3-382 oral

MIGRATIONS OF COMMON PELAGIC FISHES AND SQUIDS AS A DETERMINATIVE FOR THE NEKTON COMMUNITIES FORMING IN THE SOUTHERN OKHOTSK SEA IN FALL

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Based on long-term information it's revealed that in summer and fall in upper epipelagic layer of the southern Okhotsk Sea nekton is formed mainly of species and groups, which could be determined as seasonal and daily migrants. According to collected data, two groups of organisms constitute a major share of nekton biomass: 1) species which undertake extensive horizontal seasonal migrations and 2) species which daily ascend up to surface from the deeper layer at nighttime, i.e. perform diurnal vertical migrations. The first group consists of such species and groups as pacific salmon, Japanese anchovy, arabesque greenling and in lesser extent - saury, Japanese sardine, Japanese mackerel, Japanese common squid and salmon shark; the second one includes mainly mesopelagic fishes and squids: deep-sea smelt, lanternfish (*Stenobrachius leucopsarus)* and one of the common gonatids - boreopacific gonate squid. It's necessary to note that the latter group consists of the "local" species, which habit and reproduce in Okhotsk Sea basin while the former one is formed of both "local" (salmon, greenling) and "alien" species (saury, sardine, mackerel, common squid and salmon shark).

Share of each species and group in total biomass greatly varied depending on stock condition, oceanologic environment, extent of migration and concrete season of investigation. In fall of recent years in the upper epipelagic layer the portion of Pacific salmon (mainly juvenile and immature fishes) reached 79%, anchovy - 47%, deep-sea smelt - 26% and gonate squid - about 20% of total nekton biomass.

Thus, in summer and fall a lot of species migrates to the southern Okhotsk Sea for feeding on huge planktonic resources occurring there. That region is especially important for feeding of Pacific salmon juveniles originated from Sakhalin, Kuril Islands, western Kamchatka, northern Okhotsk coast and Japan. So, migrants compose a majority of nekton biomass in the subsurface waters.

10AM2001 S3-178 poster

FLUCTUATION OF ELVER CATCH OF JAPANESE EEL (*Anguilla japonica*) IN KOREAN WATER

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The catch data of elvers in Jeju Island were collected from 1991 to 1999. The elvers were caught in the estuaries by the dip nets during the seasons of upstream migration. We analyzed a daily, monthly and annual variation of the catch in relation to environmental factors affecting the upstream migration. The elvers appeared in January when the water temperature was about 15°C, and showed a peak in catch in February when the temperature became 14°C. Few elvers were caught when the temperature reached over 16°C in April or in May. In January of any given year if the water temperature maintained below 14°C, not only annual total catch was higher, but also elver catch was extended up to early May. On the contrary, if the January temperature maintained over 15°C, the elvers began to appeared late in February, and the duration of appearance was relatively short until early April. The catch amount fluctuated with moon phase. Thus it was the highest during the new moon. Annual catch per unit effort tends to decline. Especially it was the lowest in 1998, one year after the El Niño. We compared these data to those obtained in the other estuaries in Korea, and discussed the factors affecting the short and long-term fluctuation of elver catch.

10AM2001 S3-017 invited

MOVEMENTS OF BLUE WHALES IN THE EASTERN NORTH PACIFIC

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The estimated 2,134 blue whales feeding in summer off California constitute the largest remnant population of this species in the world, yet little is known of individual foraging ranges or stock distribution throughout the year. Since 1993, Oregon State University has tagged 100 blue whales off central/southern California with Argos (satellite-monitored) radio tags to examine summer feeding, fall migration and winter habitats. Tags transmit 4 hrs/d to obtain just a few locations/d, providing conservative estimates of distances traveled and speed. Whales tracked up to 13,000 km averaged >3.6 km/h over the entire track and some had multi-month speeds >4.8 km/h. During the feeding season whales often moved quickly between coastal areas traditionally dense in krill, presumably searching for better foraging sites. During the 1998 El Niño, many blue whales were visibly emaciated. High-speed searches and large size may be adaptations to survive such events.

The fall migration south is relatively fast, not cohesive, and includes continental shelf and offshore routes. Whales depart southern California over several months. Many whales winter off Magdalena Bay, within the Gulf of California and west of the Costa Rica Dome upwelling, where productivity is usually high. Those whales reaching Baja's southern tip, arrive in November and early December. There are some year-to-year differences in winter distribution. Many whales have winter ranges that do not overlap substantially. Examination of wintering area climatologies, AVHRR and SeaWifs data strongly suggest that blue whales continue to feed throughout the winter, unlike gray and humpback whales.

10AM2001 S3-338 poster

STUDIES OF FISH ASSEMBLAGES AND OCEANOGRAPHY OF SEAMOUNTS AT THE SOUTHERN GULF OF CALIFORNIA

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Pelagic fishes like tunas, billfishes, sharks and golden fish among others are ecologically and economically important to the sport fishing and recreational industry in the southern Gulf of California. Seamounts act as aggregation structures where these organisms are frequently observed. Reasons of their presence among others are: feeding habits, reproduction, social behaviour, and environmental conditions. To study the structure of fish assemblages of these communities, in 1995 we started our investigation by mean of visual census and icthyoplankton sampling. In 1997-1998 we started ultrasonic tagging experiments at the" El Bajo Espiritu Santo" Seamount (EBES) near the Espiritu Santo Island north to La Paz bay. Comprehensive oceanographic studies at the EBES were also carried out. Results of visual census between August 1999 and October 2000 revealed patterns in residence and seasonality of two distinct associated groups of species. Icthyoplankton studies showed a direct relationship between SST and the diversity index H' in El Niño and non-El Niño conditions. Tagging experiments of yellowfin tuna at the EBES indicate two types of behavior: a pattern of residence in which individuals are present at the Seamount on a daily basis and a pattern of homing where individuals return to the Seamount after longer periods of absence. Description of the oceanographic conditions of the EBES and the Cerralvo Island Seamount are given. A mesoscale cyclonic eddy circulation system in the southern portion of the Gulf of California was observed in 1979. Current data recorded in 1997 and satellite images obtained in 1995 correspond to that general circulation pattern.

10AM2001 S3-102 poster

CONSUMPTION OF THE FOOD HYDROBIONTS BY THE PACIFIC SALMONS IN THE EPIPELAGIAL IN THE SOUTH KURIL REGION

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There are two most numerous: pink salmon (*O. gorbuscha*) and chum salmon (*O. keta*) from 6 species of Pacific salmons (genus *Oncorhynchus*), habiting the Southern Kuril region (Okhotsk coastal both, Pacific coastal and oceanic of water). Biomass of these species during period of investigations was 80-90% from total biomass of all salmons and 1 up to 68% from general biomass of epipelagial nekton (depth 0-50). Biomass of other salmons did not exceed 10% from total biomass of all salmons. We calculated daily and seasonal food consumption, taking into account features of salmons feeding and their biomass in this area. The daily consumption of the food hydrobionts by the salmons changed over a wide range in the summer period: 15.6-1210 tons in coastal Okhotsk waters; 83.7-338.5 tons in coastal Pacific waters; 99.6-615 tons in oceanic Pacific waters. It depends from abundance of pink salmon and chum salmon in this area in different years. The volumes of seasonal food consumption by the salmons were calculated and had shown, that the salmons consumed from 19.9 up to 107.7 thousands tons of the food hydrobionts for the period 1991-1996 in coastal Okhotsk waters. The salmons were main consumers in this area, except 1991 – the period of high abundance the Pacific sardine, when its seasonal consumption has made 342.9 thousands tons.

Salmons consumed from 29.9 up to 52.2 thousands tons of the food hydrobionts in coastal Pacific waters, but the main consumers of the food hydrobionts in this regions were saury and squids (saury – 83.9-132.5 thousands tons; squids – 10.7-67.3 thousands tons). The seasonal food consumption by salmons was low (14.5-28.4 thousands tons) in oceanic Pacific waters, while seasonal food consumption by anchovy reached 128-324.6 thousands tons, myctophids – 65.6-190.9 thousands ton, squids - 44-458.7 thousands tons.

10AM2001 S3-251 poster

INTERANNUAL VARIABILITY OF SQUID DISTRIBUTION IN RELATION TO OCEANOLOGICAL CONDITIONS OF THE SOUTH KURIL ISLANDS REGION

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Distribution of three squid species was investigated in dependence on oceanological condition on the base of data scientific catches and the oceanographic data obtained by Japanese and Russian R/Vs in the region 40.5-44.5 N, 145-152 E in August - September of 1994-1999. According to the data the highest intensity of Oyashio Current was observed in 1995-1996. The Subarctic water (SA) and Oyashio water occupied the largest area of the region. The Subtropic Transformed water (STT) located in the southwestern part of the region on a small area southward of SA water. The SA water occupied the largest area in 1997 in the central part of the region between Oyashio water on North and STT water on South. In 1998-1999 STT and Subtropic (1999) waters occupied the largest area of the region. The SA and Oyashio waters were observed on small area in central and northeastern parts of the region northward of the STT water. The highest occurrence of *Todarodes pacificus* was registered in 1995-1997. The highest catches were observed near Oyashio Front in 1996-1997. In 1998-1999 *Todarodes pacificus* were met very seldom in the south Kuril Islands region. The highest catches and occurrence of *Onychoteuthis borealijaponicus* were observed in Oyashio water in 1995-1996. In 1998-1999 catches were low. The highest occurrence of *Ommastrephes bartrami* was observed in the years with the largest area of STT water. The highest catches of *Ommastrephes bartrami* were registered near Northern Subarctic Front (Novikov, Slobodskoy, Nakamura, 2000).

10AM2001 S3-025 invited

MIGRATION PATTERNS AND FORAGE HABITATS OF JUVENILE LOGGERHEAD AND OLIVE RIDLEY TURTLES IN THE CENTRAL NORTH PACIFIC

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Juvenile loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles undergo foraging migrations in the central North Pacific. Satellite telemetry from these turtles after capture and release from longline fishing gear provides information on their migration pathways and in a few instances their dive patterns. These data together with satellite remote sensing altimetry and ocean color data are used to describe the migration pathways and oceanic habitat used by these turtles. The results indicate that loggerheads tend to forage in association with fronts, eddies, and geostrophic currents. In particular, the Transition Zone Chlorophyll Front and the Kuroshio Current Extension appear to be important forage and migration habitats for loggerheads. Their dive depth is usually less than 100m and less than an hour in duration although this can vary with the specific type of habitat being used. Olive ridleys do not appear to use oceanic surface features to the same extent but rather take advantage of the ocean's vertical structure and forage subsurface at the chlorophyll maximum or the deep scattering layer. Hence they tend to dive in excess of 150m and often more than an hour in duration. Implications of these behaviors on interactions with longline fishing gear and management measures to reduce incidental takes of these species are discussed.

10AM2001 S3-174 oral

DYNAMIC GEOGRAPHY OF SMALL PELAGIC FISH POPULATIONS IN THE CALIFORNIA CURRENT SYSTEM ON SEASONAL AND INTERANNUAL SCALES

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Using live-bait monthly records for northern anchovy (*Engraulis mordax*) and California sardine (*Sardinops caeruleus*) caught by tuna bait-boats off California (Cal) and Baja California (BCal), their seasonal geographical

dynamics and interannual variability (1980-1997) were analyzed as related to environmental variability.

Given the high sensitivity of small pelagic fishes to ocean-climate variability, their distribution patterns permit recognizing the role of oceanic fronts as the processes in the California Current System determining the aggregation and forage habitats of young pelagic fishes, with a relevant influence on their recruitment.

The central anchovy population appears to relate to a geographically fixed front, while the southern one is seemingly influenced by a dynamic front, where the equator ward California Current (CCal) and the North Equatorial Current converge along the southern part of BCal peninsula. During ENSO conditions warmer water masses weaken oceanic fronts, and those regions where bathymetric or coastal features favours upwelling becoming important refuge areas.

Sardine population seems to relate to the front where the 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 favorable feeding conditions for young sardines. Interannual variations in seasonal patterns of sardines 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 progressive interannual increase of northward CcC advection following the 1976-1977 regime shift, while CCal southward advection weakened.

10AM2001 S3-029 invited

MIGRATIONS OF FISH, MAMMALS AND SEABIRDS IN THE NORTHWEST ATLANTIC: MAKING LARGE ECOSYSTEMS WORK

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The northwest Atlantic large marine ecosystem (LME) displays physical properties determined by atmospheric pressure (NAO) and current (Gulf Stream, Labrador, Irminger) driven dynamics, mediated by the bathymetry and landmasses of the northern Western Hemisphere. This LME is characterized by heterogeneity in ocean densities and temperatures, pumps of nutrient-rich waters to surface, and high primary productivity, especially in photic zones of the expansive continental shelves. The northwest Atlantic can be modeled as an overlapping system of nested and inter-related components. Physical forcing operates over the full LME, and at local scales. Biological processes also function over the full northwest Atlantic (equator to polar regions at scales of 1000s of km), and locally (kms). Distribution-migration scale is generally related to individual size or speed. Large-scale migrators such as cetaceans, whale sharks, leatherback turtles, tunas and arctic terns are either large or fast, reducing risks of long migrations. Local producers (plankton to forage fish) are smaller and more sedentary. The hypothesis is advanced that diversity in ecosystem component scales amplifies LME productivity, both among and within physical processes, biological functions and species. A system lacking scaled components does not "work" as well. The harp seal - Atlantic cod - capelin linkage is used to illustrate the importance of scaled migrations to LME productivity.

10AM2001 S3-234 oral

PACIFIC POMFRET (*Brama japonica*) MIGRATIONS: ONTHOGENETIC AND REGIONAL CHANGES

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The Pacific pomfret is one of the most abundance predators in the North Pacific Transition Zone. We suggest that total biomass of the pomfret reaches about 4-5 millions tons. The general direction of the pomfret migration is close to Subarctic water circulation. The larva and juveniles move eastward with Kuroshio Extension and North Pacific Current. The 2-year-old pomfrets enter in Subarctic water of Alaskan Gyre for feeding in summer. The pomfrets return in North Pacific Current water in fall. Thus, North Eastern part of the Subtropical Gyre is a spawning area basically for the 2-year-old pomfrets. Most part of the 3-year-old pomfrets feed in the Subarctic waters between Alaskan and Western Subarctic Gyres in summer. Fish of this age mainly spawn in the Kuroshio Extension and western part of the North Pacific Current waters in winter. The oldest pomfrets (4-year-old and

more) concentrate in North Western Pacific Ocean. Spawning areas of the oldest pomfrets are Kuroshio Current and adjacent Subtropical waters. These pomfrets migrate for feeding in the Western Subarctic Gyre waters.

Thus, adult pomfrets migrate in general in the westward direction whereas juveniles passively move with North Pacific Drift waters. It is a reason of the some spatial isolation of the pomfret different age groups. The east-west and south-north age increasing of the pomfret coincides with the changes of the dominant epipelagic nekton species mean size in the different parts of North Pacific Ocean. In the feeding of the adult pomfrets, these species are most abundant components.

10AM2001 S3-305 poster

ASPECTS OF SPATIAL DISTRIBUTION OF SABLEFISH

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This work represents an exploratory effort to investigate some of the possible spatial attributes of sablefish population distribution. Data from the National Marine Fisheries Service Triennial Shelf Survey was used to investigate spatial aspects of primarily young (ages 2-4) sablefish. Some of the basic questions that are intended to be answered are: where are the sablefish caught; is their distribution uniform, aggregated, or random; are they always in the same location year after year; is there any obvious relation between the location sablefish are catch and temperature and/or areas of upwelling? Data from the National Marine Fisheries Slope Survey was used to investigate spatial aspects of the full age distribution of sablefish. Biological studies have shown that sablefish are slow growing, long lived demersal fish different life phases. Juvenile sablefish live near shore, whereas the adults primarily inhabit the outer coastal waters of the upper continental slope at depths greater than 200 meters. An attempt was made to map the full age distribution of sablefish (ages 1-50+) in order to better describe it as a function of depth and latitude. Sablefish age clearly increases with depth and this relationship does not seem to change over latitude. Fishermen moved from inshore fishing grounds in the mid 1970 to the grounds further offshore that they began to exploit an older portion of the stock. It is quite possible that this pattern of exploitation did more to account for the sustained harvest levels at the time then the actual production of the stock.

10AM2001 S3-110 oral

THE DISTRIBUTION AND MIGRATION OF PACIFIC POMFRET, *Brama japonica*, IN THE NORTH PACIFIC

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The Pacific pomfret, *Brama japonica*, is one of the most widely distributed and abundant nektonic animals inhabiting the epipelagic waters of the North Pacific Ocean. Found across the ocean basin from about 25°N latitude to the south to waters north of 50°N latitude, this keystone species has been long believed to undergo extensive seasonal, horizontal migrations from summer feeding grounds in the northern Transitional-Subarctic waters to spawning grounds in the south Transition Zone-Subtropics during winter-spring.

A new synoptic assessment of catch data from research and commercial driftnet fishing efforts, concurrent oceanography, research plankton survey results, and fundamental life history information revisits and redefines the distribution and migration patterns for Pacific pomfret. Specifically, datasets from driftnet fishing surveys targeting pomfret through the Transition Zone conducted by the Japan Marine Fishery Resources Research Center (JAMARC) during 1978-83, the research driftnet time series maintained by Hokkaido University during 1981-1996 along the 155°E, 170°E and 175°E medians, and the multinational observer monitored commercial high-

seas driftnet fishing efforts of Japan, Korea, and Taiwan are analyzed for spatial and seasonal catch patterns of pomfret with respect to the prevailing oceanographic environment particularly during the summer-fall for the waters of the Transition Zone northward to the Subarctic Pacific. For insight into the distribution patterns and ecology of Pacific pomfret during their winter occupation of subtropical waters, information were gleaned from catch and effort data from Japan Fisheries Agency (FAJ) research surveys and commercial Japanese fishing efforts employing large mesh driftnets targeting billfishes and tunas during winters 1990 and 1991, results from associated biological sampling conducted on these surveys, and collections of larvae and juvenile pomfret in plankton tows and midwater micronekton trawls during the winter-spring in the subtropics. Patterns of distribution, abundance, and movement emerging from the assessment are discussed within the context of the prevailing physical environment and large scale frontal systems, feeding, and life history considerations.

10AM2001 S3-233 poster

THE BASIC STRUCTURE AND OPERATION METHOD OF THE MID-WATER TRAWL FOR QUANTITATIVE COLLECTION OF TYPICAL SURFACE PELAGIC FISH, PACIFIC SAURY (*Cololabis saira*)

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To improve structures and operational methods of a mid-water trawl for quantitatively collecting Pacific saury (*Cololabis saira*), we carried out the experimental operations of two types of the mid-water trawls (SM-trawl: 4 panels and KM-trawl: 6 panels) and the multi-mesh size driftnets (M-driftnets). SM-trawl was effective for collecting saury when the length of the trawl warp was shortened to 200m from the standard (300m). The KM-trawl was not effective at any length of the trawl warp. M-driftnets were effective throughout all the experimental operations. Structural analysis of these comparisons showed the essential conditions for construction of the mid-water trawl for collecting saury are the followings. (1) The maximum width of the upper panel of the trawl should be more than 330% of the maximum width of the hull of the trawler. 2) The whole head-rope including both the wingtip should be surfaced completely. Moreover, we also clarified that the depth of schools of saury considerably affected the fishing efficiency of SM-trawl and M-driftnets.

10AM2001 S3-342 poster

INTERANNUAL AND LONG-TERM DYNAMICS OF EPIPELAGIC FISH COMMUNITIES IN THE SOUTHERN OKHOTSK SEA IN CONNECTION WITH MIGRATIONS OF COMMON NEKTON SPECIES

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Peculiarities of the structure, distribution and dynamics of nekton communities in the southern Okhotsk Sea are defined by heterogeneity and high variability of epipelagic environment. The essential changes in structure of epipelagic fish communities in the Okhotsk Sea in summer were revealed by data collected in ecosystem surveys carried out by r/v of TINRO-Centre in the south Okhotsk Sea in 1991-2000. These changes are caused by a large reorganizations in ecosystems of the Far Eastern Seas resulted from the change of climate-oceanological conditions. At the beginning of 1990s pollock abundance considerably decreased in the southern part of the Okhotsk Sea and migrations of the Japanese sardine ended.

Table
Biomass (th. t) of common nekton species in upper epipelagic layers of a southern part of the Okhotsk Sea in summer 1991-2000

	1991 July-August	1992 July-August	1993 July-August	1994 July-August	1995 July-August	1996 July-August	1997 August	1998 August	1999 August	2000 August
O. gorbuscha	163.3	55.4	59.6	122.3	198.28	96.6	21.2	34.1	15.2	50.64
O. keta	14.3	5.9	12.9	47.6	17.25	51.1	33.8	64	13.87	30.66
Other salmons	4.6	1.66	2.26	2.58	1.39	3.12	4	1.35	1.09	1.44
Salmons	**182.2**	**62.7**	**74.8**	**172.5**	**216.92**	**150.8**	**59**	**99.5**	**30.2**	**82.74**
Clupea pallasi	+	1.14	15.1	-	64.46	2.99	+	-	+	-
Sardinops melanostictus	307.7	-	-	-	0.3	-	+	+	+	+
Leuroglossus schmidti	29.4	117.3	359.6	123.3	181.83	14.2	26.7	181.3	27.4	165.7
Theragra chalcogramma	145.6	40.2	21.4	0.33	3.44	+	+	+	+	0.98
Cololabis saira		-	-	-	-	1.2	3.1	0.19	43.1	+
Engraulis japonicus	6.8	+	0.1	+	56.96	+	0.3	100.8	407.4	14.6
Pleurogrammus azonus	+	41.6	6.9	1.02	33.82	42.9	302	2.56	366.5	7
Lamna ditropis	14.7	+	2.1	5.2	12.6	+	7.1	-	5.97	5.97
Others	9.4	36.4	23.8	11.7	14.42	7.6	4.6	12.44	4.23	7.43
Fishes in total	**695.7**	**299.8**	**503.8**	**314.14**	**584.75**	**219.7**	**402.8**	**396.8**	**885.2**	**284.5**
Squids	44	25.9	80.08	28.77	55.65	50.3	5.6	17	4.6	23.99
Nekton	**739.7**	**325.7**	**586.3**	**348.48**	**641.04**	**270**	**408.4**	**413.8**	**889.8**	**308.47**
Observed area, th. km^2	446	430.7	466	465.4	498	439.5	154	170	304.5	292.6

The recent increase of abundance of Japanese anchovy, arabesque greenling and salmon can be considered as partial compensation of decrease in pollock and sardine abundance. The observed interannual changes of abundance of these species can be determined by alternation of high- and low abundant generations (for arabesque greenling) and various scales of subtropical species migration in the waters of the Okhotsk Sea (for Japanese anchovy, saury). The intensity of northern migrations of these fishes depends both on their abundance, and concrete hydrological and hydrobiological conditions developing in this area in different years.

The observed interannual changes of smoothtongue abundance in upper epipelagic layers are determined mainly by vertical migration intensity from mesopelagic to surface layer in connection with dynamics of hydrological and hydrobiological conditions.

10AM2001 S3-036 invited

MIGRATION OF ANGULLID EELS IN THE OCEAN

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Fish migration is typically defined as a regular habitat transition between a spawning area and the growth habitat of a species. Migration of the catadromous eels *Anguilla* is unique because they only use a small area of marine habitat as a spawning site, in spite of their ancestral marine origin, whereas anadromous salmon use a vast range of marine habitat as growth habitat, and oceanodromous pelagic marine fishes spawn anywhere environmental conditions fit their reproductive behavior. Precise examination of the distribution of small leptocephali in relation to current direction suggest that the Japanese eel spawns at a few specific seamounts of the West Mariana Ridge (Seamount Hypothesis). A localized spawning site for finding other males and females is essential for eels that presumably arrive at the spawning site individually. Seamounts would serve as a landmark, because the geomagnetic/geopotential anomaly of the chain of seamounts in the West Mariana Ridge could be an orientation

reference for migrating silver eels. Temperate eels have large migration routes (Migration Loop) of thousands of kilometers between spawning areas and growth habitats. Every eel species/population has its own migration loop and a spatial and temporal shift of these migration loops could drive speciation and separation into subpopulations. A recent molecular phylogenetic study of *Anguilla* has suggested that the endemic tropical eel, *A. borneensis*, is the most ancestral species, which should have a short migration loop. The great migrations of temperate eels probably evolved from local migrations of tropical eels as a result of long-distance dispersal of leptocephali from spawning sites in tropical waters to temperate growth habitats.

10AM2001 S3-037 invited

DYNAMIC PROCESSES IN THE FISH COMMUNITY OF THE KUROSHIO CURRENT REGION

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The most part of the Kuroshio fish community pelagic fishes are active migrants. Some nekton and fishes migrate within areas which extend or reduce depending on their abundance and hydrological conditions. Seasonal migration is one of the essential stages of the pelagic fishes life. This migration is a complex of evolutionary and genetically formed behavioral reactions. This complex providing the periodical expansion of area ranges is specific. Migrant can use different parts of area for optimal existence on different life stages. The period from one (the migration) to some months (wintering, spawning) is a characteristic time for populations of pelagic fishes. Thus, the spatial expansion depends on the annual period of life cycle. In the period of northern (feeding) and southern migrations, the area is located from 100 to 1000 km, in the period of spawning and wintering – from 10 to 100 km. The expansion of population seasonal migrations is determined by distance of main fish aggregation annual transportation. Consequently considering the region of species distribution it is necessary to point out the general habitat which is limited by extreme peaks of fish occurrence and the main area, limited by the main portion population distribution. Adaptive qualities of annual migrations of mass plankton-eating fishes exhibit in reproduction within the Kuroshio current zone and feeding within more productive subtropical waters. Thus, they are subtropic by origin. In ontogeny, the influence of environmental conditions changes. Specifically it pointed out that during winter and spring, spawning stock of saury, sardine and also mackerel, horse-mackerel populations prefer waters of higher temperature than during period of feeding (summer and autumn). Obviously the seasonal change of habitats and environmental conditions is connected with changes of saury, sardine, mackerel and anchovy needs in the spawning and feeding periods. Analogically needs of another migrants in the subarctic front change that explains the isolation of spawning and feeding areas.

10AM2001 S3-052 oral

"POST" THE CENSUS OF MARINE LIFE INITIATIVE TO DEVELOP A PACIFIC OCEAN SALMON TRACKING PROGRAM

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There is growing evidence that all species of Pacific salmon have sharply defined migration behaviours in the sea, and that salmon may shuttle between two "postal codes"– their well-defined spawning grounds, and what may be equally well-defined ocean feeding grounds. In this talk, we will review some of the evidence for such behaviours, and describe recent efforts to develop systems that will allow us to track salmon over vast distances in the sea. Vessel surveys demonstrate that juvenile salmon remain confined to the continental shelf, moving north and west at least as far as the Aleutians before entering the open waters of the North Pacific. As a result, acoustic methods can be used to track salmon along the shelf. Acoustic tags are sufficiently small to be placed on 15 cm or larger animals, and an acoustic array placed on the continental shelf should allow tracking individual animals over many months at sea. Because the shelf off the West Coast of North America is very narrow (<20 km in many places), it should be possible to monitor the movements of individual salmon along the entire 5,000

km shelf at relatively low cost. Offshore, the use of archival tags will allow detailed reconstructions of the migration pathways and depths which larger salmon use in their open-ocean wanderings as well as demonstrate whether their foraging grounds are spatially fixed or move with changing environmental conditions. Although salmon will provide the initial focus, the concepts and technologies should be readily transferable to other species, and the array in particular could be used to track a wide variety of other animals that use the shelf as a migration corridor.

To date, the oceans have remained opaque, preventing detailed study of the migrations of most marine animals except for those few large air-breathing species (mammals, turtles) that break the surface long enough for satellites to fix their position. The prospect of relatively low-cost systems that should be able to track continuously submerged animals over months or years at sea should, if successful, open up the oceans for study in a way analogous to the use of large arrays of radio telescopes used in astronomy. The use of archival tags in the offshore and the coastal array POTENT (Pacific Ocean Tracking And Evaluation NeTwork) on the continental shelf is being evaluated by the Sloan Foundation's Census of Marine Life. We will discuss the goals of "POST", the design of POTENT, and the Census' approaches to tracking salmon in both the offshore and coastal phases of their life history.

10AM2001 S3-303 poster

HABITAT HETEROGENEITY AFFECTS WALLEYE POLLOCK TROPHODYNAMICS: COMPARATIVE ANALYSIS USING AN AGE-STRUCTURED MODEL IN THE EASTERN BERING SEA AND OYASHIO AREA

Orio Yamamura[1,2], Pat Livingston[1] and Jeff Napp[1]

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In marine ecosystems, spatial overlap and size relationship are crucial factors determining predator-prey relationships. Recently, Yamamura et al. (in press) presented the difference in seasonality of walleye pollock cannibalism between the Oyashio and Eastern Bering Sea areas, and they ascribed it to different thermal regimes. To quantitatively estimate the influence of cannibalism in population dynamics, a dynamic model accounting for age structure, ontogenetic spatial overlap and availability of alternative prey is needed. In the present study, we constructed a 3-box age-structured trophodynamic model taking these factors into account, and analyzed factors affecting population dynamics of walleye pollock.

The model included: 1) year classes of pollock, prey such as 2) copepods, 3) euphausiids and 4) micronekton, 5) generic predator and 6) fisheries as major components. Major processes considered were: 1) pollock population dynamics 2) bottom-up control of pollock growth 3) diurnal, seasonal and ontogenetic pollock migration 4) temperature-dependence of bioenergetics 5) size-dependent prey vulnerability and 6) prey production and advection.

In the model, differences in seasonality of cannibalism and pollock growth have been well simulated. Factors differentiating population dynamics and growth of walleye pollock will be discussed.

10AM2001 S3-059 poster

REPRODUCTIVE CYCLE, SPAWNING FREQUENCY AND SPAWNING GROUNDS OF THE JOHN DORY, *Zeus faber*, IN THE EAST CHINA SEA

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Annual reproductive cycle, sexual maturity, spawning frequency, and spawning grounds of the john dory, *Zeus faber*, were examined in specimens collected from the East China Sea between April 1999 and March 2001. Females with mature stage ovaries were collected between November and June; the mean gonadosomatic indices (GSI) were greatest between February and April. The total length (TL) and age at 50% sexual maturity for females were 324 mm and 4.5 years old, respectively. Although seasonal cycles in testicular maturation and the GSI of males were less clear, detailed histological examinations indicated that most males participating in spawning were larger than 300 mm TL, which corresponds to older than 6 years. In the mature stage ovary, both hydrated oocytes and postovulatory follicles at different stages of degeneration were found, suggesting that this species is a multiple spawner. Time course sampling showed that ovulation occurred throughout the day. Spawning frequency determined from the percentage of females with ovulated oocytes was 84%; this means that the average interval between spawnings was 1.2 days. During the spawning season, adults of both sexes were widely distributed from north to south, at depths between 100 and 160 m, where bottom temperatures ranged from 16 to 20°C. More adult fish were found in northern waters. These observations indicate that the main spawning grounds of this species are the waters of the northern East China Sea.

S4 POC Topic Session
Coastal ocean physical processes responsible for biological productivity and biological resource distribution

Convenors: Susan E. Allen (Canada) and Yuri I. Zuenko (Russia)
Thursday, October 11, 2001 08:30-12:30

Of the many physical processes occurring in the coastal ocean some have disproportionately strong effects on biological processes. This session invites papers that present new results on coastal physical processes that determine: (1) nutrient concentrations in the euphotic zone, (2) spatiotemporal variability in water stability and mixing layer depth, (3) retention, advection, aggregation or dispersal of plankton, fish and other marine organisms or (4) regulation of predator-prey interactions. Interdisciplinary papers are encouraged but purely physical papers with clear biological applications are also sought.

Invited speakers:

A. Edward Hill (Proudman Oceanography Laboratory, UK) - Baroclinic processes on continental shelves: cold pool systems and their impacts on shelf biology

Tetsuo Yanagi (Research Institute of Applied Mechanics of Kyushu University, Japan) - Mixing processes along the shelf edge

10AM2001 S4-370 oral

SEABIRD RESPONSE TO OCEAN STRUCTURE DURING UPWELLING AND DOWNWELLING EVENTS OFF THE OREGON-CALIFORNIA COAST: A GLOBEC STUDY

David G. Ainley[1], Larry B. Spear[1], Cynthia T. Tynan[2] and Jack Barth[3]

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We investigated seabird distribution with respect to ocean features in the coastal region of the California Current off southern Oregon and northern California during two cruises in summer 2000. During June, ocean processes fluctuated between early-season upwelling to full-fledged down-welling events; during late July, upwelling was in full swing, with well-developed fronts and eddies. Seabird occurrence patterns were highly structured with respect to the coastal upwelling front, with species sorted sequentially from the coast outward, piscivores on the inside of the front, planktivores on the outside. Structure was not related to bottom depth and diving capabilities of the seabirds (deepest divers occurred in shallowest waters). Structure was maintained during short-term down-welling events, which scrambled the upwelling front. We will discuss these patterns further with respect to continuous, underway data acquired on physical and biological variables using SeaSoar and multiple-frequency acoustic systems.

10AM2001 S4-237 oral

VARIATIONS IN BIOLOGICAL CARBON AND NITROGEN UPTAKE DURING COASTAL UP- AND DOWNWELLING

Debby Ianson[1], Susan E. Allen[1], K. Orians[1], S. Harris[1], D. Varela[1] and C.S. Wong[2]

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Biological uptake of inorganic carbon (TCO_2) and nitrate (NO_3) were investigated during July, 1998 off the southwestern coast of Vancouver Island, Canada (48.5°N, 126°W). Local wind and current data were used to identify physical circulation regimes. Data were collected during an intense period of summer downwelling, a relaxation period and immediately following upwelling. TCO_2 and NO_3 uptake were contrasted within the inner shelf buoyancy current, and for each wind regime over the mid-shelf and slope. Spatial regions were identified using temperature and salinity data. We show that TCO_2 uptake increases relative to NO_3 uptake during downwelling, while the TCO_2:NO_3 uptake ratio is close to 6.7 (Redfield) following upwelling. These data suggest that when NO_3 becomes limiting, phytoplankton still process TCO_2 in response to light stimulation. As measured ratios of particulate carbon to particulate nitrogen do not change with wind regime, we propose that the excess TCO_2 uptake is excreted in the form of dissolved organic carbon. The inner shelf buoyancy current is rich in NO_3 and biologically productive throughout the study, however no pattern in TCO_2:NO_3 uptake is observable, rather TCO_2 is always high regardless of NO_3 concentration. This lack of correlation and high TCO_2 concentrations is discussed relative to the intense mixing that occurs at the source of the buoyancy current.

10AM2001 S4-369 poster

SCALES AND FACTORS OF SPATIAL AND TEMPORAL VARIABILITY OF THE BIOGEOCHEMICAL BARRIER CHARACTERISTICS IN MARINE PART OF THE YANGTZE RIVER ESTUARY IN THE EAST CHINA SEA

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To assess scales of spatial - temporal changeability of parameters of biogeochemical barrier in marine part of the Yangtze River estuary in the East China Sea the following observations were carried out:

a) Polygon surveys during period of the beginning and stationary action of the winter monsoon at maximum discharge of river waters (October 1988 and December 1989);
b) transects in longitude and latitude directions in summer (July 1987);
c) diurnal stations in winter and summer periods.

Synchronous registration of following parameters of water column was fulfilled at each station:
- temperature, salinity, velocity and direction of currents;
- components of carbonate system, content of dissolved and particulate organic carbon;
- the values of the biomass of phyto - zooplankton and primary production.

On the basis of the results of the analysis of obtained hydrophysical data, the conclusion is that thermohaline structure of water masses of frontal zone in winter is regulated by a wind influence on the transport of cold brackish waters of the Yellow Sea and by an interaction between estuarine waters and waters of the warm Taiwan current.

Spatial - temporal variability of hydrochemical regime in estuarine waters is controlled by the temperature gradients and ratio between photosynthesis and destruction processes. The biomass of the plankton and lithodynamic processes are basic factors regulating the spatial and temporal variability of chemical composition of particulate matter of this estuary.

Obtained data were used to assess carbon fluxes between atmosphere, water column and bottom sediments in this estuarine system.

10AM2001 S4-229 poster

SPATIAL AND TEMPORAL DISTRIBUTIONS OF MESOZOOPLANKTON IN IDEALIZED MODELS OF COASTAL UPWELLING ECOSYSTEMS

Harold P. **Batchelder**[1], Christopher A. Edwards[2], Craig V. Lewis[3], Thomas M. Powell[3] and Dale Haidvogel[4]

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As part of a U.S. GLOBEC funded effort in the Northeast Pacific, we have been developing coupled biophysical models that link 1) physical circulation, 2) lower trophic level ecosystems, and 3) higher trophic levels, in wind-driven upwelling systems. Here, we present results of some two and three dimensional simulations that use idealized coastal geometry and bathymetry, simple physical forcing, and relatively well understood lower trophic (NPZD) ecosystem models. We model the spatial and temporal distributions of higher trophic levels using individual based models (IBMs) in order to account for physiological and behavioral effects that cannot be easily modeled in the more traditional Eulerian framework. These idealized simulations are a crucial first step toward achieving more realistic simulations with fully coupled biophysical models using observed spatially and temporally varying forcing (wind, surface fluxes) and realistic coastal geometry and bathymetry.

10AM2001 S4-296 poster

A CLIMATE-DRIVEN PHYSICAL MECHANISM FOR PLANKTON DECLINE IN THE CALIFORNIA CURRENT

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A 25-year warming trend in the southern California Current System has resulted in a substantial deepening of the thermocline and increase in stratification of the upper water column, leading to a reduction in the vertical transport of inorganic nutrients into the euphotic zone and a subsequent decline in zooplankton biomass of nearly 70%. The reduction in vertical nutrient transport has occurred even though there has not been a significant trend

in local wind-driven coastal upwelling or equatorward advection, which could affect vertical transport through geostrophic adjustment processes. This suggests that large-scale near-surface warming, whether associated with a transient climate regime shift or global warming, is a large contributor to variability in West Coast pelagic ecosystems. The biological recovery of the system following the decay of the strong El Niño event of 1997-98 could signal a transition to a temporarily cooler, more biologically productive regime in the California Current.

10AM2001 S4-086 oral

ENVIRONMENTAL FACTORS AFFECTING FORAGE FISH DISTRIBUTION AND THEIR AVAILABILITY AS PREY FOR SEA BIRDS

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The main objective of this analysis was to identify and model factors affecting the availability of surface schooling pelagic fish as prey for seabirds. Fish abundance and distribution affect availability and therefore both types of information were required. This study focused on the juvenile stages of Pacific herring (*Clupea pallasi*) and Pacific sand lance (*Ammodytes hexapterus*), however information on capelin (*Mallotus villosus*) and eulachon (*Thaleichthys pacificus*) was also included. All four species exhibit extreme variability in vertical and offshore/onshore distribution as a function of life stage and season. Acoustic methods were limited when fish were in very shallow water and aerial methods were limited by distribution below the visual range. Therefore, both types of data were collected and combined. Aerial data provide good spatial coverage for measures of horizontal distribution. Acoustic data was used to provide a sub-surface correction factor for aerial data and a measure of variability in vertical distribution. Net captures were used to validate and interpret data from both methods. Oceanographic factors played a major role in forcing horizontal and vertical distribution of forage fish. A two-stage generalized additive modeling approach was used in a geospatial context to identify factors key in forcing horizontal distribution (first stage), then factors key in forcing vertical distribution. Topographic features such as bays, shallow shelves, and locations with eddy mixing were important factors in determining horizontal distribution. Zooplankton abundance and upper surface water temperatures were key in forcing vertical distribution. The results are presented here.

10AM2001 S4-005 oral

MONSOON AND TYPHOON RAINS ALSO NURTURE OCEANIC PRODUCTIVITY

Chen-Tung Arthur **Chen**[1], A. Snidvongs[2], N. Saadon[3] and T.M. Tengku Rozaina[4]

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A large area ranging from northeast Africa and India to east Asia and north Australia is influenced by both monsoons and typhoons. Many aspects of the oceanic environment of the north Indian Ocean, the East and South China Seas, and the many seas of Southeast Asia, are affected by monsoons and typhoons/hurricanes. Rains accompanying southwest monsoons and typhoons, although sometimes raising havoc on many coastal areas, are most welcome by farmers as the rains nurture the frequently parched land at the end of the dry, northeast monsoon season. In addition, these rains nourish the coastal oceans as well.

It is well known that the southwest monsoon induces upwelling off the eastern coast of a land mass such as that off Somalia, the Arabian Peninsula and Viet Nam. Off the western coast, however, the southwest monsoon, in fact, induces downwelling. It is shown, nevertheless, that the increased buoyancy effect due to a larger runoff in the wet season does enhance upwelling off Sarawak, Sabah and Brunei Darussalam, despite the unfavorable wind conditions. As a result, the nutrient concentration increases but pCO_2 decreases, presumably due to higher primary productivity. In addition, upwelling and higher primary productivity were observed off northern Taiwan after a typhoon passed, perhaps also due to the enhanced buoyancy effect.

10AM2001 S4-055 poster

TROPHIC CONDITIONS IN THE MOUTH OF THE SEA OF CORTES, DURING SUMMER

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During the Pato II cruise to the mouth of the Sea of Cortes (México), samples of particulate matter and zooplankton were taken, following four transects across the main hydrographic water masses. Samples of Particulate Organic Matter (POM) were taken at three depths, following light attenuation (1, 10 and 100%). At the same stations samples of zooplankton were taken with oblique tows of a bongo net from 200 to 0 m. The area has a complex hydrographic structure, cool waters from the California Current mix with rich water from the Sea of Cortes and with poorer and warm tropical waters arriving from the south. According to their T-S diagrams, three water masses were separated: North, south and east. Particulate proteins and particulate carbohydrates were obtained as well as POM (proteins+carbohydrates = POM). Significant differences were found for protein and POM at the 1% light attenuation depth ($H=9.24$, $P=0.009$ and $H=6.09$, $P=0.0476$). For zooplankton biomass, there is a significant difference among the three sectors ($H=17$, $P=0.0002$). By multiple correlation analysis, we found a significant correlation between zooplankton biomass and POM at the three depths, for the north ($R=0.845$, $n=9$) and east ($R=0.788$, $n=8$) sectors, but no-correlation was found for the hydrographically more complex southern sector ($R=0.196$, $n=16$). In general higher zooplankton biomasses were found near Cabo San Lucas, in a frontal area, coincident with higher particulate matter concentrations.

10AM2001 S4-013 invited

BAROCLINIC PROCESSES ON CONTINENTAL SHELVES: COLD POOL SYSTEMS AND THEIR IMPACTS ON SHELF BIOLOGY

A.E. **Hill**[1], J. Brown[2], K.J. Horsburgh[3], L. Carillo [1,3] and L. Fernand[2]

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In the spring and summer months, tidally energetic continental shelves usually comprise a patchwork of tidally well-mixed and thermally stratified regions, separated by tidal mixing fronts. Over the past 5 years the important role of the strong horizontal density gradients at the base of tidal mixing fronts (bottom fronts) has become increasingly clear. Bottom fronts appear to drive organized, intense, jet-like flows near the surface which are expected to be generic features of similar shelf systems world-wide. Results from several measurement campaigns on the European shelf which demonstrate the existence of these jets are presented and some of the direct impacts on the biology of shelf systems are reviewed. The challenges of adequately representing these systems in shelf simulation models is briefly considered along with the wider implications of the coupling between biology and baroclinic (density-driven) processes on continental shelves under changing climate regimes.

10AM2001 S4-267 oral

USE OF A BIOPHYSICAL NPZ MODEL TO INVESTIGATE THE EFFECT OF ALONGSHORE VS. CROSS-SHELF TRANSPORT IN THE COASTAL GULF OF ALASKA ON QUALITY OF HABITAT FOR MIGRATING JUVENILE SALMON

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The coastal Gulf of Alaska (CGOA) is an extremely productive region which is an important habitat for migrating juvenile salmon. It is not clear why this area is so productive, especially as it is, for the most part, a downwelling system. The origin of the nutrients which fuel this productivity is an open question, as are the roles of alongshore vs. cross-shelf transport. We have used a 10-compartment Nutrient-Phytoplankton-Zooplankton (NPZ) model developed for the CGOA under the auspices of the GLOBEC NEP Program to investigate these questions. In our model experiments, the NPZ model is implemented on a 3-D grid representing an idealized, alongshore segment of the continental shelf within the CGOA. Offshore NPZ boundary conditions are derived

from a biological model appropriate to the deep North Pacific. Velocity is specified with a few parameters that control amplitude (upwelling vs. downwelling) and seasonal variation. A Monte Carlo optimization procedure is then used to understand what combination of cross-shelf vs. alongshore transport (with seasonal variation) (1) maximizes the amount of food available for juvenile salmon migrating through the region, and (2) produces model output which best matches data collected by the GLOBEC NEP program along the Seward (GAK1) line. We compare the resulting flow fields with each other, and with actual flow fields measured at the Seward line, to explore possible sources of nutrients to this coastal system.

10AM2001 S4-094 poster

LONG-TERM TRENDS IN CARBON FLUX IN THE PERUVIAN UPWELLING SYSTEM AND ITS EFFECT ON GUANO-PRODUCING SEABIRDS

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The long-term time-series on abundance of guano-producing seabirds off Peru shows two opposite trends during the last century. First, there was a major population increase from 1925 to 1955 that has been attributed to seabird recovery from uncontrolled exploitation of guano. Later seabirds underwent a severe decline from 1955 to 1965, from which the birds never recovered that has been attributed to the industrial fishery for anchovies, the main prey of these seabirds, which became the largest fishery in the world in the 1960s. We hypothesized that fluctuations in the guano-producing seabird population of Peru were indirect responses to changes in the primary and secondary production of the upwelling system. To test this idea, we modeled nitrate input to the upper layers through upwelling by using data on wind stress and sea surface temperature. We used this model to predict the amount of carbon fixed by primary production between 6°S-14°S, which was then apportioned to anchovy biomass and ultimately to the seabird population. The model explains 72% of the variation in seabird abundance from 1925 to 2000. Model results suggest that seabird population growth from 1925 to 1955 was likely a response to increased productivity of the Peruvian upwelling system and not an effect of seabird management. The decrease in numbers of guano-producing seabirds during the 1960s, and low population levels later on, may have been due to competition for food with the fishery that removes 85% of the prey otherwise available to seabirds.

10AM2001 S4-077 poster

TSUSHIMA AND WEST-SAKHALIN CURRENTS DRIVING ROLE ON THE RED KING CRAB EARLY ONTOGENETIC STAGES IN THE SEA OF JAPAN

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Early ontogenetic stages of the (red king crab) *Paralithodes camtschaticus* population inhabiting western shelve of Sakhalin in the Sea of Japan are characterized by fertilized eggs development around 1 year, larvae hatching at 15-50 m depth range, subsequent distribution and sedimentation on the shelve. In the same time, red king crab juveniles (carapace less than 8 cm) are concentrated at 3 sites according 1986-1995 trawl surveys. Plankton stages of red king crab zoea-III, IV, glaucothoe are obtained in the same sites in 1991, 1994, 1998, 1998, 1999, 2000. Currents distribution analysis based on the 1976-1989 archive; geostrophic calculations by CTD surveys 1988-1994, 1998, 1999, 2000, 2001; ADCP measurements in April, 2001; autonomous mooring currents measurements during 1996-2000 is confirmed bi-flows system with embedded eddies at the south-western Sakhalin. West-Sakhalin and Tsushima streams interaction is developed to bi-poles crab larvae distribution linked with stable anticyclonic eddies at Delanglya Bay and at Kril'on Peninsula. Interannual variety for eddies location is noted, which is depending from Tsushima and West-Sakhalin currents intensity. Taking to account depth range of the larvae hatching we noted coincide in time with larvae releasing beginning with Tsushima seasonal gaining independently from solar radiation. Hence, in the spring currents are driving of early ontogenetic stages red king crab in the Sea of Japan, included larvae hatching and distributions consequence plankton stages. Perhaps,

analogous role currents are played in the early ontogenetic stages for different *P. camtschaticus* populations in the Sea of Japan and Sea of Okhotsk.

10AM2001 S4-098 oral

FORTNIGHT SHIFTS OF INTRUSION DEPTH OF OCEANIC WATER INTO ISE BAY AND ITS EFFECT ON THE BIOLOGICAL PRODUCTIVITY

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It is often observed in Ise Bay that the oceanic water intrudes through the intermediate layer in summer, and bottom bay water is excluded from the exchange circulation. This pattern is different from the classical estuarine circulation, in which brackish water flows out in the surface while the oceanic water flows into the bottom layer. Hydrographic observation has been repeatedly conducted since June 2000, to elucidate the transition process of the intrusion. The results show that the oceanic water always intrudes into the bay through the bottom layer in winter, following the classical estuarine circulation theory. In summer, on the other hand, the intrusion depth shifts according to the tidal range; the oceanic water intrudes into shallower layer during the spring tide than the neap. The water at the bay mouth is mixed well during the spring and its density is equivalent to that in the intermediate layer inside the bay. During the neap tide, however, the weaker tidal current insufficiently mixes the bay mouth water. The bottom water inside the bay, therefore, becomes lighter than that at the bay mouth where the water tends to stratify. This difference in density leads the shift of the intrusion depth in summer. Primary production is restricted during the period of intermediate layer intrusion because nutrients are depleted in the surface layer. Once the oceanic water intrudes into the bottom layer, the nutrient rich bottom water inside the bay is uplifted to the euphotic zone and then the primary production is temporarily enhanced.

10AM2001 S4-326 oral

BIOLOGY AND PHYSICS IN THE COASTAL OCEAN: A DECADE OF GEORGES BANK GLOBEC MODELS

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Georges Bank GLOBEC has yielded a variety of insights on the interaction between biological and physical oceanographic processes in the coastal ocean. This U.S. program supports a coordinated set of models and field observations addressing the circulation and ecosystems of this productive fishery region.

I focus on three contributions of the modeling studies: 1) shaping of the observational program; 2) increasing understanding of shelf processes; and 3) testing biological hypotheses. Simple idealized models have identified interactions between winds, tides, stratification and plankton dynamics that are likely to be of general interest throughout the coastal ocean. In contrast, a detailed regional model has been used to test hypotheses about the vital rates and life history of individual species on and around Georges Bank. This model has also yielded valuable, post-hoc insight into the actual spatial and temporal resolution of the field program. These dual ongoing modeling approaches (idealized vs. detailed) promise to yield greater scientific understanding of the coastal ocean and to guide future research in this and other regions.

10AM2001 S4-358 oral

THE VARIATIONAL TENDENCY OF THE PROPERTY OF SEAWATER IN THE CENTRAL AND SOUTHERN PARTS OF THE BOHAI SEA DURING 1960-1996 AND ITS INFLUENCE ON MARINE ECOSYSTEM

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Using the data of temperature, salinity, PO_4-P and SiO_3-Si which obtained from the sectional observation by SOA and a few marine ecosystem survey by HSFRI in the central and southern of the Bohai Sea during 1960-1996, the variational tendency of t he property of seawater and its influence on marine ecosystem were described. It shows, in the central and southern of the Bohai Sea the salinity appears to have a fluctuationly ascent, the content of P and Si have a fluctuationly decline, and the temperature in summer to have decline, and in winter to have ascent during study period. The trends of the annual mean salinity, the content of P and Si in the central and southern of the Bohai Sea were $0.04 \sim 0.14$ y^{-1}, $-0.0049 \sim 0.0087$ $\mu moll^{-1}$ y^{-1}, $-0.385 \sim -0.602$ $\mu moll^{-1}$ y^{-1}. The tendency of temperature $-0.021 \sim -0.003°C$ y^{-1} (summer half year), $0.023 \sim 0.01°C$ y^{-1} (winter half year), respectively. During 1980s, the content of P and Si in sea water appears lower value (some time near to 0 value) for a long time and large area in central and southern of the Bohai Sea, the ecosystem restricted by the content of P and Si.

As stated above variational tendency of the property of seawater may be relation to freshwater deficit to be about 1 m y^{-1} in the Bohai Sea since 1980s. Due to freshwater deficit and the higher salinity water from the Huanghai Sea entrance to the Bohai Sea and cause salinity ascent in the Bohai Sea. The decreased of the content of P and Si in seawater can be attributed to rapid reduction by decreased of the total river discharge into the Bohai Sea.

The results of marine ecosystem survey in recently proved that above mentioned the variations of the property of seawater since the 1960s had made decreasing average biomass and alternation of dominant population, thus may be to transform the distribution of feeding ground and migratory time of *Penaeus chinensis*.

10AM2001 S4-238 poster

VARIATIONS OF PHYTOPLANKTON PRODUCTIVITY CHARACTERISTICS IN THE COASTAL ZONE OF PRIMORYE, JAPAN SEA, AS A RESULT OF MESOSCALE EDDIES FORMATION

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Observations of hydrographic and hydro-biological parameters implemented by *r/v Professor Gagarinskiy* in the period October 12 - November 3, 2000 along the coast of Primorye Area, Russia are discussed to study water mass composition of southwestward flow along continental slope known as Liman or Primorye Current. NOAA AVHRR (sea surface temperature) and SeaWiFS (ocean color) satellite images collected for this period are also considered. SeaWiFS data were processed to separate Chl *a* and suspended matter distribution.

During three weeks period between first and second surveys of the cruise a structure of Primorye Current had changed resulted in formation of anticyclonic mesoscale eddies located along the slope. This was associated with strong upwelling events localized at some places along the coast, off-shore streams of coastal water and intrusions of open sea water into the shelf. Autumn cooling and convection process had started at the same time.

High concentration of Chl *a*, suspended matter and phytoplankton were observed over the shelf of Primorye and especially in the Peter the Great Bay. Because of eddies generation the well manifested tongues of coastal water transported off shore were formed. Advection of water out the bay caused significant increase of phytoplankton biomass up to 7 g/m^3. Upward flow of nutrients in coastal area resulted in grow of Chl *a* concentration at subsurface layers of 10-20 m and increase of primary production.

10AM2001 S4-245 oral

THE MEAN AND SEASONAL CIRCULATION IN A THREE DIMENSIONAL MODEL OF THE GULF OF CALIFORNIA

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A three dimensional model is used to describe the mean and seasonal circulation of the Gulf of California. The model is forced by the Pacific Ocean prescribing sea level, temperature and salinity fields at the mouth of the gulf. At the sea surface, forcing by the wind as those due to heat and freshwater fluxes are also included. The model reproduces previous calculations of heat and salt balances derived from observations as well as the sea surface temperature climatology as obtained by AVHRR imagery. It also reproduces the surface general circulation of the northern gulf which consists of basin-wide gyres: cyclonic in summer and anticyclonic in winter. It was found that both tides and heat fluxes are indispensable to reproduce the sea surface temperature spatial structure and its temporal evolution. Tides provide the mixing to introduce the cooler subsurface waters (also upwelled by the winds) found in the large islands area are, and heating from the surface to rise the temperatures. The general circulation of the southern part of the gulf is due to the wind (prescribed as an annual function) and the Pacific (prescribed as annual plus semiannual functions) forcing and produces cyclonic and anticyclonic circulation twice a year, mainly due to the Pacific action. In the northern part, on the other hand, the tides also play a role producing important mean residual currents, and both, tides and winds compete with the Pacific forcing and produces an annual variation of the circulation only. Also a very rich mesoscale structure of the currents there was found to be a product of tidal rectification.

10AM2001 S4-124 poster

THE CURIOUS ABUNDANCE OF EVIDENCE OF THE 18.6-YEAR LUNAR NODAL CYCLE IN PACIFIC AIR AND SEA SURFACE TEMPERATURES, AND ITS ASSOCIATION WITH MAJOR ENSO EVENTS

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Although, much of the pan-coastal correlation among SST anomalies at the margins of the northeast Pacific Ocean can be attributed to interannual variation in the strength and position of the Aleutian Low pressure system in winter, we provide evidence of a significant contribution to temperature associated with the 18.6-year lunar nodal cycle. All of the 6 major warm periods of the past 400 years that were identified in tree rings on the North American coast by Ware and Thomson (2000) have occurred while the lunar nodal cycle was at a minimum. SSTs at most coastal lighthouses in British Columbia and at Ocean Station Papa also co-vary at this frequency. It is not present at coastal shorestations in Washington and Oregon and north/central California shorestations but does appear at Scripps Pier in winter. The pattern is evident in the reconstructed global Pacific SST field since 1950. We note that many of the extreme positive SST anomalies of this century (1925, 1940/41, 1957/58, 1997/98) that have been generally attributed to the effects of El Niño have occurred during years when the 18.6-year cycle is at its minimum, at which time mixing by diurnal-period tidal currents is also a minimum. We have simulated 100 years of tidal currents along the West Coast of Vancouver Island, a region where diurnal-period tidal currents are relatively strong. This record reveals 18.6-year variations in mixing rates of up to ±35% and may account for some of the 18.6-year signal in temperature records there. The mechanism for an 18.6 year cycle where the diurnal-period tides are less dominant remains unclear.

10AM2001 S4-101 poster

AN INTER ANNUAL SURVEY ON INTERTIDAL MACRO-ZOOBENTHIC COMMUNITIES AND ENVIRONMENTAL VARIABILITY, THE SETO INLAND SEA

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Introduction: Within an estuary, the interaction between environmental variables and intertidal macro-zoobenthic communities is highly dynamic and flexible. To assess the relationship between physico-chemical processes and biological events, extended and comprehensive surveys are required as a fundamental background of information. In light of this, we conducted an interannual survey on the seasonal variation of major chemical parameters of the sediments and the macro-zoobenthos on an intertidal flat in the Seto Inland Sea. We will focus here on the temporal variability of the dominant species of the macrobenthos and major chemical parameters of the sediments. This work was conducted in the framework of a project aiming to propose an original model on the dynamics of bio-philic elements.

Materials and Methods: Sampling was carried out monthly from April 1994 to April 1996. Samples of emerged sediments were collected at 5 stations set along the shore line at low tide. Major chemical pararneters (i.e. Chla, acid-volatile sulfide, nutrients in the pore water) of the surface (0-0.5 cm) and the sub-surface (0.5-2 cm) sediments were determined. The macrobenthos were simultaneously collected for 2 years and the dominant species were determined. Major chemical parameters were also investigated through the vertical profile (0-10 cm) at an individual station for 1 year.

Results and Discussion: We will present here the spatial and seasonal variation of the nutrient concentrations (ammonium, nitrate+nitrite, phosphate and silicate) in the pore water, as a preliminary attempt to relate their seasonal changes with those of the macrobenthos. Among the macrobenthos, the bivalves *Ruditapes philippinarum* and *Musculista senhousia* and the polychaeta *Nereis* sp.,

Cimformia tentaculata and *Polydora* sp. were dominant. The biomass of the two bivalve species was generally much higher than that of polychaeta. We found that the temporal fluctuation of bivalve biomass was significantly parallel to that of the total biomass throughout the whole survey. The pertinent results are discussed in the context of a study which quantifies the contribution of the macrobenthos on the processes on nutrient regeneration within the intertidal zone.

10AM2001 S4-307 poster

RECENT RESULTS FROM A BIOPHYSICAL MOORING ON THE GULF OF ALASKA SHELF

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A biophysical mooring was deployed for one year beginning March 2000 at 200 m depth, 60 km from shore along the Seward Line on the shelf in the Gulf of Alaska. The mooring included measurements of full water column velocities from ADCPs, temperature, salinity, nitrate, fluorescence, transmissivity, and PAR. The results show that abrupt changes in upper water column salinity, temperature, fluorescence and nitrate are probably due to advection of two kinds of water masses: Alaska Coastal Current (ACC) water and Alaska Shelf Water (ASW). The ACC water has low salinity and nitrate and high fluorescence and the ASW has the opposite characteristics. The Alaska Coastal Current water derives from a permanent eddy, the Seward Eddy, that is formed by a recirculation of the ACC steered by bottom topography. Satellite images of chlorophyll support the high fluorescence in the ACC and its recirculation. The mean barotropic current over the year was 1.6 cm/s, 306°, which orthogonal to the coastline, but parallel to the bottom topography.

10AM2001 S4-354 oral

INTERNAL WAVE GENERATION AND THEIR ROLE IN BIOPRODUCTIVITY OF THE COASTAL OCEAN

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It is known from many observations and physical reasons that bioproductivity in the ocean depends substantially on vertical mixing and fine structure (FS). Coastal zones of the ocean, including shelf break and continental slope, are just the zones with high intensity of mixing and frequently well defined FS. A model of internal wave (IW) generation by periodical (tidal or inertial) currents near the shelf boundary is proposed and analyzed in mixed coordinates - Eulerian for horizontal and Lagrangian for vertical coordinates. Numerical simulations have shown that hydraulic jump-like structures and trains of short IW are generated in times and places, when and where the IW phase velocities are equal to the current velocity. In the conditions of the Japanese Sea shelf zone, used for simulations, such resonance appeared mainly for the second mode of IW. In many cases two or three soliton-like waves are generated, which are followed by a train of sinusoidal waves. In the case of a thick upper thermocline the hydraulic jump and IW become unstable during from one to three tidal periods, and turbulent mixing will result.

Following our previous results and currently performed calculations the propagating short IW interact effectively with vertical density and velocity structure and lead to the formation of vertical FS. Subsequently, we should receive anomalies in the spatial structure of parameters characterizing local bioproduction. Analysis of some data of the Pacific Oceanological Institute on plankton, suspended organic matter and bottom organic sediments near the shelf boundary of the Japanese Sea is made to verify and support the results of our calculations.

10AM2001 S4-239 oral

CONTROL OF NORTHWEST COAST ESTUARINE PRIMARY PRODUCTION BY THE SUPPLY OF OCEANIC NITROGEN

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Three years of carbon-uptake experiments in the productive coastal estuary, Willapa Bay, Washington, reveal that primary productivity is limited by nitrogenous nutrients during the growing season, March-October. Importation of oceanic water during coastal upwelling events appears to be the major source of nitrogen to the estuary. Riverine nitrogen loads are significant October through April only. The oceanic supply of nitrogen is influenced by a combination of the upwelling intensity and the depth of the oceanic mixed layer. Climate variation appears to exert substantial influence on both factors, and thus is an important determinant of coastal productivity. The data from growing seasons following the 1998 El Niño and 1999 La Niña demonstrate this relation. We have derived a multiple linear regression equation to predict primary production in Willapa Bay with a high r^2 value (0.97). The dependent variables are chlorophyll *a*, PAR, and NOAA's Bakun Upwelling Index. The relation is important because all three variables can be monitored remotely, making now-casting of primary production in Willapa Bay possible. The applicability of the equation to other Pacific coast locations will be discussed.

10AM2001 S4-235 poster

CURRENT STRUCTURE IN THE NORTHERN SAKHALIN SHELF AND SLOPE GAS VENTING AREAS IN THE OKHOTSK SEA DERIVED FROM STANDARD SHIPBOARD ECHOSOUNDER SURVEY

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The observation of the bubble size and 3-D orientation of the chains of floating gas bubbles can be a tool for investigation of water flow above underwater gas bubble sources. The current structure in the natural active methane venting areas in the Okhotsk Sea near the shelf and slope of Northern Sakhalin was reconstructed from analysis of standard shipboard acoustic echosounder signal and hydrographic CTD data, obtained in two cruises during summer 1998 and 1999 on Russian/German project KOMEX. The obtained current field is necessary for better estimation of methane flux to the atmosphere and understanding the process of transformation in water column of methane bubbles originated from oil/gas deposits and underground destabilization of gas hydrates.

Echo signal was digitally processed and recorded by using registration system UDM, developed in Pacific Oceanological Institute, Vladivostok, Russia (V.P. Shevtsov). Acoustic survey of 1999 (RV *Marshal Gelovany*, echo sounder GEL-3, 12 kHz) on the same area as in 1998 (RV *Akademik M.A. Lavrentiev*, echo sounder SARGAN, 20 kHz) show different flare features due to inter year variability of gas seeping from the sea floor and frequency dependence of reflected acoustic signal from bubble size. Multiple sections in several directions of some flares obtained in each expedition showed more exactly the 3-D flare shape and its variability in time. Joint adjustment of velocity field reconstructed from acoustic imaging with taking into account some constrains following from the model of evolution of reflected acoustic signal from emerge bubbles with depth and CTD observations permits overcome some problems related to uncertainty in real bubble spectrum in vents. The obtained current patterns are in agreement with known current tidal structure of this region.

10AM2001 S4-269 poster

DIEL FEEDING CHRONOLOGY, PREY SELECTIVITY AND DAILY RATION OF JUVENILE CHINOOK (*Oncorhynchus tshawytscha*) AND COHO (*O. kisutch*) SALMON IN THE COLUMBIA RIVER PLUME

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Juvenile chinook and coho salmon migrating out to the ocean were caught by trawling at stations located 8 and 20 nautical miles offshore of the mouth of the Columbia River throughout a diel period on three consecutive days (21-23 June 2000). After each trawl, the available prey field was sampled with 4 different types of nets (Bongo Net, Meter Net, Neuston Net, Isaacs-Kidd Midwater Trawl). The Meter Net caught the largest variety of prey items; however the abundance estimates for more evasive prey items like adult euphausiids were more reliable in the Bongo Net samples. Stomach contents, by percent body weight, peaked during morning hours and reached their minimum at night, suggesting a predominantly diurnal feeding pattern. At the offshore station, the diet was dominated by the hyperiid amphipod, *Vibilia australis,* reaching more than 900 individuals in one coho stomach. Other important food items were larval and juvenile fish, various crab megalopae, euphausiids, and other hyperiid amphipods. The mechanism by which salmon feed on these amphipods, which are reported to live commensally on gelatinous zooplankton, is discussed. With increasing body size, juvenile chinook salmon included a higher proportion of fish in their diet. In general both species were highly selective predators, cueing in mostly on large and heavily pigmented prey items. Small copepods and the early developmental stages of euphausiids dominated the prey field, but were almost absent in the salmon diet. Estimates for daily rations ranged from 1.7 to 3.0% wet body weight for juvenile chinook to 3.6% for juvenile coho salmon.

10AM2001 S4-325 poster

BIOGEOCHEMICAL CONSEQUENCES OF COASTAL EROSION IN THE NORTH ASIAN MARGINAL SEAS

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Global effects on the Arctic (including the Bering Sea) are reflected in regional climate changes and their impacts and consequences. Global climate models have long projected that greenhouse-induced changes in climate would be first felt in the polar regions, epecially in the Arctic, with subsequent global feedbacks (Walsh, 1995; Kattsov et al., 2000; Morrison et al., 2000). Under the greenhouse scenario underlined by "polar amplified" warming essentially all cryospheric features of the Arctic will be affected, and there will be increased wind and precipitation (Serreze et al., 2001), larger freshwater input into the margins from the rivers (Shiklomanov et al., 2000; Semiletov et al., 2000), reduced sea ice extent and thickness (Rothrock, 2000; Wadhams, 2001). Energy and water fluxes clearly shape the regional temperature regime, which is a primary factor in determining the surface state (frozen vs. thawed), trace gas fluxes, rates of productivity, and the link to regional climate (Sarmiento and Toggweiler, 1984; Broecker and Peng, 1989; Weller *et al.*, 1995; Everett *et al.*, 1998; Forman et al., 2000; Serreze et al.,2000).

Any attempt to understand the effect of the Arctic Ocean on global change or the effects of global change on the Arctic Ocean requires thorough knowledge of the coastal processes as a linkage between land and ocean processes in the Arctic and SubArctic. The coastal zone plays an important role in the Arctic/SubArctic land-shelf-basin system (Codispoti et al., 1990; Grebmeir and Whitledge, 1996), because the major transport of fresh water and solid material (including ancient organics) into the Arctic Ocean is determined by 1) the riverine discharges from Eurasia and North America and 2) coastal erosion. Degradation of the former permafrost material dispersed and settled in the coastal zone is considered as a significant source of shelf productivity limiting nutrients (Semiletov, 1999, 2001).

In this paper I examine transport and fate of terrestrial organic material entering the shallow shelves of all North Asian Marginal Seas including Anadyr Gulf of the Bering Sea using data obtained on the field research of 1994-2000. Positive feedback loop between increased atmospheric emission of carbon dioxide and methane from northern ecosystems and change in atmospheric circulation and land hydrology-shelf environment is discussed also.

10AM2001 S4-113 poster

AUTONOMOUS MEASUREMENTS OF WATER CHARACTERISTICS DURING PETROLEUM DRILLING ON THE NORTHEASTERN SHELF OF SAKHALIN ISLAND IN AUGUST - SEPTEMBER 2000

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Sakhalin Institute of Fisheries & Oceanography deployed an autonomous station for registration of variations of water characteristics in the Piltun-Astokh marine oil-bearing area on the northeastern shelf of Sakhalin Island during petroleum drilling (Sakhalin II project). This station included the three dimension current-meter SonTek and water quality monitor YSI6600 that measured water temperature, salinity, concentration of oxygen, pH, chlorophyll and turbidity. The period of observation was 11 August - 20 September, 2000. The horizon of current measurements was 15 m, YSI sonde was located in the upper layer, it's horizon changed from 5 to 11 m due flow force. Residual currents (tides were filtered) had southeasterly directions for all period of observation. Vertical component of the current was negative (average value equal -1.6 cm/s). It means that water of upper layers went downward. Probably, there is the upward flux in the bottom layer at the nearest shore is known as Piltun summer upwelling. Upwelling events occurred during 17-27 August and 4-8 September 2000. The cold, salt water (about 2°∇ and 31.5‰) observed existed in the upper layer where usually low salinity and warm water mass (26-28‰ and 12-14°∇). Concentration of pH decreased during upwelling. Concentration of oxygen and

chlorophyll increased approximately synchronously in the moments of water mass changing. Turbidity increased rapidly several times during period of observations. We did not find the correlation of turbidity with another parameters. Most probably, the increasing of turbidity was connected with drilling activity. Thus, autonomous measurements at Piltun-Astokh field had shown effectiveness for objective and independence monitoring water masses properties and drilling waste waters discharge registration.

10AM2001 S4-041 invited

MIXING PROCESSES ALONG THE SHELF EDGE

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Material exchange processes along the shelf edge of the East China Sea are reviewed. The overall horizontal diffusivity of salt across the shelf edge is 1.3 x 107 cm^2 s^{-1}, which is estimated from the result of box model analysis. Contributions of tidal current, wind-driven current, frontal eddy, interleaving, upwelling and storm are calculated from the results of field observations and/or the literature. The contributions of wind-driven current, frontal eddy, and storm are large for the exchange of salt along the shelf edge of the East China Sea. As for the exchange of suspended material, the contribution of wind-driven current is the largest. The exchange of salt is largest in summer and that of suspended sediments is largest in autumn.

10AM2001 S4-332 poster

INFLUENCE OF HYDROLOGICAL CONDITIONS ON DISTRIBUTION OF CHLOROPHYLL *a* CONCENTRATION IN PETER THE GREAT BAY IN AUTUMN OF 1999

S.P. **Zakharkov**, E.A. Shtraihert, A.V. Alekseev, N.S. Vanin, G.I. Yurasov

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The hydrographic observations and phytoplankton pigment distribution in Peter the Great Bay was received in autumn of 1999 at cruise R/V *Lugovoe*. Survey has been conducted from November 24 to December 3, 1999. 104 stations were conducted to evaluate hydrological conditions and 78 of these - to define the phytoplankton pigments. It permitted to obtain both the picture of distribution of chlorophyll *a* and hydrological parameters. Samples for pigment analysis of phytoplankton have been mainly taken from the sea surface with horizon of 0.5 m. The concentration of chlorophyll *a* varied from 0.756 mg/m^3 to 8.11 mg/ m^3. Lowered concentration of chlorophyll *a* was observed in Amurskiy Bay (1.3-2.7mg/ m^3) and some higher - in Ussuriyskiy Bay (2.3-4.4mg/m^3) that is bound up with the light limitation for photosynthesis due to enhanced water turbidity in Amurskiy Bay. High concentrations of chlorophyll *a* were marked along the southwest coast of Peter the Great Bay (3.5-4.68mg/m^3), with highest value in Posjeta Bay - 7.48 mg/m^3, and at stations near the Povorotniy Cape (6.3-8.1 mg/m^3). It is probably bound up with the raised concentration of nutrients, which were caused by the coastal runoff in the southwest and the tidal mixing in the south-eastern part of the region. It should be marked also that in both cases the high content of dissolved oxygen was observed. Investigation of the phytoplankton pigment distribution in Peter the Great Bay is the necessary part of detailed studies of seasonal phytoplankton productivity influenced by coastal ocean physical processes.

10AM2001 S4-317 oral

COASTAL DYNAMICS INFLUENCE ON NUTRIENT TRANSPORT AT THE AREA OF MAGDALENA-ALMEJAS LAGOON SYSTEM, BAJA CALIFORNIA SUR, MEXICO

Oleg **Zaytsev**, F. Salinas-González, R. Cervantes-Duarte and C. Turrent Thompson

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The preliminary results of two oceanographic surveys designed to delineate the ocean forcing on the Magdalena-Almejas lagoon area, located at the Baja California coastal zone, are presented. Measurements of near-bed currents, CTD and ADCP surveys were conducted in April 2000 and February 2001, and coincided with relatively strong west-north wind and coastal upwelling in front of the lagoon. Nutrient distribution was simultaneously observed during the second survey. The data set obtained is used for discussing a nutrient supply

mechanism for the lagoon system which consists in a joint influence of coastal upwelling and tidal pumping of surface waters into the lagoon system. Despite the limited area studied, evidence of the upwelling pattern is found in the thermohaline stratification. An analysis of AVHRR satellite images since 1996 shows that cold, nutrient-rich surface waters were located in front of the lagoon during the period from January to June. Strong ebb- and flood currents at the principal mouths of the system (up to 1.5 m/s) force a very intensive water exchange between the lagoons and the adjacent ocean waters, affecting nutrient transport and plankton migration into the lagoons. We found a turbulent energy level and wave impact sufficiently high to produce an intensive vertical mixing inside the lagoons; the shelf stratification is maintained close to lagoon entrance only. Comparison with other dynamically similar studies in the region of the Baja California, including the Gulf of California, shows that the described mechanism is not typical for Mexican coastal lagoons.

10AM2001 S4-318 poster

NUMERICAL SIMULATION OF TROPICAL CYCLONE IMPACT ON COASTAL CIRCULATION IN THE SOUTHERN BAJA CALIFORNIA PENINSULA

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Historical analysis of tropical cyclones in the Eastern Pacific during the last 60 years shows that one third of them passed close to or crossed the southern part of the Baja California peninsula. Intense longshore current and storm waves, generated by the cyclone passage, bring about morphological changes and shifts in ecological conditions.

In order to examine variability of longshore currents the Wes Implicit Flooding Model (WIFM), based on the shallow water equations, was applied. Surface wind fields, imposed as a surface boundary condition for WIFM, were calculated via the Standard Project Hurricane model (SPH) of the Coastal Engineering Research Center (CERC), using real cyclone parameters. Nested grids were used for specification of dynamic lateral boundary conditions; first, a current field was calculated on a broad grid with remote boundaries, then the results were applied as boundary conditions for a small grid, inscribing the area of interest.

The response of coastal circulation to cyclone passage was simulated for both the Bay of La Paz and the tip of the Baja California for cyclones Doreen (1977), Faust (1996) and Isis (1998). Storm sea level elevation (surges) did not exceed 0.5-0.6 m in good agreement with the analysis of residual sea level variations based on Godin's algorithm. At the same time longshore current may reach to 1.5 m/s or more. Under the influence of cyclones the normal circulation pattern in the Bay of La Paz may reverse.

S5 POC/BIO/FIS Topic Session
The physics and biology of eddies, meanders and rings in the PICES region

Convenors: William R. Crawford (Canada), Jeffrey J. Polovina (U.S.A.) and Takashige Sugimoto (Japan)
Tuesday, October 9, 2001 08:30-12:30

Mesoscale processes in North Pacific boundary currents, such as eddies, meanders and rings, have been examined in the past decade to determine the physical dynamics contributing to their formation, motion and decay, but the biological implications of these features are uncertain. In many cases, repeated oceanographic cruises, and satellite observations have enabled the tracking of individual eddies and meanders as well as the passive and active association of some species with these features. This session explores the important physical and biological processes of eddies, meanders and rings in the PICES region, and considers how they may affect production of local biota and fisheries.

Invited speakers:

Robert R. Bidigare (University of Hawaii, U.S.A.) – Influence of cyclonic eddies on new production rates in the vicinity of the Hawaiian Islands

Michael G. Foreman (Institute of Ocean Sciences, Canada) - Numerical modelling of the generation of the Haida eddy

Hideaki Nakata (Nagasaki University, Japan) - Effect of Kuroshio frontal eddies on the biological production and pelagic fish recruitment

Konstantin A. Rogachev (Pacific Oceanological Institute, Russia) - Eddies in the western subarctic Pacific: Dynamical structure, biological significance and linkages to the regime shift phenomena

Selected papers from this session (oral and posters) will be published in a special issue of *Journal of Oceanography*. If review and final revision can be completed by April 1, 2002, publication might be scheduled before PICES XI, in October 2002.

10AM2001 S5-001 oral

EFFECTS OF THE BUSSOL ANTICYCLONIC EDDY ON WATER MASSES, CHEMICAL PARAMETERS AND CHLOROPHYLL DISTRIBUTIONS IN THE WESTERN SUBARCTIC PACIFIC

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Detail survey of the area off the Kuril Islands was conducted in May-June, 2000 by R/V *Mirai*. The survey included continuous underway measurements of current, temperature, salinity, nutrients, dissolved oxygen, carbonate parameters (dissolved inorganic carbon and pCO_2) and fluorescence in the surface water. XCTD profiling and deep hydrocasts were also carried out. The data obtained gave us an opportunity to consider the distributions of physical and chemical parameters in the surface and intermediate water layers of the western subarctic Pacific. We show that these distributions are significantly affected by an anticyclonic eddy located in the front of the Bussol Strait through the advection and water mixing. Topex/Poseidon data are used to explore the pathway of the eddy from its origin in April-May 1998 in the Kuroshio-Oyashio Zone till September 2000 when it was consumed by the Oyashio Current. By using SeaWifs chlorophyll data we also discuss the impacts of the eddy (together with other Oyashio eddies) on the spatial variations in the biological production of the study area.

10AM2001 S5-138 oral

MESOSCALE MEANDERS IN THE NORTHERN CALIFORNIA CURRENT SYSTEM

Jack A. **Barth**, T.J. Cowles, S. Pierce and W.T. Peterson*

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During spring and summer 2000, two mesoscale mapping cruises were carried out in the northern California Current System between 41.9 and 44.6N and offshore for 150 km. The primary measurement platform was a towed undulating vehicle equipped with a CTD, two fluorometers, a multi-wavelength light absorption and attenuation instrument, and a PAR sensor. A shipboard ADCP measured water velocities and a bio-acoustics instrument measured multi-frequency (38, 120, 200, 420 kHz) backscatter. Surface drifter trajectories and satellite SST imagery provide context for the mesoscale maps. A variety of wind regimes were encountered from strong upwelling to strong downwelling. The data provide good examples of flow-topography interaction including the influence of a major submarine bank and a large coastal promontory on the eastern boundary current circulation. Early in the season the upwelling front and jet followed the bottom topography fairly well. There was cold water inshore of the shelfbreak all along the coast with pockets of elevated biomass (up to 4 mg/m^3) near the coast. Mesoscale activity was minimal. During the summer cruise, the upwelling front and jet were much more convoluted including major meanders offshore associated with Heceta Bank and Cape Blanco. High levels of phytoplankton biomass (in excess of 10 mg/m^3) were found over Heceta Bank and near the coast south of Cape Blanco. The large offshore meander near Cape Blanco carried cold, nutrient-rich, high phytoplankton biomass (2-4 mg/m^3) away from the coast over 100 km offshore. Details of the physical and biological structure of the meanders will be presented.

10AM2001 S5-002 invited

INFLUENCE OF CYCLONIC EDDIES ON NEW PRODUCTION RATES IN THE VICINITY OF THE HAWAIIAN ISLANDS

Robert R. **Bidigare**[1], Michael P. Seki[2], Carrie L. Leonard[1], Claudia Benitez-Nelson[1], Robert D. Vaillancourt[3] and Jeffrey J. Polovina[2]

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In November 1999, ship (CTD casts) and satellite (SeaWiFS ocean color imagery, GOES temperature and T/P altimetry) platforms were used to map the vertical and horizontal structure of two cyclonic eddies, *Loretta* and *Mikalele*. Based on a time-series of GOES thermal imagery, *Loretta* and *Mikalele* were formed in early May and late October 1999, respectively. Depth-integrated nitrate+nitrite levels measured in the centers of *Mikalele* (120 mmol N m^{-2}) and *Loretta* (490 mmol N m^{-2}) were 3 to 15-fold higher than observed for control stations (35 mmol N m^{-2}). *Mikalele*, a relatively "young" eddy, exhibited a deep chlorophyll maximum layer (DCML) at 80 m with chlorophyll levels comparable to control stations. The DCML of the "mature" *Loretta* eddy feature was located at 65 m with chlorophyll levels approaching 1 mg m^{-3}. HPLC analyses revealed that the enhanced chlorophyll was largely due to chromophyte microalgae. A bio-optical production algorithm was used to estimate primary productivity rates for these mesoscale features. Daily production rates for control, *Mikalele* and *Loretta* stations averaged 600, 980, and 1230 mg C m^{-2}, respectively.

In order to investigate eddy-induced shifts in phytoplankton community structure and new production rates, an additional suite of measurements were performed within cyclone *Haulani* during November 2000. Flow cytometric analyses revealed increases in large photoautotrophs and decreases in photosynthetic bacteria within *Haulani* relative to control stations. New production rates, as estimated from ^{234}Th inventories and food web model calculations, were elevated at stations occupied near the center of *Haulani*. Our findings suggest that these mesoscale features enhance the efficiency of the biological pump, and facilitate the export of carbon to the deep-sea and/or higher trophic levels in the lee of Hawaii.

10AM2001 S5-120 oral

SEASONAL CHANGES IN THE OCEANIC CARBON DIOXIDE SYSTEM IN THE HAIDA-2000 EDDY IN THE NORTHEAST PACIFIC OCEAN

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An anticyclonic eddy, named the Haida-2000, formed off the southern Queen Charlotte Islands during winter 2000, and subsequently tracked northwest, transporting a core of fresh, warm, and nutrient rich water out into the Northeast Pacific Ocean. Based on nutrient, oxygen, DIC, A_T, and pH, as well as particulate carbon and nitrogen, data from four seasonal cruises between February 2000 and February 2001, we found that the oceanic carbonate system of the eddy changed in relation to the surrounding waters. We estimated air-sea exchange of CO_2 from the difference between the biological carbon consumption (Cbio) estimated from integrated nitrate loss in the surface waters and the observed change in the dissolved inorganic carbon (DIC). Based on this estimate, the centre of the eddy appears to be a sink for atmospheric CO_2 from February through September, while the edge and the outside stations worked as sources of CO_2 during summer (June to September). The highest biological consumption of carbon was observed at the centre station between February and June and decreased into summer. During all periods and at all stations, DIC concentrations increased below 100 meters, presumably due to oxidation of organic matter, with the largest increase observed between September 2000 and February 2001.

10AM2001 S5-190 oral

A REVIEW OF SITKA AND HAIDA EDDIES AND THEIR IMPACT ON THE GULF OF ALASKA

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Anti-cyclonic mesoscale eddies form along the Pacific continental margin of North America in winter, mainly north of 51N, and drift throughout the eastern Gulf of Alaska for several years. They tend to be larger in winters following major El Niño events. Those formed west of British Columbia, Canada, are denoted "Haida", whereas the eddies formed west of Alaska, USA, carry the name "Sitka". Many of the features of Sitka Eddies described by Tabata (1982) are shared by Haida Eddies, which were only recently established as distinct features. Both eddies transport heat and fresh water away from the continental margin into mid gulf. They are typically 50 to 100 km in radius, and always anti-cyclonic. Both are mainly baroclinic with a small barotropic component of motion.

Sitka Eddies occupy a more northerly region of the gulf, and occasionally enter the Alaskan Stream where they drift westward for as long as three years. Previous studies indicate that Sitka Eddies are formed by the process of baroclinic instability. Recent observations of Haida Eddies suggest these eddies are mainly formed by winter outflow currents from Hecate Strait into the Gulf of Alaska.

Much of the excess heat advected northward along the continental margin in winter is carried into mid-gulf by these eddies. During El Niño winters this westward heat advection is even greater. A review of historical temperature and salinity profiles of Haida Eddies has found that water temperatures at 150 m in the core of Haida Eddies match the temperature of surface waters at the southern tip of the Queen Charlotte Islands in winter in which they were formed. The impact of this heat and salt transport will be described.

10AM2001 S5-361 poster

TINRO INVESTIGATIONS OF UNDERWATER MOUNTAINS OF THE NORTHEAST PACIFIC

Vladimir B. Darnitsky, Mikhail A. Stepanenko and Vladimir N. Vologdin

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TINRO investigated underwater mountains of the northeast Pacific Ocean in 1970–1980. Since 1976 to 1984 surveys in this region were conducted on more than 10 expeditions, in which 26 underwater mountains were studied.

Species composition most of underwater mountains is very poor, as well as abundance of fishes. At the same time some numerous high seas species as well as the off bottom fish of adjacent shelf can be abundant at some underwater mountains off Pacific coast of Northern America.

Oceanic jack mackerel spend most of life cycle at high sea and can periodically to concentrate in area of underwater mountains during feeding migrations. A lot of jack mackerel was observed in the area of Cobb Mountain in autumn period of 1979–1981. The duration of existence of jack mackerel concentration above mountains, probably, depends on oceanic dynamic processes. Some off bottom species inhabit above the mountains a significant part of ontogenesis. Some species of rockfish are abundant as it confirm by hydroacoustic surveys above mountains (Cobb Mountain area, R/V Poseidon, 1979). At the same time the rockfish abundance at adjacent continental shelf is much higher. These rockfish juveniles are widely distributed inshore and offshore (250-300 miles). Therefore the numerous species of rockfish in area of underwater mountains is possibly to name rather as dependent pseudo - populations.

The eddy systems can have a variable dynamic structure in region of underwater mountains of northeastern Pacific Ocean, that depends both on interaction of water masses and morphology of underwater mountains. The number of eddies can be of 2–15, from 5 up to 180 miles diameter. Eddy systems have maximum intensity and scale in regions of clusters of underwater mountains, for example, off coast of California (32°-36°N, 123°-128°W), where there are 7 underwater mountains, or in region of 15 underwater mountains located between mountains Miller and Brown.

The zooplankton biomass can reach 1500-1700 mg / m^3 in eddies field of underwater mountains, while in adjacent oceanic waters usually consist of about 30-100 mg / m^3.

10AM2001 S5-281 poster

INSIDE AND INTERDAILY WATER DYNAMICS ABOVE THE TOPS OF HAWAIIAN AND IMPERIAL SEAMOUNTS

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During intensive researches of underwater seamounts in the Hawaiian and Imperial ridges in the 1970s, TINRO executed 23 two-three day stations above 9 seamounts with 2-hour observations of T, S, O2, P, Si and one 10-daily station above the top one of Imperial seamounts (36° 48N, 171° 22E) with step-type behaviour on S and 02 - 12 hours and T - 6 hours.

On the various morphology seamounts in near-bottom horizons (200-500 m) the fluctuation of temperature can change from 0.6 up to 1.9°. The fluctuations of biogenic elements also achieve significant sizes: silicate - from 17.5 up to 370 mkg/l, phosphate - from 14 up to 50 mkg/l. In the winter period the fluctuation of temperature in a top quasi-uniform layer are insignificant - in limits of 0.34-0.49°, however, with increase of depth amplitude of fluctuations is increased up to 2.6-3.4°C in a 75-100 m layer, decreasing up to 2.1°C on 150 m horizon and further with depth.

On character of temperature fluctuations the periods from 6 till 20 hours were marked on the average the period 6-8 hours. For other elements characteristic was a wrong different periodicity in approach within day. The extremes of phosphate and silicate concentration in most cases coincided on time, but were not coincided with the periods of approach of the dissolved oxygen extreme.

The semidiurnal wave are more brightly shown in intermediate horizons, however, correct periodicity in a course of the oceanographic characteristics almost never was observed. On the longperiod diurnal wave allowance and semidiurnal wave the pulsations of maximum styles were imposed, forming packages the different-period and different amplitude waves, however energy of the diurnal allowance and semidiurnal of waves was prevailing. The characteristic phenomenon for seamounts of the given area is that large on the size of tops of seamount cause also gives the large amplitudes of variability of the oceanographic characteristics.

In the winter period the maximal amplitudes of temperature were observed in a 100-150 m layer, the summer occurs shift of the maximal amplitudes in a 50-75 m layer in connection with development of the seasonal thermocline. The amplitude of internal waves is increased on the average by the order in comparison with background conditions. On supervision from underwater devices and hydroacoustic information of the fishes jambs react on the internal wave movements of waters, changing horizons and their site concerning a bottom relief (Kemenov, 1979, Zuferman, Kemenov, 1987).

Registration of temperature and currents at the Bermuda islands within 9 months have allowed to observe internal Kelwin waves, seized by an island, with the periods 1.1-1.9-2.2-3.8 day (Hogg, 1980).

On the 10-day station on the one of the Imperial seamount in a top of the 0-100 m layer the periodicity 1-3 day was marked, in a 200-400 m layer intensive deep upwelling was for the fifth day of supervision with three-multiple upwelling of deep waters. The vertical displacement of the isoxygens achieved 100-110 m in 100-400 m layer. The vertical displacement of the isotherm did not exceed 30-50 m. Obviously there is a redistribution of the wave energy between separate types of wave movements.

10AM2001 S5-282 poster

TOPOGRAPHICAL AND MID-OCEAN EDDIES NEAR HAWAIIAN AND IMPERIAL RIDGES

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Northern part of Hawaiian and southern part of Imperial seamounts is characterized by high bioefficiency. In 1968-74 ye. the catches of *Pentaceros richardsoni* was 20-30 t for 5-10 mines CPUE (Komrakov, 1970; Chikini, 1971). For the period with 1968 to 1977 above the tops of seamounts by the general area 2760 km^2 was extracted about 800 000 t of fish, thus annually here was caught on the average 29 t/km^2, i.e. fish productivity was in 3 times more high than the same of southwest Africa shelf (Boretz, Darnitskyi, 1983). The reasons such high fish productivity are connected to influence of mid-Pacific topography ridges and separate seamounts on average waters circulation, which essentially becomes complicated at the expense of generation macro-, meso- and microscale eddies near to the seamounts, having flown - having cast interactions of waters with a bottom relief and upwelling, accompanying this processes a plenties of biogenic elements in intermediate and underthermocline layers and, at the end, in a photic layer.

Before introduction by USA of the 200-mile economic zones TINRO carried out a macroscale of oceanographic survey of northern part Hawaiian ridge between 27-33°N, 170°E - 178°W and to the north in area of average and southern Imperial seamounts. So, in February - March 1974 the survey above 9 northern Hawaiian seamounts was made. On all water area of survey was fixed 9 geostrophic eddies of the elliptic form by a diameter from 70 up to 240 miles with differences of a dynamic relief from 0.2-0.5 up to 0.83 din.m. The eddies in fields of the oceanographic characteristics (T, S, O2, Si) were observed up to last horizon of supervision (1000 m) and were focused, basically, in meridional direction till both parties from an axis of seamounts (Darnitskyi, Mishanina, 1982). Let's notice, that the vortical movement covered all water area of survey. Vortical and jet meridional current alternated almost without a zone component.

Research of vortical activity in area of Kolahan seamount with 1968 on 1980 ye. (13 survey) at some fixed parameters (b-effect and topographical parameter) has shown, that the vortical structures of various scales (from 5 up to 50 miles) were observed in any seasons, their intensity and vertical development varied only (Darnitskyi, Zigelman, 1986). From many features of vortical structure we shall note the fact of existence of a Tailor column above the top and four eddies, connected to it, of the greater diameter and various marks of rotation, for which the Tailor column was the centre of eddy interaction. The eddy speeds changed from 20-40 up to 150 sm/s. Below than top 4 eddies was packing up to last horizon of supervision (1000 m) were observed. The cellular structure of a vortical field was observed in the fields of the all hydrological and hydrochemical characteristics. The vertical movements covered all 1000 m of the water layer, representing a high gradient a zone on the area 2500 mile^2, where there was a powerful upwelling in subsurface and photic layers. Recurrence of microsurveys with 2-5-day discretency above the top of Kolahan seamount has shown, that on this time interval there is a regular upwelling of biogenic substances in various layers down to a surface and enrichment the top of 300 m layer by periodic lowering of oxygen.

The close periodicity was observed and in commercial catch trade parameters of obtaining fleet during an intensive craft a *Pentaceros rihardsoni*.

10AM2001 S5-156 poster

SENSITIVITY OF A CALIFORNIA CURRENT SYSTEM ECOSYSTEM MODEL TO CHANGES IN MEAN FLOWS VERSUS CHANGES IN EDDY STATISTICS

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Do eastern boundary current ecosystems change more strongly due to altered mean conditions or to altered mesoscale eddy statistics? Model simulations of the California Current System clearly reveal that the statistics of the eddies strongly depend on decadal and interannual changes in the atmospheric forcing along the coast. Analysis of the wind stress curl reveals a strong link with the variability of the California Current core and the offshore extent of the upwelling front. The biological response to these different physical forcings is investigated

with a 7-component ecosystem model. By comparing different scenarios of wind forcing we are able to distinguish a coastal region where high productivity is associated with maximum variance of the wind stress curl and a deep ocean region in which the biological processes are controlled by the evolving eddies that are generated at the boundary between the two regions.

10AM2001 S5-131 poster

PHYSICAL AND BIOLOGICAL INTERACTIONS BETWEEN HAIDA EDDIES AND SHALLOW SEAMOUNTS IN THE NE PACIFIC

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Haida eddies have been monitored since the mid 1990s. During that time, several Haida eddies have passed near (and one became temporarily "stuck" to) shallow seamounts in the NE Pacific. As Haida-2000 passed over Bowie Seamount, 200km west of the Queen Charlottes (shallowest depth 25m), its westward motion slowed and the eddy remained associated with the seamount for several months. ADCP data demonstrate that circulation within Haida-2000 was significantly disrupted during this time: flow south of Bowie Seamount showed a typical clockwise rotation while velocities in the northern portion of Haida-2000 (over Bowie) were slower and often abruptly changed direction within a short distance. Biologically, this interaction is quite interesting. Like other shallow seamounts in the NE Pacific, Bowie Seamount supports significant populations of several rockfish (*Sebastes*) species. It remains unclear, however, how these populations are maintained in the long-term. There appears to be only limited genetic differentiation between the Bowie rockfish and those from the neighbouring Queen Charlotte Islands, suggesting at least occasional communication with coastal populations. Since adult rockfish are not generally found offshore in open waters, it therefore seems likely that Haida eddies may function as a larval transport corridor for rockfish (as well as other fish and benthic species) and provide an important connection between coastal populations and isolated seamount populations in the NE Pacific. Plans are underway to examine the elemental structure of archival rockfish otoliths to determine to what degree the Bowie populations are linked to populations from the neighbouring Queen Charlottes.

10AM2001 S5-009 invited

NUMERICAL MODELLING OF THE GENERATION OF THE HAIDA EDDY

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Satellite altimeter data have recently revealed that eddies are formed off the West Coast of the Queen Charlotte Islands every winter. The magnitude of these Haida Eddies varies with winter setup along the northern British Columbia coast, particularly in Hecate Strait. Accordingly, a very large eddy was formed after the demise of the 1997-98 El Niño. Water property samples show that theses eddies are comprised of coastal water and, as such, they play an important role in transporting nutrients, plankton, and larvae from the coastal region into the Northeast Pacific Ocean.

In this study, a high resolution numerical model is used to simulate the generation of the Haida-1998 Eddy. The model is forced with tides, and winds observed at several offshore buoys. Initial salinity and temperature fields are computed by adjusting climatological water property observations to correspond with observations taken over the winter of 1997-98, while southern upstream boundary conditions are deduced through the inversion of current meter observations. Results show that the eddy is formed by strong flows streaming past Cape St. James, at the southern tip of the Queen Charlotte Islands. The numerical results compare favourably with available tide gauge and satellite altimeter data. Estimates of the total volume of water leaving Hecate Strait and its biological impact are made.

10AM2001 S5-154 oral

TWENTY YEARS OF EDDIES IN THE ALASKA COASTAL CURRENT

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Velocity and salinity fields, spanning a full twenty-year period (1978-1998) in the northern Gulf of Alaska near Shelikof Strait, have been generated with a three-dimensional, eddy-resolving (~4 kilometre resolution), primitive equation model of the Alaska Coastal Current. The model is driven with daily winds and monthly estimates of freshwater runoff at the coast, in order to hindcast March-September currents affecting the early life stages of walleye pollock (*Theragra chalcogramma*). Eddies in the Alaska Coastal Current play a vital role in the dispersal, retention and hence recruitment of pollock larvae in this area, and form in abundance within Shelikof Strait in some, but not all, model years. Here, we relate eddy and mean flow statistics from the model output to the statistics of the winds and runoff, with the ultimate goal of developing better predictors of the "eddy climate" for a given year, based on the anticipated forcing. Results are interpreted by considering hypothesized mechanisms of eddy generation for this region (e.g. baroclinic instability), and how those mechanisms are affected by the spatial and temporal patterns of the forcing.

10AM2001 S5-092 poster

NUMERICAL EXPERIMENTS ON THE MOVEMENT OF THE WARM-CORE RINGS IN THE KUROSHIO-OYASHIO TRANSITION ZONE

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Behavior of Kuroshio warm-core rings is investigated by means of data analyses and numerical experiments. The trajectory of the warm-core ring 93A(WCR93A), a recent representative of a long-lived ring suggests that the basic mechanism of the northward movement of the Kuroshio warm-core rings is the mirror effect, while the interactions of rings with other rings, the Kuroshio Extension and the Oyashio is also important in short time scales. A single warm-core ring near a western boundary, in previous numerical experiments, decayed out in a year, gradually approaching the coast. However, WCR93A were supplied with warm water and advected off-shore by other warm eddies and the Kuroshio extension, and kept their intensity for several years in the Kuroshio-Oyashio transition zone. WCR93A tended to move southward in winter and northward in spring by the amplitude of about 100km, and the seasonal variation of the southward advection of the Oyashio can explain this tendency. The numerical experiments are designed to study these detail behavior and the physical significance of rings in the Kuroshio-Oyashio transition zone. A biological impact of the behavior of the rings is discussed through an example of the formation of saury fishing grounds.

10AM2001 S5-158 oral

ZOOPLANKTON DISTRIBUTIONS AND DYNAMICS IN A LARGE ANTICYCLONIC EDDY OF COASTAL ORIGIN: HAIDA 2000

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Near the end of most winters, large volumes of coastal water accumulate along the eastern margin of the subarctic Pacific (very often near the southern tip of the Queen Charlotte Islands, Canada and off Sitka, Alaska), and then detach from the coast and move seaward into the Alaska Gyre as large anticyclonic eddies. Each eddy contains a core of anomalously low density water of coastal origin, and produces an upward doming of the sea-surface which can be tracked by satellite altimetry, and sampled repeatedly by research cruises. We present evidence from the 2000 and 2001 'Haida Eddies' that these features have important effects on the zooplankton community of the Alaska Gyre:

- Seaward transport of zooplankton taxa from coastal/continental margin environments. Transport and retention within the eddy appear to be especially effective for species that undergo some diel vertical migration. Examples from 2000 include the copepod *Pseudocalanus mimus*, and the medusa *Aurelia aurita*.
- Colonization of the eddy by 'open ocean' zooplankton taxa, combined with enrichment and altered pathways for lower trophic level productivity. These produce cross-eddy spatial structure of biomass and species composition, with a local abundance maxima often occurring within, but near the outer margin of the eddy.

10AM2001 S5-248 poster

QUASI-GEOSTROPHIC TWO-LAYER MODEL OF BACKGROUND CURRENTS IN THE GULF OF CALIFORNIA

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A two-layer quasi-geostrophic model was used to simulate a background current having a homogeneous potential vorticity and minimum of total mechanical energy of the system. The summary geostrophic stream function in each of layers was presented as a superposition of planetary, topographic (barotropic and baroclinic) stream functions, and potential flow through the liquid boundaries. The appropriate contributions were found from the numerical solution of independent boundary value problems. The calculations for the Gulf of California were carried out in spherical coordinates over a five-minute regular grid. For construction a bottom topography the data array ETOPO5 was used.

The simulated background circulation consists of two large rings - anticyclonic in more shallow northern part, and cyclonic - in a southern part above a system of depressions. The dynamic front between the main rings is located approximately at latitude of 27.5 degree, in region of northern extremity of the depression Guaymas. The position and intensity of this front are varied depending on a season and a specified water transport through the liquid boundary, however the rotating sense of rings does not change. This scheme not quite coincides with traditional opinion about a seasonal nature of circulation in the surface layer of the gulf, but it is mainly conditioned by monsoon character of wind and large seasonal thermohaline structure variations. Nevertheless, the presented model allows evaluating the main formation mechanisms of background currents, which can be taken into account for other dynamic processes studies.

10AM2001 S5-160 oral

MESOSCALE PHYSICAL LINKS BETWEEN COASTAL UPWELLING AND PELAGIC TUNA FISHERY IN THE EASTERN TROPICAL PACIFIC OCEAN (ETPO)

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Intense jet wind events in the Gulf of Tehuantepec (Mexico) and in the Gulf of Papagayo (Central America) produce upwelling events in coastal areas of the ETPO. CZCS and SeaWIFS imagery is used to characterize seasonal and intra-annual variability of coastal upwelling at these two locations. Well defined seasonal signals are modulated by El-Niño and La-Niña years.

Formation of mesoscale eddies are associated with coastal upwelling processes. Eddies travel westward with average speeds close to Rossby waves for the 10N–15N latitudinal band. These eddies are detected by Sea Surface Height Anomalies (SSHA) from Topex/POSEIDON altimeter data, for the years 1993 through 1998.

Eddy and tuna catch variance and correlation in time-space are studied with Empirical Orthogonal Functions (EOF's) and Canonical Correlation techniques. Seasonal and intra-annual periods are well resolved in the EOF's modes. Tuna fleet distribution is in good agreement with seasonal and intra-annual eddy variability for the 10N-15N band.

SSHA time series variability (SSV) in upwelling coastal areas is studied by definition of two indices, the gradient or the difference between SSHA at two stations in each side of the jet winds in Tehuantepec and Papagayo, and the velocity or the 10 day time change value of SSHA in each four stations.

Statistical significant cross-correlation in time-series are found for wind pseudo-stress in the two coastal areas, SSV and catches one offshore area (116W, 10N) with a 5 to 6 month time lag, and a second offshore area (124W, 10N) with a 6 to 7 month time lag.

10AM2001 S5-222 oral

ON THE KUROSHIO MEANDER FORMATION SOUTH OF JAPAN

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Kuroshio index of its path south of Japan is introduced using a bimodal decomposition of temperature field at 400 m depth. Sorted accordingly, historical data provided better description of 3D structure of the modes and of the differences between them. Precise water property analysis on isopycnal surfaces revealed lack of any alien water in the center of the large meander. Instead, its interior is filled by the lifted deep waters lying underneath the Kuroshio Current in its straight path state, and modified by increased vertical mixing in the upper ocean. Estimates of available potential energy reveal its larger value for the meander state and deny any kind of instability as a potential source of the meander formation. Instead, decay of the meander is, likely, due to baroclinic instability that is also confirmed by the higher index variability of the offshore Kuroshio path. Vertical displacement of isopycnals during the meander formation is sensible through the very deep levels and approximately a linear function of the distance from the ocean bottom that can be a kinematic evidence of the time-variable deep circulation (namely, of its interaction with a complex bottom topography) as a source of excessive accumulation of deep waters south of Honshu. Being pushed by this water offshore, Kuroshio plays just a passive role in its meander formation that can also explain failures of previous theories. We investigate horizontal extent of the meander-related signal and forward a hypothesis of the physical mechanism of the process.

10AM2001 S5-163 oral

CHAOTIC ADVECTION OF KUROSHIO COASTAL WATERS

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The shallow coastal water of the Enshu-nada Sea (ENSW) recirculates regardless of whether the Kuroshio path is straight or has meanders. The recirculation is formed as a result of flow separation at the sharp coastline; the size of the separation bubble changes due to mesoscale perturbations. The output of a recent numerical simulation of a short-term meander caused by an anticyclonic eddy was analyzed to track the motion of the ENSW. In contrast to the steady-flow cases, the simulation showed that the ENSW discharges into the Kuroshio extension region and intrudes further north into the Kuroshio-Oyashio confluence region due to chaotic advection. This advection is likely caused by a deterministic diffusion of particles characterized by meso-scale perturbation of saddle points in the flow; one located north of the Izu ridge and the other at the Kuroshio extension. This mechanism exists even without the Ekman drift and may play an important role in the transportation of the Japanese sardine egg and larvae from the southern Japan spawning ground to the nutrient rich Kuroshio-Oyashio transition zone. Results from other numerical simulation that includes large-meandering state with various wind condition will be analyzed and presented in the talk. A simple analytical flow will be utilized to introduce this recently becoming popular kinematical diagnosis tool in oceanography that originates from the dynamical systems theory.

10AM2001 S5-022 invited

EFFECT OF KUROSHIO FRONTAL EDDIES ON THE BIOLOGICAL PRODUCTION AND PELAGIC FISH RECRUITMENT

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In recent years, satellite remote sensing has revealed that mesoscale cyclonic eddies caused by frontal disturbances of the Kuroshio are a ubiquitous feature along the coastal edge of the Kuroshio. These eddies could play an important role in primary production due to the upwelling of nutrient-rich deep water to the surface euphotic zone, subsequently enhancing copepod production. According to rough estimate, the annual carbon production due to the eddy formation could amount to 40 $gCm^{-2}y^{-1}$. In addition, under the influence of the eddy, pelagic fish larvae originating from neighboring spawning grounds could be entrained into the eddy. These functions of the eddy possibly contribute to larval retention and provide a favorable condition for larval growth and survival.

Intensive transect surveys in combination with Lagrangian drifter tracking have been carried out several times in the vicinity of frontal eddies in the Kuroshio and the Kuroshio Extension regions. This paper reviews recent findings of these surveys and discusses the effect of the frontal eddy on the transport and food availability of anchovy larvae. Although physical mechanism has not yet been fully understood, it is noteworthy that aggregation of anchovy larvae quite frequently coincided with the eddy site. Increase in the copepod production corresponding to the increase in chlorophyll-a concentration in the eddy with a time lag of 1-2 days was also recognized in several cases, where nutritional conditions of anchovy larvae within the eddy site were often improved. These suggest that oceanic conditions leading to frequent occurrence of the frontal eddy will increase the probability for the larvae drifting in the Kuroshio or Kuroshio Extension to encounter with a favorable nursery; this could subsequently result in a successful recruitment.

10AM2001 S5-157 oral

DYNAMICS OF THE SOUTHERN CALIFORNIA BIGHT OCEANIC ECOSYSTEM RESPONSE TO PHYSICAL FORCING

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The time-dependent physical fields derived from fitting observations with an eddy resolving ocean model are used to drive 3-D NPZ-type ecosystem models in the Southern California Bight. Validating data include sub-surface chlorophyll and nitrate from CalCOFI hydrography and surface chlorophyll from SeaWiFS. The biological response to physical forcing is analyzed by diagnosing the spatial and temporal evolution of the ecosystem balances which include trophic level interactions.

10AM2001 S5-053 poster

A LAGRANGIAN APPROACH TO TEMPORAL CHANGES IN THE ABUNDANCE OF LARVAL FISH AND THEIR PREY ORGANISMS IN THE KUROSHIO FRONTAL EDDY

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Cyclonic frontal eddies are often recognized along the frontal area of the Kuroshio and Kuroshio Extenstion. The upwelling of nutrient-rich deep water in the vicinity of the eddies possibly contribute to the enhancement of prey production for fish larvae which are horizontally entrained into the frontal region. In May 1997 and May 1999, the temporal changes in abundance of larval fish and their prey organisms in and around the frontal eddy were tracked using drifters launched at the eddy center. In both years, dominant larval fish collected were anchovy (*Engraulis japonicus*), and their peak abundance was found in the vicinity of the frontal eddy, suggesting that those larvae were entrained and accumulated in the eddy. The dome shape isotherm distribution along the eddy section in the latter half of the buoy tracking in May 1997 indicated that marked upwelling occurred; however chlorophyll concentrations and naupliar copepods densities were still low. In May 1999, on the other hand,

chlorophyll concentrations were apparently high in the eddy center but decreased with time. By contrast, copepod naupliar abundance in the eddy was twice as high as the initial condition. These results of the first Lagrangian approach to the dynamic feature of the Kuroshio frontal eddy has confirmed that it could play a significant role in the growth and survival of larval fish which are distributed in the Kuroshio and its coastal waters.

10AM2001 S5-164 oral

EDDY AND MEANDERS AROUND UNDERWATER PLATEAU OFF THE CENTRAL KURIL ISLANDS: OCEANOLOGICAL FEATURES AND BIOLOGICAL EFFECTS

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Distributional peculiarities of groundfishes in the Pacific shelf and continental slope waters along the northern Kuril Islands and southeastern Kamchatka are depending mostly on distributional features of oceanographic characters (especially of water temperature), which are defined by water dynamics of East Kamchatka Current. Spatial and temporal variability of that current is determined mainly by peculiarities of bottom relief. Analysis of 25 oceanologic surveys conducted during 1992-2000 showed that interaction of East Kamchatka Current with bottom relief lead to forming in the area considered of several mesoscale meanders and eddied, which are occurred to depths of 100-200 m. Some of them have stationary character in inter-annual and seasonal aspects. Southerly of the Forth Kuril Strait interaction of East Kamchatka Current with complex bottom relief (underwater plateau and several small banks) caused existing of many local eddies and meanders with different directions. Distribution and absolute values of oceanological characters there are also depending on (besides complex dynamics) subarctic waters forming in the Forth Kuril Strait as a result of intensive tidal intermixing.

Existing of several eddies and meanders above underwater plateau and banks causes specific environment for fish inhabitation that is essentially differ from adjacent waters. Composition of ichthyofauna of the area considered consisted of several endemic fish species such as *Puzanovia virgata*, *Lycenchelys fedorovi*, *Hemilepidotus. zapus*, which captures outside of plateau are incidental. Some species widely distributed within the Pacific waters off the Kuril Island and eastern Kamchatka are highly abundant in plateau and banks area: *Allocareproctus jordani*, *Palmoliparis beckeri*, *Polypera simushirae*, *Careproctus zachirus*, *Thyriscus anoplus*, *Icelus perminovi*, *Triglops scepticus*, *Malacocottus zonurus* and others.

Within eddies and meanders favorable conditions for zooplankton concentrations exist. As a result of fine foraging conditions feeding aggregations of Atka mackerel *Pleurogrammus monopterygius* and Pacific Ocean perch *Sebastes alutus* are occurring there and their fishery is conducted all the year around.

In the waters around plateau and banks pelagic larvae and juveniles of some fishes, which are permanent dwellers of the area, are developing till settlement: broadbanded thornyhead *Sebastolobus macrochir*, longfin Irish lord *Hemilepidotus zapus*, some snailfishes (Liparidae) and others.

Waters of eddies and meanders above plateau and banks serve as nursery areas for some fishes, which spawn outside of the area considered: shortraker rockfish *Sebastes borealis*, darkfin sculpin *Malacocottus zonurus* and others. Pelagic larvae and juveniles of these species are transported by East Kamchatka current from main spawning areas, which are placed off the eastern Kamchatka and Paramushir Island coasts, to the south. Then they got into eddies and meanders, inhabit these waters until settlement, feed on plateau slopes and with size increasing start to reverse migrations.

10AM2001 S5-258 oral

A NUMERICAL STUDY ON THE PHYSICAL PROCESSES AND SEASONAL VARIABILITY OF EDDIES IN THE EAST/JAPAN SEA

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To explore the physical processes and seasonal variability of eddies in the East/Japan Sea (JES), a numerical study was performed. The method is a three-dimensional Princeton Ocean Model (POM) with horizontal resolution (1/12)°×(1/12)°and 25 sigma levels conforming to a relatively realistic bottom topography, which is free-surface, primitive equation model. To initiate the model conditions, two-step method is used. In the first step, the POM is integrated for 5 years from zero velocity and August climatological temperature and salinity fields. The final states resulted from first step is used the initial condition of second step, simulation step. Realistic temperature and salinity data of Generalized Digital Environmental Model (GDEM) and Na wind (Na and Sea, 1998) were used. At open boundaries, 2.4 Sv inflow through the Korea Strait, 1.6 Sv outflow through the Tsugaru Strait and 0.8 Sv outflow through the Soya Strait. The model simulated well the East Sea circulation and it's variability. The formation and seasonal variation of eddies resulted from the variability of the Polar-Front intensity. In the southern area of the East Sea, eddies are well formed during from summer to autumn.

10AM2001 S5-243 poster

SEASONAL CHANGES IN PHOTOSYNTHETIC BIOMASS AND PRIMARY PRODUCTIVITY IN A MESOSCALE EDDY IN THE GULF OF ALASKA

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Mesoscale eddies spawned from eastern boundary currents carry coastal waters offshore as they propagate westward. Haida-type anticyclonic eddies originating off the Queen Charlotte Islands transport coastal waters to the open Gulf of Alaska in winter, when nutrient concentrations are high, and photosynthetic biomass and light are low. In order to characterize seasonal changes in photosynthetic biomass distribution ten stations were sampled through the eddy in June and September, 2000, and two stations (inside, outside) in February, 2001. Total photosynthetic biomass was highest at the eddy centre in June, at the edge in September, and inside the eddy in February 2001. To examine primary productivity, three stations were chosen (eddy centre, edge, and outside reference station). Primary productivity was higher at the eddy centre with respect to the outside station in both June and September. Normalized carbon assimilation was higher in June. Photosynthesis versus irradiance curves suggest that cells in the deeper waters at the eddy edge have higher photosynthetic efficiencies (P_{max}) than do those at the centre or outside stations, and that photosynthetic efficiency is more uniform over depth at the eddy edge. These data suggest that Haida-type mesoscale eddies can maintain a unique phytoplankton community characterized by higher primary productivity over time, and that physical processes such as mixing at the eddy edge exert an influence on the photosynthetic efficiency of cells within the eddy.

10AM2001 S5-065 poster

DRIFTER OBSERVATIONS OF ANTICYCLONIC EDDIES SEAWARD OF BUSSOL' STRAIT, KURIL ISLANDS

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Cold-core anticyclonic (AC) eddies are commonly found in the area offshore from Bussol' Strait, the deepest of the straits connecting the western North Pacific and the Sea of Okhotsk. These eddies are regularly recorded during hydrographic surveys and in satellite imagery (cf. Yasuda et al., 2000). To examine the flow field associated with these eddies, we deployed groups of satellite-tracked surface drifters over the Kuril-Kamchatka Trench (KKT) in the fall 1990 and late summer 1993. Drifter trajectories for both groups revealed mesoscale AC eddies centered over the axis of the trench, seaward of Bussol' Strait. The physical characteristics of the eddies are estimated and their potential influence on the spread of North Pacific Intermediate Water into the Pacific examined. Slow northeastward movement of the eddies along the KKT indicates the presence of topographic Rossby waves ("trench waves") propagating over the oceanic slope of the trench. Drifter 1315, deployed near the center of the AC eddy in 1990, remained in the eddy for over 40 days and made five loops at successively greater distances from the eddy center. Large-amplitude, storm-generated inertial oscillations (30-50 cm/s) were observed during the first two loops. The vorticity field in the eddy resulted in a Doppler "red-shift" of the inertial frequency (Kunze, 1985) such that the measured "effective" inertial period of 21 hours was roughly 4 hours greater than the nominal inertial period for this latitude (45°N). In 1993, a drifter was retained in the AC eddy for about 40 days. This eddy had characteristics similar to those of 1990 eddy but was relatively devoid of significant high frequency motions until the drifter's final half loop (a detailed thermohydrodynamic description of this eddy can be found in Yasuda et al., 2000). The extent and apparent persistence of KKT eddies suggests that they have a major impact on the transport dynamics of the East Kamchatka and Oyashio currents.

10AM2001 S5-048 poster

INTER-COMPARISON OF CURRENT VECTOR ESTIMATES AND MESO-SCALE EDDY CHARACTERISTICS BETWEEN MODELS AND ALTIMETER DATASETS IN THE EAST SEA

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The East Sea draws particular attentions from scientific and geopolitical aspects. Understanding of the general circulation pattern in the East (Japan) Sea is of crucial importance. However, the quantity and quality of direct measurements of the various existing currents such as Tsushima Current, East Korea Warm Current, North Korea Cold Current, and Liman/Primoriye Current are far below our expectation level.

To compensate the incompleteness of direct measurements of currents in the East (Japan) Sea, indirect estimates of the current vectors (CV) are obtained based on three different approaches; 1) P-Vector method using T-S climotological database, 2) surface geostrophic current estimates using TOPEX/POSEIDON altimeter datasets, 3) output of a numerical model (POM-ES). The inter-comparison of the CV will be made in terms of 1) current speed and direction, 2) volume transports in the major currents at selected locations and 3) meso-scale eddy parameters of size, rotational speed and seasonality. The circulation patterns will be suggested in comparison to various traditional schemes in the East (Japan) Sea.

10AM2001 S5-028 invited

EDDIES IN THE WESTERN SUBARCTIC PACIFIC: DYNAMICAL STRUCTURE, BIOLOGICAL SIGNIFICANCE AND LINKAGES TO THE REGIME SHIFT PHENOMENA

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Large anticyclonic eddies form at the confluence of the Kuroshio and Oyashio and then migrate northeastward into subarctic waters along the full length of the Kuril-Kamchatka Trench. Such eddies play important role in the mixing of subtropical and subarctic waters. Of particular interest is the fact that each large eddy has well-mixed core, thus facilitating the vertical supply of nutrients to the upper layer.

In fall 1990, ARGOS drift buoys were deployed in the Oyashio off the Kuril Islands, as part of a joint Russia/Canada study of western boundary current dynamics. Superimposed on the mean anticyclonic rotation of the eddy were near-diurnal period "loops" of radius 7-8 km. During successive rotations the buoys spiraled outward, the mean period of rotation increased, and the amplitude of near-inertial loop motions decreased.

Two explanations for these high-amplitude motions are offered. The first is that the relative vorticity of the eddy, itself, shifts the lower bound of the inertial wave band from the Coriolis frequency to an *effective* frequency, which is near that of the diurnal, and thus allows trapping of energy at the diurnal frequency. The proximity of the anticyclonic eddy to tidally oscillating flow in Boussole Strait raises the possibility that these motions are eddy-trapped near-inertial waves rather than topographic waves. The second explanation is that wind-force perturbations may be trapped and amplified within the vortex of the eddy. In either case, amplification at the base of the eddy's core would then lead to shear-induced turbulence so that the rate of mixing should vary with external forcing.

Significant temporal variability has been observed in the western subarctic boundary currents in 1990-2000. This variability can be compared with the well-recognized regime shift that occurred in 1976-1978. Our observations show a new index of these rapid climatic changes: the structure and thermohaline properties of anticyclonic eddies of the western subarctic boundary currents. These properties, in turn, are linked to interactions between the seas of Japan and Okhotsk.

10AM2001 S5-099 poster

THE MECHANISM OF NUTRIENT SUPPLY TO WARM CORE RING OFF SANRIKU JAPAN

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The nutrient concentration and the primary production are higher in warm core ring (WCR) than in the Kuroshio which is the origin of WCR. We observed the same WCR at January and May in 1997. The difference in the thermostad of WCR from January to May is as follows: Δwater temperature:-0.60°C, Δsalinity:-0.044, •sigmaθ : 0.073• • (NO2+NO3)-N : 1.83 μM. We thought the mechanism of nutrient supply to WCR at winter is 1)mixing with Oyashio surface water, 2)mixing with isopicnal mixing with Oyashio water, 3)entrainment in the bottom of WCR. 1) If the decreasing of salinity was due to mixing with Oyashio surface water, the increase of nitrate was estimated to be only 0.25μM. 2) If the decreasing of salinity was due to the isopicnal mixing, the increase did to be 0.88 μM. 3) We thought that the decrease of salinity in the WCR in May was due to mixing of the WCR in winter with the less saltier water under the WCR. When we calculated the amount of the salt decrease which was equal to that of the water in WCR in May, the mixing depth was calculated to be 620m. The increase of nitrate was calculated to be 1.52 μM when the WCR at January was mixing by 620m. We thought that the mechanism of nutrient supply to WCR was due to deepening and entrainment of the underlying water. If so, cooling was stronger, nutrient supply became more.

10AM2001 S5-109 oral

BIOLOGICAL AND FISHERY IMPLICATIONS OF CYCLONIC EDDIES IN HAWAIIAN WATERS

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The combination of prevailing northeasterly tradewinds and island topography results in the formation of vigorous, westward propagating cyclonic eddies in the lee of the Hawaiian Island Chain on time scales of 50-70 days. These mesoscale ($\sim 10^2$ km) features are nowhere more conspicuous or occur more frequently than in the Alenuihaha Channel off the Kona coast of the Big Island of Hawaii. Like other open-ocean eddies, their biological impact can be significant, although Hawaii's open-ocean, wind-driven features dynamically contrast the well-studied current-generated eddies such as those that spin off the Gulf Stream and characteristically trap or isolate an adjacent water mass and retain its developed floristic composition.

Cyclonic eddies vertically displace the underlying nutricline into the overlying, nutrient-deplete euphotic zone creating localized biologically enhanced patches. Recent direct high-resolution horizontal and vertical observations of these vortices made from satellite and shipboard platforms provide new perspectives on biological enhancement within open-ocean cyclonic eddies and are presented here. From a trophic standpoint, these localized regions of high productivity may lead to aggregation and development of a forage base. Additionally, mesoscale eddies have been postulated to play a key role in recruitment processes, mechanically both limiting and aiding dispersal of littoral and pelagic young through entrainment and transport of organisms and the physical gradients may provide cues for predators to locate prey.

How eddies may directly influence pelagic fish distribution are examined from recreational and commercial fish catch data coinciding with the presence of eddies. We highlight the 1995 Hawaii International Billfish Tournament in which a cyclonic eddy dominated the ocean conditions during the week long event and appeared to be the principal factor influencing fish availability.

10AM2001 S5-159 oral

WARM-CORE RINGS AND STREAMERS AND THEIR EFFECT ON FISH MIGRATION AND LARVAL TRANSPORT IN THE KUROSHIO-OYASHIO TRANSITION REGION

Takashige Sugimoto[1], Hideo Tameishi[2], Sachihiko Itoh[1] and Pravakar Mishura[1]

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In a typical oceanographic condition off the northeast coast of Japan, when two large-scale warm-core rings (WCRs) locate persistently, these WCRs and northward meandered path of the Kuroshio Extension are often connected by northward extending warm streamers. These warm streamers, of a few tens of kms in width and a few hundred m in thickness, carry not only heat, but also plankton and larval fish. Adult fish, such as skipjack, sardine and mackerel utilize them when they migrate northward for feeding in spring and summer. WCRs attached to the coast disconnect the first branch of the Oyashio along the coast, which controls not only southward transport of cold and nutrient rich water along the coast affecting on coastal production, but also on southward wintering/spawning migration of pelagic fish such as saury, mackerel and salmon. Physical characteristics and biological implications of these phenomena off the east coast of Japan will be described with several examples, based on the oceanographic observation, and by using SST thermal images, satellite tracked drifters, fish catch data etc.

10AM2001 S5-043 oral

FORM AND FORTUNE OF HAIDA EDDIES

Frank **Whitney** and Marie Robert

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Haida eddies are 150 to 200 km diameter anticyclonic eddies that form near the coast of the Queen Charlotte Islands late each winter. These eddies move offshore in NW to SW directions, transporting up to 5000 km^3 of coastal water into the North Pacific. The core water of these eddies is warm, fresh and relatively nutrient rich when compared to oceanic waters of similar salinity. Haida eddies occasionally persist for more than 3 years, travelling as far as 1000 km from their source region. The water properties of 3 Haida eddies will be shown, and the loss rate of nutrients from the largest of them, estimated. The effect of nutrient shedding on primary production will be discussed.

10AM2001 S5-155 poster

IRON DISTRIBUTION AND TRANSPORT BY HAIDA EDDIES IN THE NORTHEAST PACIFIC OCEAN

C.S. **Wong**, W. Keith Johnson, Nes Sutherland and Melissa Chierici

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This paper describes the evolution of changes in dissolved and total iron in the Haida 2000 eddy, observed over a year from the CSS *J.P. Tully* tracking it in the Northeast Pacific Ocean.

The Haida eddy is a slow-moving, anti-cyclonic eddy of 200-300 km diameter, originated in the coastal waters off the Queen Charlotte Islands on west coast of Vancouver Island, moving in a northwest direction into the open-ocean, typically at speed of 3-5 km per day. Iron measurements were made using a chemiluminesence technique on samples collected from the surface to a depth of 600 m at the center, the edge and outside the eddy. In June 2000, surface unfiltered iron was already at a low of about 0.2-0.3 nM in the surface 40 m, then increased to about 1.3 nM in the permanent pycnocline at about 100-120 m. However, in deeper waters of > 150 m to 600 m, iron at the edge or outside the eddy was decreasing slightly with depth at about 1.1 to 1.3 nM, while in the center of the eddy, iron was much higher at about 2 nM, indicating accumulation inside the eddy. The eddy transported 10^5 moles of iron from coastal into the intermediate water (200-600 m) and could be an important supply of iron to the HNLC surface waters via upwelling and vertical diffusion, so as to enhance biological draw-down of upper ocean CO_2.

10AM2001 S5-073 poster

CURRENT STRUCTURE OF A HAIDA EDDY

Douglas R. **Yelland** and William R. Crawford

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An anti-cyclonic, meso-scale eddy approximately 150 km in diameter was tracked by satellite-based radar altimetry from its origin near British Columbia's Queen Charlotte Islands in February, 2000, as it traveled westward. While its height slowly changed over time, the eddy's westward motion stopped almost completely in the vicinity of Bowie Seamount, remaining fixed in one location for several months, before later moving northward. During the time it was stationary, ADCP (Acoustic Doppler Current Profiler) transects showed classic clockwise rotation of the water mass in the southern portion of the eddy, with a maximum surface speed of 60 cm s^{-1} at a distance of approximately 60 km from the core. Geostrophic velocities were substantially lower, possibly due to data collection limitations (wide station spacing and a relatively shallow reference depth). In the northern area, from the latitude of Bowie northward over Hodgkins and Davidson Seamounts, the velocities (both ADCP and geostrophic) were lower and confused. Tidal influences around the seamounts and a general disruption of the eddy's flow by the shallow topography are possible explanations. Current velocity within the eddy also varied with depth. There was a zone of higher speed ($> \sim 35$ cm s^{-1}) above 100 m which narrowed considerably and rapidly below that. Maximum current speed was at a depth of 25 m. Geostrophic calculations

indicate that rotational flow continued to at least 2000 m, and probably deeper. Acoustic backscatter data show that the zooplankton biomass was generally lower near the core of the eddy and higher around the "edge" where the current speeds were highest. This elevated biomass was primarily in the upper 50 m.

10AM2001 S5-127 poster

EFFECT OF KUROSHIO FRONTAL WAVE AND COASTAL TOPOGRAPHY UPON COASTAL ENVIRONMENT

Takafumi Yoshida and Takashige Sugimoto

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In Kuroshio region, frontal waves have a wavelength of 100-200 km, the period of 10-20 days and a vertical scale of 100 m. They tend to move downstream at a speed of 10-20 cm/s, and develop to a cyclonic eddy with warm streamer in the periphery. When eddy and streamer approach the coastal region, rapid currents and sudden increase of water temperature are induced. Furthermore these intrusions influence fishery ground formation, egg and larvae transport, water exchange in the coastal region. In this study, we analyze this warm water intrusion with special interest in the effect of interaction with peninsulas based on laboratory experiments. In the laboratory experiments, frontal waves are associated with coastal boundary density current are produced in an annulus rotating tank by discharged warm water over the inner cylindrical wall. Facts revealed in the laboratory experiments are as follows: (1) When frontal waves accompanying cyclonic eddy pass the offshore of the peninsula, the wave was divided into cyclonic eddy and anticyclonic warm streamer; (2) When the wave pass to the downstream of the peninsula, the offshore water intruded into the bay, inducing efficient water exchange; (3) Rate of water exchange depends on the amplitude of the frontal wave, ratio of wave length and the distance of the peninsulas, as well as the distance of the front from the coast.

S6 MEQ Topic Session
Sediment contamination – the science behind remediation standards

Convenors: Steve C. Samis (Canada) and Dong-Beom Yang (Korea)
Thursday, October 11, 2001 08:30-12:30

Scientific criteria for the regulatory management of contaminated aquatic sediments are being developed in various jurisdictions around the North Pacific. Approaches to criteria setting for sediment quality evaluation and protection vary based on the legislative regime, the contamination history of regions, aquatic life at risk, human use of fish and economic factors. A number of other factors need to be defined, such as: appropriate thresholds for triggering remedial actions, dealing with mixtures of contaminants while using numeric criteria, definition of baseline or background conditions, importance of bioavailability, inter-calibration of bioassay test organisms and the use of risk assessment in lieu of numeric sediment criteria. Risk assessment is driven in part by socio-economic factors, but from a scientific perspective, contaminants that cause endocrine disruption in fish or that bioaccumulate in tissues will also drive regulatory decision making. From an ecological standpoint no observable effects in receptor biota is a reference point that can be implemented through the regulatory application of the lowest observable response level in carefully selected species. These and other factors will form the crux of a debate that this session and others that follow will need to foster.

Invited speakers:

Peter C. Grevatt (Environmental Protection Agency, U.S.A.) - Trends in the development of scientific remediation standards for contaminated sediments

James Meador (Northwest Fisheries Science Center, NMFS, U.S.A.) - Tissue and sediment concentrations of TBT and PCBs to protect juvenile salmonids under the Endangered Species Act

10AM2001 S6-049 oral

THE UTILITY AND USE OF SEDIMENT QUALITY VALUES (SQVs)

Peter M. Chapman
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Sediment quality values (SQVs) have been developed by a variety of researchers and jurisdictions, for both site-specific and generic use. There are basically two approaches to development of SQVs: correlative and mechanistic. Different SQV values for the same substance are typically derived by the different approaches and by the same approach depending on the data base and individuals involved. The development of SQVs is far from a certain science. Problems common to all SQVs include no or inadequate consideration of: exposure via diet or overlying waters; the influence of behaviour on exposure; sediment heterogeneity. Also, SQVs, with the possible exception of the U.S. EPA potency scheme for polyaromatic hydrocarbons (PAH), do not address the issue of mixtures of chemicals, which are the norm in contaminated sediments. Uncertainties with SQVs are compounded by the fact that presently we have a fundamentally poor understanding of normal ecological conditions and the natural variability associated with those conditions. Accordingly, SQVs should comprise a range of values, reflecting their uncertainty (e.g., the nature and extent of the protection they afford), rather than the current point estimates. Further, SQVs should not be used for definitive stand-alone decision-making, though they can be used for such as part of a weight of evidence approach. They should only be used alone for screening (e.g., dredging and disposal; ecological risk assessment; contaminated site investigations; natural resource damage assessments; baseline evaluations).

10AM2001 S6-072 oral

CANADIAN SEDIMENT QUALITY ASSESSMENT TOOLS

Connie Gaudet, Kathie Adare and Doug Spry
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A variety of sediment assessment tools, such as national sediment quality guidelines (SQGs), have been developed and applied in Canada for the assessment and remediation of contaminated marine sediments. The purpose of this paper is to provide the scientific background information for the derivation and implementation of Canadian marine sediment quality guidelines for the protection of aquatic life. Canadian SQGs are biological effects-based numerical criteria derived from available toxicological information according to a formal protocol established by the Canadian Council of Ministers of the Environment (CCME). Canadian SQGs have been developed for 31 substances of concern, including metals, PAHs, PCBs and number of organochlorines. Two assessment values, the SQG and the Probable Effects Level (PEL), are recommended for the assessment of contaminated sediments. These numerical guidelines define three ranges of chemical concentrations - below the SQG, above the SQG and below the PEL, and above the PEL. These ranges are consistently defined as 1) the minimal effect range within which adverse biological effects rarely occur, 2) the possible effect range within which adverse effects occasionally occur and 3) the probable effect range within which adverse biological effects frequently occur. Sediment quality guidelines have a broad range of potential applications, and in Canada are routinely applied as screening tools in the site-specific assessment of the potential risk of exposure to chemicals in sediment and in formulating initial management decisions (e.g., acceptability for open-water disposal, required remediation, further site investigation, and prioritization of sites). The applicability of Canadian SQGs in a regulatory context will be discussed using case-studies.

10AM2001 S6-010 invited

TRENDS IN THE DEVELOPMENT OF SCIENTIFIC REMEDIATION STANDARDS FOR CONTAMINATED SEDIMENTS

Peter C. Grevatt

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Contaminated sediments pose a significant threat to human health and the ecosystem. Management of contaminated sediments is a considerable challenge in the U.S., with 6-9% of sediments in rivers and estuaries contaminated to toxic levels. Remediation of contaminated sediments can be extremely costly; effective management is best achieved through the use of science-based remediation standards. Development of scientific remediation standards for contaminated sediments requires a detailed understanding of contaminant sources, fate and transport, potential receptors and pathways of exposure. Contaminants may be released into the water column from point and non-point sources, including atmospheric deposition resulting from global cycling. Fate and transport of contaminants in sediments are impacted by a myriad of factors including binding to organic carbon, deposition, resuspension and burial of fine-grained sediments, bioturbation and dissolution to sediment pore water, diffusion into the water column and in some cases, volatilization into the atmosphere. Contaminants in sediment may also be subject to microbial degradation, and uptake and metabolism by benthic organisms. Development of scientific remediation standards requires an understanding of the uptake mechanism and threshold for adverse effects in ecological species and humans. Understanding the sources, fate and transport, receptors and pathways of exposure at contaminated sediment sites will allow a focus on the most significant issues and identification of the most effective solutions.

10AM2001 S6-254 poster

RESULTS OF ENVIRONMENTAL MONITORING OF THE PILTUN-ASTOKHSKOYE OIL AND GAS FIELD (NORTHEAST SHELF OF SAKHALIN ISLAND)

Tatiana Konovalova, James Robinson, John Coil and Valentina Andreeva

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Over the 3-year period Sakhalin Energy Company has conducted the environmental monitoring in the oil and gas development area offshore northeastern Sakhalin. Area around Molikpaq production platform and appraisal drilling site were surveyed in 2000. Hydrological, hydrochemical and hydrobiological parameters were determined in the water column. Sediment was analyzed for granulometric composition, heavy metals, hydrocarbons content as well as benthos species composition and abundance.

All hydrochemical parameters analyzed in 2000 did not exceed baseline level and fisheries maximum permissible concentrations as well as in 1998. No changes of diversity, structure and abundance of plankton were observed.

Concentrations of heavy metals and hydrocarbons in the sediments of the Molikpaq platform area and the appraisal drilling site also did not exceed the background values estimated for the Piltun-Astokhskoye area and are consistent with the levels specific for northern seas unaffected by human activities.

As a result of installation of the Molikpaq platform in 1998 associated with dredging and dumping operations, a change in soil granulometric composition was observed. However, natural lithodynamics have mitigated this anthropogenic impact on the bottom sediments. By 2000 the sediments have returned to the original condition and restoration of the benthos community in under way.

10AM2001 S6-285 oral

DEVELOPMENT OF SEDIMENT QUALITY CRITERIA FOR CONTAMINATED SITES IN BRITISH COLUMBIA

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In British Columbia, the federal and provincial governments share authority for assessing and managing contaminated sediments (i.e., under the *Fisheries Act* - FA, the *Waste Management Act* -WMA, and, the *Canadian Environmental Protection Act* - CEPA). Currently, standard procedures for assessing contaminated sediments have not been established by either level of government. In addition, numerical sediment quality criteria have not been formally established for assessing or managing contaminated sites.

In recognition of the need to establish harmonized procedures for assessing and managing contaminated sites in British Columbia, a federal-provincial Sediment Technical Committee was established in January, 1998. This committee was charged with the task of developing a joint federal-provincial framework for assessing and managing contaminated sediments, a guidance manual to support the design and implementation of sediment quality assessments at contaminated sites, and sediment quality criteria to support the management of contaminated sediments. The work of the Committee's contractor (MESL) has provided:

1) An overview of the history of the guidelines derivation and evaluation process;
2) A summary of the preliminary results of the most recent evaluations of the predictive ability of the SQCs when applied in a mixture model, and a discussion of the implications of these analyses; and,
3) A discussion of the results of an evaluation of the draft SQC for individual substances.

The results of MESL's evaluations of the comparability, reliability, and predictive ability indicated that the CCME SQGs provide a relevant basis for deriving numerical SQC for assessing and managing contaminated sediments in BC. More specifically, these results clearly demonstrate that there are definable dose-response relationships between contaminant concentrations and sediment toxicity in both freshwater and marine sediments. As such, sediment chemistry data alone can generally be used to accurately classify marine and freshwater sediments as toxic or non-toxic.

The sediment management framework under development is designed to offer clear benchmarks that can be used or adopted by parties for decision making on a site specific basis. MESL's findings may additionally obviate the need to of parties to conduct expensive and time-consuming evaluations of sediment toxicity and benthic invertebrate community structure assessments at all but the largest and most complicated sediment contaminated sites. The management framework recognizes the role and value that can be derived through the use of progressively more detailed analysis tools such as the sediment TRIAD, benthic community analysis and ecological risk assessments as part of a weight of evidence approach. Such work is typically recommended at sites where the cost of remediation are likely to greatly exceed the costs of further investigations.

10AM2001 S6-018 invited

TISSUE AND SEDIMENT CONCENTRATIONS OF TBT AND PCBS TO PROTECT JUVENILE SALMONIDS UNDER THE ENDANGERED SPECIES ACT

James Meador

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Under the Endangered Species Act, NMFS has authority to protect listed species from any adverse actions that may jeopardize the population's ability to recover and increase to sustainable levels. Salmon often spend several weeks in urban estuaries where they can bioaccumulate contaminants from sediment and prey to levels that may impact the ability of individuals to grow and mature normally. This presentation will cover our recent work to determine tissue and sediment concentrations that are expected to be protective for salmon and their prey.

Effects on salmon prey species due to TBT will be discussed first and two approaches for determining adverse sediment concentrations due to tributyltin (TBT) contamination will be presented. The first is the equilibrium

partitioning (EqP) approach, which relies on a sediment-water partition coefficient and toxicological data for water exposures. The second approach involves determination of a TBT tissue residue that is considered harmful for most species, which is then used to predict the sediment concentration that would likely produce this adverse tissue concentration.

The second common urban contaminant to be discussed will be PCBs. All relevant studies that related biological effects to tissue concentrations in salmonids were examined. The tissue concentration associated with the 10^{th} percentile of these studies was chosen to represent the residue effect threshold (RET) above which juvenile salmonids would be expected to exhibit adverse sublethal effects. This value is expressed in terms of the lipid-normalized concentration because of the large effect lipid can have on the expressed toxicity and the substantial variability in lipid content observed in salmonids over their life cycle. A sediment concentration that is expected to produce the RET was then determined using the BSAF approach. Bioaccumulation of PCBs was examined in one river system as a model for determining an appropriate BSAF for juvenile chinook.

10AM2001 S6-255 poster

THE CONTENTS OF RADIONUCLIDES IN OFFSHORE BOTTOM SEDIMENTS OF NORTHEAST SAKHALIN IN THE AREA OF OIL AND GAS DEPOSITS

Galina V. Moiseychenko and G.S. Borisenko
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The marine bottom sediments accumulate toxic elements and are indirect indication of ecological contamination of water areas. Determination of a background environmental condition in the area of Lunskoe oil and gas deposit was conducted in connection with planning of drilling activities and production of petroleum at the east coast of Sakhalin. Drilling activities in northeast Sakhalin offshore region inevitably cause the increase of marine environment radioactive background due to increased contents of natural radionuclides and products of their disintegration in drill cuttings and formation waters. According to the state ecological experts commission conclusion based on Piltun-Astokhsky deposit feasibility report the ^{226}Ra and ^{232}Th volumetric activity of formation water reaches the level of 400 Bk/kg. The ability of clays, which are the base of drilling muds and are discharged in large quantities when drilling on shelf, to accumulate radioactivity is known. Therefore when conducting integrated ecological monitoring of oil and gas deposit regions it is necessary to make measurements and registration of radiation.

Sediment samples were taken in the area adjacent to the oil and gas deposit. The analysis showed the following limits of concentration of natural radionuclides: Ra-226 from 4.5 up to 15 bk/kg, Th-232 from 9.2 up to 29 bk/kg, K-40 from 390 up to 940 bk/kg, and contents of an antropogeneous radionuclide Cs-137 did not exceed 2.5 bk/kg of dry weight.

10AM2001 S6-256 poster

HEAVY METALS ENVIRONMENTAL CONTAMINATION DURING OFFSHORE OIL AND GAS DEPOSITS DEVELOPMENT

Galina V. Moiseychenko and U.G. Blinov
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The increase of heavy metals content in the bottom sediments of the offshore oil and gas deposits areas is observed. According to the Molikpak technical project hundreds of tons of barite is required. That's why the effect of heavy metals accumulation in the bottom sediments and hydrobionts is under way.

The heavy metals background concentrations in the bottom sediments of the northeast Sakhalin shelf before drilling activity were Fe: 0.92-0.28; Zn: 42.5-2.5; Cd: 5-0.5; Hg: 0.03-0.02; Cr: 24.5-3.5; As: 5.0-1.8; Pb: 1-0.5 micrograms per gram.

Heavy metals influence all levels of biological organization, including cellular and molecular levels, causing metabolism malfunction. These effects can be discovered before the death or tissues and organs injury take place in organism. Chronic experiments were made with mollusks, being typical representatives of bottom benthos. Scallop organs after 50-day exposure to water-based drilling mud mixed with sea water at 2000 mg/l (the mud

contained 94.2% of barite) accumulated cadmium, zinc, copper, manganese, iron, chrome and showed histological changes in tissues. Grey mussel gills and digestive gland accumulated cadmium, irreversible histological changes were observed. Chronic experiments with fish showed the increase of lipid peroxidation and total SH-groups content, decrease of total proteins concentration when exposing to 0.05 mg/l cadmium concentration in the environment. This proves biological membranes injuries, antioxidant system mobilization and whole organism depletion.

10AM2001 S6-257 poster

METHODICAL ASPECTS AND EVALUATION OF BOTTOM SEDIMENTS CONTAMINATION LEVEL

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The evaluation of quality of water environment in Russia is oriented at an existing system ecological and fishery specifications (MPC And MPD). The temporary methodical guidance (Mikhailova, 2000) stating the normal levels of the contents of chemical substances in bottom sediments of surface water objects represents the first experience of such documentary assessments and passes now the stage of confirmation and legalization.

At the present stage of environmental protection activity the use of methods for environment condition evaluation, based on biota response registration, is especially actual. To provide toxicological control of the bottom sediments, the influence evaluation of contamination on hydrobionts in certain areas of Nakhodka Bay, Sea of Japan, was carried out experimentally. Since bottom sediments are capable to accumulate and bear an integral evaluation of environmental condition, the bottom sediments extract biotesting was made, test object was plankton crustacean.

The regions of bottom sediments sampling are characterized by antropogeneous sewage disposal: Nakhodka Bay - 21872, 46 thousand m^3, total MPC excess - 120, Novitsky Bay (petroleum terminal) - total MPC excess - 4,5, Vrangel Bay (Vostochny Port) – total MPC excess - 0,13.

The analysis of the obtained data has shown that above-sediment fluid, taken from Nakhodka Bay and diluted 4 times, caused 100% mizidae mortality during 48-hours. While biotesting of Novitsky Bay grounds the dilution of 2-4 times did not reduce the influence impact and caused 60-70% mizidae mortality during 48hrs.

10AM2001 S6-054 oral

METAL CONCENTRATIONS IN MUSSELS AND OYSTERS IN RELATION TO CONTAMINATION OF AMBIENT SEDIMENTS

Vladimir M. Shulkin, B.J. Presley and V.Ya. Kavun
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The chemical composition of the bottom sediments is often considered as an integrated assessment of anthropogenic impact, and metal concentrations in mussels and oysters are often taken as indicators of anthropogenic influence on the biological compartments of the coastal ecosystems. Therefore even the simple empirical relationships between metal concentrations in molluscs and those in associated bottom sediments can supplement and improve the scientific basis for the sediment quality criteria. In the work reported here, the set of similar coastal localities in the Peter the Great Bay, Sea of Japan were sampled. Included were locations with extremely enriched Pb, Cu, Zn, Cd, and Ni concentrations in both sediments and molluscs (mussel *Crenomytilus grayanus* and oyster *Crassostrea gigas*). Metal concentrations were determined in the different pools of sediments (resuspended matter, fine grained fractions and easy-leachable metal forms), and in the different organs of molluscs (muscle, mantle, gills, digestive gland, and soft tissues as a whole). Significant bioaccumulation of metals by mussels was observed only after some apparent threshold of sediment contamination had been reached. Threshold values increased in order Pb < Cu < Zn < Cd in accordance with the particle reactivity of metals, and possible physiologic control of accumulation. Oysters began to accumulate metals without a distinct threshold of metal concentrations in sediments. Joint consideration of metal concentrations in the somatic and excretory organs of mussels improves their sensitivity as a biological indicator of contamination. Thresholds of

metal contamination in sediments established by using the chemical composition of associated mollusks will be compared to those determined by other criteria.

10AM2001 S6-080 oral

HEAVY METALS AND METALLOIDS FROM MINING OPERATIONS IN COASTAL MARINE SEDIMENTS OF THE PENINSULA OF BAJA CALIFORNIA

Evgueni **Shumilin**[1], G. Rodríguez-Figueroa[1], O. Morton Bermea[1,2], D.Yu. Sapozhnikov[3], E. Lounejeva Baturina[4] and E. Hernández[2]

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Santa Rosalía was a center of copper mining and processing activity from 1894 until 1984, being during almost a century a permanent source of local contamination of this portion of the coast of central Baja California Peninsula and of adjacent part of the Gulf of California and until now it still reveals prominent features of strong environmental impact. Extremely high levels of Cu, Zn, Cd, Pb, Mn and elevated contents of As, Ba and lanthanides were detected in beach black sands and coastal marine sediments. The area with anomalously high heavy metal contents is rather limited in square being oriented on the arroyo de Santa Rosalía and Santa Rosalía Harbor with a sharp decreasing gradient of HM concentrations out of this zone. Vertical profiles of HM contents in sediment cores on the transect from the hot spot to open gulf confirm this tendency, probably due to relatively high self-purification of sedimentary material caused by relatively high sedimentation rates with a dilution of contaminants by natural, mainly biogenic components of the sediments.

10AM2001 S6-232 oral

PLAN AND PRACTICE OF SEDIMENT QUALITY CRITERIA IN CHINA

Mingjiang **Zhou** and Tian Yan

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China will publish a "Marine Sediment Quality" soon as one of her National Marine Standards along with "Marine Biota Quality", "Marine Atmosphere Quality" and existing "Sea Water Quality". For long time, lack of such an national marine sediment quality standard, which should be effectively authorized, scientifically well defined, most comparable to other standards/criteria used in the world and satisfactorily matched with historical data on marine sediment, raised not only problems in the assessment of increasing sediment data coming from different investigations but also the difficulties of management on marine sediment environment. This paper summarized the history of the development of the "marine sediment criteria/regulation, the scientific challenges to the effort, the approaches used in the development and step by step practice to work out the national criteria/ standard for marine sediment. Which included a three-stage project, determining of suitable items in the list, testing/validation of the criteria and comparison the developing criteria with others in the world.

S7 MEQ Topic Session
Physical oceanography to societal valuation: Assessing the factors affecting coastal environments

Convenors: Julia K. Parrish and John E. Stein (U.S.A.)
Tuesday, October 9, 2001 08:30-12:30

The Pacific Northwest Coastal Ecosystems Regional Study (PNCERS) is a five year, multi-investigator, multi-disciplinary exploration of the natural and human-mediated factors affecting the health and sustainability of estuarine and nearshore environments in Oregon and Washington. Individual research projects include the physical oceanography of nearshore-estuarine linkages, the use of salmon, seabirds, and benthic invertebrates as bio-indicators of system change, and the dichotomy between human uses and expectations of the local marine environment. This symposium will highlight the results of individual projects as well as those emerging from cross-disciplinary efforts. The latter include how spatio-temporal patterns of mesoscale circulation translate into differential crab and oyster production, the use of hydroacoustically determined biomass estimates as predictors of upper trophic distribution and abundance, and the development of indicators and indices of system integrity. Although PNCERS concentrates on a part of the California Current System, the comprehensive approach, including bottom-up, top-down, and human-mediated factors, is a model for future programs throughout the North Pacific.

Invited speaker:

Julia K. Parrish (Northwest Fisheries Science Center, NMFS, U.S.A.) - Indicators of estuarine structure and function: Physics, biology and socioeconomics

10AM2001 S7-185 oral

ESTUARINE-OCEAN COUPLING AND LINK TO COASTAL FISHERIES: DUNGENESS CRAB AND ENGLISH SOLE

David **Armstrong**, Chris Rooper and Donald Gunderson

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Whereas few commercial species have life history stages that use estuaries as nurseries, Dungeness crab (*Cancer magister*) and English sole (*Parophrys vetulus*) are dependent on recruitment to nearshore and estuarine habitats for successful year classes. Dungeness crab and English sole are two important indicators of the ecological, economic, and social health of estuarine systems. Although larval crab supply is variable, limited intertidal refuge habitat (shell and eelgrass) is saturated by several incoming cohorts of crab each year, and subsequent abundance of older subtidal 1+ is relatively constant. Estimates for 1+ abundance in Grays Harbor and Willapa Bay are about 8-10 x 10^6 which could equate to about 20 to 40% of the coastal fishery for 3-4 yr old males. Summer abundance of 0+ English sole in Willapa Bay and Grays Harbor range from 30-60 x 10^6, perhaps derived from spawning populations off central Oregon. Drowned river coastal estuaries of the Pacific Northwest are generally large in Washington (Grays Harbor and Willapa Bay are about 150 km^2 each) and smaller in Oregon (tens km^2; Coos and Yaquina Bay). Although Oregon systems account for much less of coastal fishery production, crab and sole density and population structure across all four PNCERS estuaries correlate to variables such as temperature, extent of secondary channels and adjacent tideflats, predator abundance and prey production. Human perturbations in the form of exotic species (*Spartina* and the crab *Carcinus maenas*), dredging, landfill, and resource conflicts involving oyster culture and use of pesticides are threats to system integrity and certain coastal fisheries.

10AM2001 S7-410 poster

GEOSPATIAL HABITAT ANALYSIS IN PACIFIC NORTHWEST COASTAL ESTUARIES

Amy B. **Borde**[1], Ronald M. Thom[1] and Steven Rumrill[2]

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The overall goal of the Pacific Northwest Coastal Ecosystem Regional Study (PNCERS) is to provide resource managers and decision-makers with information about habitats that are useful in making management decisions in coastal estuaries of the Pacific Northwest. To achieve this goal, a portion of our study focused on a geospatial analysis to understand and document existing and historic patterns of primary benthic habitats. Through a retrospective analysis, we documented large scale changes in the primary benthic habitats that have taken place in four estuaries in Washington and Oregon: Grays Harbor, Willapa Bay, Tillamook Bay and Coos Bay. The primary data sources were historical navigation charts, but also included other maps containing habitat distribution data. All estuaries had maps dating from the late 1800s, with limited information regarding the three major parameters we were interested in: bathymetry, shoreline position and habitat distribution. Using a geographic information system (GIS), we developed layers for each of these parameters for the years where data were available.

The general conclusion regarding historical changes is that tidal wetland area has declined in coastal estuaries, while flats may have increased in Tillamook Bay, and decreased in Willapa and Coos bays. The high intertidal flats in Willapa have been converted to salt marsh (*Spartina alterniflora*). The implications for fisheries resources awaits future analysis, but we can conclude that key resources that are the target of PNCERS, such as Dungeness crab and juvenile salmon have probably suffered some impact from loss of key estuarine habitats. The losses are explained by development of agriculture and forest practices in the watershed and tidal wetland portions of the systems. Dredging of navigation channels, such as Coos Bay and Grays Harbor, has deepened channels which has changed circulation, physical processes and the bathymetry in the systems.

In addition to the historical analysis, we were able to use the most current bathymetry information to estimate eelgrass distribution and abundance in Willapa Bay and Coos Bay. By linking eelgrass elevation data collected in the field (i.e., upper and lower limits), with the bathymetry data, we were able to estimate the amount of area

where eelgrass could potentially be located. We then used our eelgrass density data to extrapolate the number of shoots in the area. This information can be used to estimate habitat resources and help determine potential areas for restoration.

10AM2001 S7-276 poster

COASTAL RESIDENTS' ATTITUDES REGARDING ESTUARINE ENVIRONMENTS AND RESOURCE MANAGEMENT

Christopher Farley and Rebecca Johnson

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Since the beginning of the environmental movement in the 1960s, the public has become increasingly interested in the management and use of natural resources. Through various mechanisms, the public has become more involved in natural resource decision-making. Consequently, it is important for resource managers to understand public environmental attitudes, and to understand how those attitudes are related to other variables such as demographics (e.g., age, income, career, and family) and sources of environmental information (e.g., government, interest groups, scientific reports and the various types of news media). A survey of coastal residents in five communities surrounding Pacific Northwest estuaries allows us to analyze these relationships using both quantitative and qualitative data. Residents responded to closed-ended questions about sources of environmental information, environmental attitudes, and preferences for resource management. In addition, they also wrote extensive comments on the surveys when asked for open-ended responses. Both sources of data are used to examine the relationship between demographics, information sources and environmental opinions.

10AM2001 S7-274 poster

THE ROLE OF INDICATORS IN THE MANAGEMENT OF PNCERS ESTUARIES

Bridget Ferriss and Tom Leschine

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Indicators are becoming a popular tool in environmental management. They are being used, on both national and international scales, for the purposes of comparison, research, communication, and as aids to policy decisions. This study examines the utility of indicators in local management regimes, specifically in estuaries along the Oregon and Washington coasts. Their current use and development are being explored, as well as the factors limiting their use. The results will aid in the practical application of current academic research, which has focused largely on indicator development.

10AM2001 S7-179 oral

OCEANOGRAPHY OF THE PACIFIC NORTHWEST COASTAL ZONE AND ITS COASTAL ESTUARIES

Barbara M. Hickey and Neil Banas

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Because the shelf in the Pacific Northwest is relatively narrow, nutrient-rich deeper water can be effectively brought to the surface by wind-driven upwelling. The coastline is relatively straight and wind systems are large scale so that currents and water properties are similar over relatively large distances. However, several mesoscale features such as river plumes, submarine canyons and coastal promontories exist and such features may be particularly important to primary and secondary production well as to larval transport and/or retention. For example, the plume from the Columbia River strongly effects turbidity, salinity, temperature, velocity, velocity shear and density fronts both nearshore and in coastal estuaries.

Water properties in estuaries during the spring to fall growing season are primarily controlled by processes occurring in the adjacent ocean. Because wind systems are large scale, changes in water properties usually occur at the same time in estuaries separated by as much as 300 km along the coast. Water presented at the mouth of the estuaries (for both upwelling and downwelling events) travels up-estuary at the rate of several km per day. In

late summer, local rainfall and thus riverflow into these estuaries is minimal; thus stirring by the region's large (4 m) tides, not density-driven estuarine circulation, is generally responsible for estuarine flushing and rate of exchange with the coastal ocean. In winter and the early growing season density-driven flushing may compete with or dominate tidal flushing.

10AM2001 S7-272 poster

A SPATIALLY EXPLICIT BIOENERGETIC MODEL FOR *Cancer magister*

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Bioenergetic models have been developed for a number of fish species, predicting the energy flow through an individual using a number of environmental and physiological parameters. In recent studies, spatially explicit models have used factors such as temperature, prey density, and prey vulnerability to predict areas of highest growth for foraging fish. Many of these models have provided information critical for the management of fish stocks. In contrast, bioenergetic models for crustaceans are limited and have not yet incorporated ontogenetic shifts in habitat, diet, and growth. In this study a spatially explicit bioenergetic model for three different life stages of Dungeness crab, *Cancer magister*, was developed using the computer software Fish Bioenergetics 3.0. This poster details the process of deriving the parameters used for consumption, respiration, egestion, and excretion rates of an individual crab and explores the potential applications of this model.

10AM2001 S7-186 oral

ASSESSING THE STATUS OF HUMAN COMMUNITIES IN PACIFIC NORTHWEST COASTAL ESTUARIES

Daniel **Huppert**, Rebecca Johnson and Kathleen Bell
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Just as ecologists attempt to understand the structure, dynamics, and status of estuaries, social scientists seek to understand the social and economic structure and status of human communities. Based upon readily available demographic and baseline economic data and two surveys (of coastal residents and coastal visitors), we have found both similarities and contrasts between the five bays studied -- Willapa, Grays Harbor, Tillamook, Yaquina, and Coos. All communities experience relatively high unemployment, low household incomes, and are unusually dependent on non-labor incomes. Coastal county population growth has lagged behind state averages, young people are out-migrating, and the remaining communities are older than state and national averages. Residents were attracted to the coast by rural conditions and natural resources, but chose specific locations based on job opportunities and proximity of friends and relatives. Newer residents support greater consideration of environmental over economic factors in making natural resource management decisions. Finally, coastal residents rely heavily on local information sources and overwhelmingly support government-citizen partnerships for making natural resource management decisions. Coastal visitors differ between the two States. In Washington, visitors are attracted to the beach and ocean activities, whereas Oregon coastal visitors more frequently focused on estuarine resources including crabbing, boating, and wildlife viewing. Some of these differences reflect differences in the biophysical features such as estuary size and habitat type. We explore how social-economic conditions, demographics, resource problem perceptions, and public process preferences vary across the five estuaries. These have important implications for local resource management agendas, procedures and organizations which also rely on local scientific understanding.

10AM2001 S7-273 poster

POTENTIAL LOCAL ECONOMIC SUPPORT FOR COHO LOCAL ENHANCEMENT PROGRAMS

Daniel Huppert and Kathleen Bell

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Coho salmon (*O. kisutch*) in Oregon coastal rivers are listed as a threatened species, while coho in southwest Washington are depleted but not listed under the Endangered Species Act. In a recent survey of residents near five Pacific Northwest estuaries, we sought to determine the degree to which local residents would be willing to support increased local efforts to restore salmon runs. We approached this using a standard Contingent Valuation Method which postulates outcomes of the restoration effort and determines respondents willingness to pay specified increased taxes. Using a non-parametric Turnbull estimation procedure, we find that the average willingness to pay ranges across the bays from $17 to $97 dollars. Also, the distribution of values among residents in each location is non-normal and double-peaked.

10AM2001 S7-277 poster

IMPORTANCE OF BIOPHYSICAL ATTRIBUTES ON COASTAL RESIDENTS' LOCATION DECISIONS

Rebecca Johnson Kathleen Bell and Daniel Huppert

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Biophysical attributes of bays and estuaries in the Pacific Northwest are important to local communities. Clean water, scenery, recreation opportunities, and resources for commercial extraction all contribute to the quality of life for residents. Changes in those attributes can influence migration patterns, and can impact the well-being of those continuing to live in these communities. In our survey of coastal residents in five communities surrounding Pacific Northwest estuaries, we found that factors such as scenery and recreation opportunities were very important characteristics for current residents, but were not the primary reason most people moved to these coastal areas. Instead, job opportunities - some of which are linked to resource extraction - were the most important factor causing people to move to their current coastal community. Similarly, a perception of job opportunities and cost of living worsening in these communities was the most cited reason for people who were considering moving away from their coastal community. For those considering moving away, fewer than 11% of the reasons cited were environmental in nature. Most often, the worsening environmental condition that was causing them to consider moving was decreased recreation opportunities in their bays and estuaries.

10AM2001 S7-187 oral

TOWARD BETTER USE OF SCIENTIFIC INFORMATION IN THE ENVIRONMENTAL MANAGEMENT OF PACIFIC NORTHWEST COASTAL ESTUARIES

Thomas Leschine, Andy Bennett, Michelle Pico, Kathleen Bell, Daniel Huppert, Bridget Ferriss and Sarah MacWilliams

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Scientific information rarely enters a management arena free of non-scientific influence. The scientific basis for adopted policies may be weak, and monitoring to assure policies are having their intended effects weak or absent. The goals of environmental management programs may be framed in ways that show less orientation toward assuring favorable environmental outcomes than concern for administrative or public process. Moreover, economic concerns, particularly where economic health is relatively poor, can have a pervasive influence on environmental policies. We have found all these things to be true in our studies of estuarine governance in the PNCERS region, but also instances where more ecosystem-oriented resource management is taking shape. Surveys of environmental managers and researchers reveal disconnects that make it difficult for managers to identify or utilize relevant research results. Also, managers and residents may have differing views of the severity of various threats to coastal estuaries. Nevertheless, managers support greater use of collaborative approaches that bring researchers more directly into environmental decision making, and more opportunities to learn what science can contribute to management. Ecosystem management and other systems-oriented

approaches to environmental management emphasize a broad, integrative, and participative process of seeking sustainability in the use of living resources. But the incremental nature of most policy and organizational change makes it unlikely that a dramatic shift to such an approach can occur. Nevertheless, strategies that focus on incremental improvement in the use of science in decision-making can be identified, and current work on environmental indicators and opportunities for collaborative environmental decision making points in that direction.

10AM2001 S7-181 oral

RELATING SALMON SURVIVAL TO ENVIRONMENTAL VARIABLES USING GENERALIZED ADDITIVE MODELS

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The first few months of ocean residency are thought to be a critical period in coho salmon early life history. Thus their survival may be an indicator of the state of the nearshore ocean. We developed a statistical model that explains a significant proportion of variability in west coast coho salmon smolt-to-adult survival from 1969 to the present. A generalized additive model (GAM) was constructed to represent the effects of ocean conditions during early life history from the winter before smolt migration to sea, through the first spring at sea and on into the first winter at sea. Model parameters were winter sea surface temperature, date of spring transition, water column stratification, and spring upwelling. The model fit was statistically significant with an explained variance of 73%. Our results suggest that in addition to average spring upwelling winds, the effect of the previous winter on water column stability plays a role in determining coho survival. Equally important are the timing of the spring transition and ocean conditions during the coho's first winter at sea. Because the environmental variables included in the GAM were not correlated, our results indicate that a lack of coherence among environmental processes may be the key to understanding the large year to year variability observed in west coast coho survival. To evaluate the utility of the model for predicting coho survival, we hindcasted coho survival back to 1948 and compared the model output to observed trends in coho production (derived from catch statistics). We also forecasted coho survival for upcoming years and compared the model predictions to forecasts based on the return rate of precocious males ("jacks").

10AM2001 S7-275 poster

STYLES OF COLLABORATIVE RESOURCE MANAGEMENT IN PACIFIC NORTHWEST COASTAL ESTUARIES

Sarah **MacWilliams** and Daniel Huppert

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Management of estuarine environments requires balancing conflicting interests among local residents and resource users, while the management process is complicated by overlapping jurisdictions of local, State, and Federal authorities. These two characteristics can lead to continuing conflict, poorly operating management systems, or stalemate and inaction. In recent years, collaboration among the stakeholders and authorities, rather than conflict and legal challenge, has been held up as a preferred means of achieving consensus and implementing effective management regimes. This study documents the range of interests and institutions involved in specific aspects of environmental management in the Grays Harbor, Willapa, and Tillamook Bays. We describe the ways that the management regimes utilize collaborative approaches. We find that a variety of styles for collaboration in estuary management have evolved for reasons tied to history and local context. We evaluate the outcomes of some collaborative efforts based upon criteria used in the literature on collaborative management and institutional analysis.

10AM2001 S7-278 poster

OCEAN-ESTUARY COUPLING IN THE COOS BAY ESTUARY: NEARSHORE AND ESTUARINE DELIVERY OF LARVAL AND JUVENILE FISH AND INVERTEBRATES

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Certain fish and invertebrates, such as English sole (*Parophrys vetulus*) and Dungeness crab (*Cancer magister*), enter Pacific Northwest estuaries during early life history. The importance of estuarine residence for the success of these species and whether certain behaviors promote delivery into estuaries is not as well documented. Are, for example, patterns of larval and juvenile delivery and abundance within estuarine areas similar to those in nearshore areas? An effort to explore this component of ocean-estuary coupling was made with a time series of light trap collections in Coos Bay and Sunset Bay, 2 km south of Coos Bay. Potential delivery mechanisms were identified through time series analysis of species' abundance and wind stress, upwelling indices, water temperature, and maximum daily tidal exchange. The light traps collected larval *C. magister*, hermit crab (*Pagurus* spp.), other *Cancer* species, juvenile northern anchovy (*Engraulis mordax*), black rockfish (*Sebastes melanops*), and sculpin (*Clinocottus* spp.). Results indicate strong coherence in delivery timing but not relative abundance between the two areas. For example, *C. magister* abundances in both areas were significantly correlated with upwelling indices and neap tides. However, total catch of *C. magister* in Sunset Bay (581 individuals) was lower than total average catch in the estuary (26,150 ± 674). For juvenile *E. mordax*, delivery to both areas occurred when northwest upwelling winds relaxed and water temperature increased. The total catch of *E. mordax* in nearshore collections (573 individuals) was greater than the total average catch in the estuary (165 ± 2.3). Additional information on species composition and potential delivery mechanisms will be presented.

10AM2001 S7-023 invited

INDICATORS OF ESTUARINE STRUCTURE AND FUNCTION: PHYSICS, BIOLOGY, AND SOCIO-ECONOMICS

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The PNCERS project is developing indicators for West coast estuaries for use in planning and management of estuarine resources. PNCERS defines indicators by two ideals: ecological integrity - a dynamic state in which physical and biological processes are unimpaired - and system health - a state in which interactions between society and the ecosystem result in stable ecological conditions, a sustainable local economy and a rich quality of life. We are attempting to create a list of candidate indicators, responsive to system structure and function, which are currently measured (or can be proxied) or would have a high benefit to cost ratio if added into a current monitoring scheme. To do this we focus on the broad "system" perspective, which recognizes three major elements: the physical environment, composed of the pelagic and benthic systems; the biological system, described trophically and exemplified by keystone species; and the socio-economic system, itself composed of the local economy, quality of life, and management of human activities. All three system elements interact via forces (e.g. climate change, fisheries) producing flows of materials and services (e.g. nutrients, biomass, aesthetic enjoyment). Candidate indicators include: for the physical environment - Pacific Decadal Oscillation, Pacific Northwest Index, flushing rate, dissolved oxygen, transport index, river plume index, *in situ* production indices, and habitat availability index; for the socio-economic system - indices of habitat alteration, exploitation, pollution, appreciation, human welfare, and management; and for the biological system - primary production, harmful algal blooms, indices of architecture species, salmon survival, aquatic biomass and biodiversity, and upper trophic diversity.

10 AM2001 S7-390 poster

COMMUNITY INTERACTIONS BETWEEN SEABIRDS AND COASTAL PELAGICS: STARVATION OR SATIATION?

Julia K. Parrish[1], Elizabeth Logerwell[1], David Hyrenbach[2] and William J. Sydeman[3]

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In the California Current System (CCS), piscivorous seabirds, including Alcids, Procellariids, Larids, and Phalacrocorids, are both resident and wintering visitors. On the shelf, on an annual basis, these seabirds comprise more than 3,600 metric tons of predatory biomass. Yearly energy requirements are species-specific, ranging from Brandt's cormorants (75 Kcal/gm/yr) to black-legged kittiwakes (200 Kcal/gm/yr). Excluding annual reproductive output, piscivorous seabirds demand 431 billion Kcal of energy. These seabirds extract energy from the coastal environment predominantly in the form of forage fishes, including Clupeids, Engraulids, Osmerids, Ammodytids, as well as juvenile Salmonids, Scorpaenids, Pleuronectids, and Gadids. Energy content of these prey items varies by a factor of 2.5, from Pacific cod (0.94 Kcal/gm) to eulachon (2.55 Kcal/gm). Therefore, depending on which prey species are consumed, seabirds eat 220-300 thousand metric tons of fish annually. Changes in the forage fish community, including the recent recovery of the Pacific sardine stocks may have dramatic effects on seabird consumption and forage fish population dynamics. Because sardine energy content is relatively high (second only to eulachon), upper trophic level predators should specialize on this species. Current fishery landings in the sardine fishery are estimated at 120,000 metric tons. If seabird energy demand was applied solely to sardines, consumption would roughly double the fishery take, or about 15-20% of the total age 1+ biomass of 1.58mmt. However, unlike anchovies - the former predominant species - sardines grow beyond the range of seabird prey size within the first year of life. Thus, a transition to sardines could negatively impact seabirds even though this prey species is richer in energy.

10AM2001 S7-182 oral

BLOOM AND PLUME INTRUSIONS INTO PACIFIC NORTHWEST ESTUARIES

Curtis Roegner, Barbara M. Hickey, Jan Newton, Alan Shanks and David Armstrong

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Event-scale physical forcings can have strong impacts on biological systems. We studied estuarine-nearshore links in two Pacific Northwest estuaries, Coos Bay, OR and Willapa Bay, WA, during the upwelling-favorable season. In Coos Bay, estuarine circulation patterns and phytoplankton transport were measured from an anchor station located near the estuarine mouth at roughly weekly intervals. For the Washington system, estuarine-nearshore links during an upwelling-downwelling cycle were measured simultaneously from a series of cross-shelf transects and from instrument moorings at estuarine sites. The results demonstrate that material transfer in both estuaries was strongly influenced by the water imported from the coastal ocean, which in turn was influenced by local wind stress. The Coos Bay data delineates a strongly marine-dominated system which exhibited periodic imports of coastally-derived phytoplankton. The Willapa data clarified the role of upwelling-downwelling wind stress in promoting the intrusions of both phytoplankton and low salinity Columbia River plume water into the estuary. Both estuaries exhibited enhanced chlorophyll in flood-tide water and reduced levels in estuarine water. This coastally-derived phytoplankton is likely an important yet episodic food source for estuarine suspension-feeding fauna.

10AM2001 S7-270 poster

MEASURING VARIATION IN LARVAL SUPPLY TO ESTUARINE SITES WITH LIGHT TRAPS

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Many of the important invertebrate species utilizing estuarine habitat in the Pacific Northwest have pelagic larvae that are exported from the estuaries and develop in the coastal ocean. The population dynamics of these species can depend strongly on the relative numbers of mature larvae returning to estuarine systems. We seek to understand the causes of this variation in larval supply and its influence on subsequent recruitment. This poster describes the design and function of a light trap used to acquire daily measures of larval abundance. Light traps are behavioral samplers that utilize the propensity of many marine organisms to swarm towards a light source during nocturnal periods. The traps are very effective at capturing a wide variety of creatures, notably fishes and crustaceans, and are a superb method for acquiring live and robust specimens for observational or experimental studies. The best attributes of our light trap design are ease of deployment, rapid sampling, and simple and inexpensive construction. We have employed light traps in three Pacific Northwest estuaries for over three years to acquire daily time series of meroplankton abundance. These data are being analyzed in conjunction with cruise data and time series of oceanographic variables to better understand the processes controlling variation in the supply of larvae to estuarine and coastal sites. Examples of these time series, highlighting some of our recent findings for brachyuran crabs, are presented.

10AM2001 S7-271 poster

ENGLISH SOLE EGG AND LARVAL TRANSPORT ON THE OREGON/WASHINGTON SHELF IN 1997-2000

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Studies exploring the early life history of fish have resulted in a variety of mechanisms to explain recruitment patterns. For English sole (*Pleuronectes vetulus*) spawn timing and transport are thought to be important in determining the fate of pelagic egg and larval stages on the shelf off Oregon. English sole spawning is highly protracted and spawning activity can occur from September to April, exposing the 8-10 week egg and larval stages to a variety of oceanographic conditions. Young-of-the-year sole are found in shallow nearshore waters and estuaries in May and June. The purpose of this study is to examine the processes that influence transport of egg and larval stages from spawning grounds to nursery estuaries. A regression model was constructed using existing coastal wind and current data to predict larval transport. English sole spawning was simulated based on water temperature relationships developed by Kruse and Tyler (1983). Peak English sole spawning generally occurred in February and March of each year, with some additional spawning in other months. English sole larvae were carried predominantly northward and onshore towards nursery estuaries in Oregon and Washington, with the pattern of larval supply varying both interannually and among estuaries.

10AM2001 S7-183 oral

ASSESSING BENTHIC-PELAGIC COUPLING THROUGH DEMOGRAPHY OF OYSTERS (*Crassostrea gigas*)

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Oysters are an ecological and socio-economic keystone species within the PNCERS region. They act as an architecture species, creating habitat for other species in the estuaries, and are an important part of the socio-economic system as well. We studied oyster (*Crassostrea gigas*) growth and recruitment to explore benthic-pelagic coupling and the linkages between the ocean and estuary in a west coast estuarine system. Juvenile oysters were transplanted to four sites in Willapa Bay, Washington, in arrays including four positions from shore and four tidal elevations. Growth was recorded after two months, along with natural recruitment. Growth and

recruitment rates varied along two of three axes: throughout the bay and vertically in the water column. Growth rates near the mouth of Willapa Bay were >60% higher than at more estuarine sites. Highest rates of secondary production near the estuary mouth corroborate recent findings that phytoplankton biomass in Pacific Northwest estuaries is strongly influenced by oceanic inputs, rather than by terrestrial sources or *in situ* production. Growth rates generally rose with immersion time, except that oysters just above the substrate had depressed growth rates. These on-bottom oysters also had distinct stable isotope ratios, indicating relatively high consumption of benthic diatoms. Recruitment of oysters was lowest where growth was highest among sites, but within sites, recruitment and growth patterns were coincident. These results are consistent with larval production and retention entirely within the estuary and suggest larvae select tidal elevation but not spatial location for settlement. Altogether, we found close relationships between water-column processes and the densities and productivity of a dominant benthic filter feeder.

10AM2001 S7-180 oral

MESOSCALE BIOTIC FEATURES OF THE COASTAL NEARSHORE ENVIRONMENT

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Acoustic survey data were synthesized in an effort to identify broad scale biological response to physical forcing in the nearshore region of PNCERS. Analysis of data collected at 38 and 120 kHz by the National Marine Fisheries Service during summer 1995 and 1998 along the coast of Washington, Oregon, and California provided a high resolution map of fish schools and zooplankton patches as well as detailed bathymetric and oceanographic features (currents and fronts from ADCP data; water properties from CTD data).

Exploratory data analysis of these data revealed consistent and statistically significant biological responses over space and time:

1. A consistent layer of zooplankton was observed over the continental slope below the thermocline. The depth of this layer became shallower further north. The top of the layer appeared to be associated with a temperature range between 7 and 8 degrees C. The depth of the top layer was different between the years (~170 m in 1995 and ~120 m in 1998).

2. The shelf break was a region of consistently high fish and zooplankton abundance; higher than both the shallower shelf region and the deeper offshore region.

3. The density of zooplankton patches appeared to be higher in the neighborhood of submarine canyons.

These patterns occurred both years, despite one year (1998; an El Niño year) having fish schools (mostly Pacific hake) distributed much further north than in 1995. These results suggest patterns of fish-zooplankton overlap and zooplankton spatial distributions that transcend mesoscale oceanographic phenomena, and provide a consistent signature to the nearshore ocean region studied by PNCERS.

10AM2001 S7-184 oral

HISTORICAL CHANGES AND SHORT-TERM SPATIAL AND INTERANNUAL VARIABILITY IN MARSHES AND SEAGRASS MEADOWS IN WILLAPA BAY, WASHINGTON, AND COOS BAY, OREGON

Ronald M. Thom, Amy B. Borde, Steven Rumrill, Gregory Williams, Dana Woodruff and John Southard
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Within the larger program of Pacific Northwest Coastal Ecosystem Regional Study, the habitat studies form a key link between geophysical conditions and the quality of the estuarine system for a variety of fisheries resources. We examined changes in the areal extent of major vegetated habitats in Coos Bay and Willapa Bay estuarine systems using data from available maps along with an analysis of elevation data. Our historical analysis showed that large areas of tidal marshes have been lost in Coos Bay, and smaller but significant marsh areas have been lost in Willapa Bay. The mapping also showed that the invading species *Spartina alterniflora* has increased tidal marsh area in some locations in Willapa Bay. Our study on short-term variation used directed field and

laboratory studies coupled with geospatial analysis to understand and document the factors responsible for spatial and interannual dynamics of eelgrass (*Zostera marina* L.) habitats. As an architecture species, eelgrass creates essential intertidal/shallow subtidal refuge habitat for other organisms, such as Dungeness crab, living in the estuaries. We documented a major increase in eelgrass abundance over the study period (1998-2000), which occurred during a period of transition from a strong El Niño event to a strong La Niña event. As confirmation of our findings, recent published studies have shown global increases in ocean primary productivity during this period. Overall, salinity, temperature, and wave energies explained within-estuary variation, and water temperature variation explained interannual variation in eelgrass abundance in these systems. Smaller-scale factors include human disturbances such as boat wakes, oyster aquaculture, and clam harvesting.

S7

S8 MEQ Topic Session
Emerging issues for MEQ: A 10-year perspective

Convenors: Richard F. Addison (Canada) and Ming-Jiang Zhou (China)
Tuesday, October 9, 2001 13:30-17:30

PICES' tenth anniversary is a suitable occasion to look forward to issues which MEQ will face over the next decade. This session will build on the PICES X Anniversary Symposium and will focus in greater detail on evaluating the importance of emerging issues of pollution (e.g., "new" chemicals), marine resource use (e.g., the shift from commercial fishing to mariculture; offshore oil and gas or mining development), and projected impacts of onshore development on coastal systems.

Invited speaker:
Robie W. MacDonald (Institute of Ocean Sciences, Canada) - Emerging issues: danger or opportunity?

10AM2001 S8-129 poster

ON-LINE OIL SPILL MODEL FOR SAKHALIN SHELF (VOS-RT 2)

Alexander A. Bogdanovsky[1], Igor E. Kochergin[1], Valentina D. Budaeva[1], Vyacheslav G. Makarov[1,4], Vasiliy F. Mishukov[2], Viktor F. Putov[3], Sergey I. Rybalko[1] and Evgeniy P. Uraevsky[1]

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[4] *National Politechnic Institute, La Paz, Mexico*

FERHRI has worked out and implemented Regional System for on-line prediction of the oil spills in marine environment of the northeastern Sakhalin Shelf (VOS-RT 2). The main tasks of the System are on-line risk assessment for emergency oil spills and training. The System allows to model various aspects of oil spill impacts including specific oil characteristics (trajectories, shoreline pollution, spill characteristics) and dynamics of coastal waters. The System works automatically (24 hours a day) and is on free access via Internet (http://vosrt.hydromet.com).

Global and regional models such as *Global AVN Model of NOAA (USA), Global GSM Model of JMA (Japan), and Regional Far-Eastern Model of Roshydromet (Russia)* are used for the prediction of meteoparameters. Based on these models a comparative analysis of the surface wind forecast in the investigated area was made.

Hydrodynamic block includes diagnostic and prognostic modules. Problem of the nontidal current diagnosis for the typical wind situations is solved by using the baroclinic Ekman type model and multiyear hydrological data. Tidal current field is constructed over tidal harmonics calculated using multiday instrumental data. Prognostic module includes construction of the forecast hydrometeorological scenarios consisting of fields of nontidal and tidal currents, wind and other environment parameters. Hydrodynamic block was verified over instrumental data sets.

The model for oil spills fate consists of trajectory and physical-chemical blocks. Physical and chemical calculation block was approved during *in situ* testing on the northeastern Sakhalin Shelf. Trajectory block was successfully tested on the real oil spill, which occurred on the northeastern Sakhalin Shelf in autumn, 1999.

10AM2001 S8-406 oral

CONTAMINANTS IN SURF SCOTERS WINTERING IN THE STRAIT OF GEORGIA, BRITISH COLUMBIA, CANADA

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Populations of several sea duck species, including surf scoters are declining along the Pacific Coast. These declines have gone largely unexplained and have raised concerns about contaminant exposure as large numbers of surf scoters winter in the Georgia Basin, often in polluted estuarine areas and harbours. They are long-lived birds and therefore have the capacity to accumulate contaminants. Scoters feed principally on molluscs and other benthic organisms, a food chain known to accumulate endocrine disrupting substances. We examined temporal uptake of contaminants by surf scoters during the winter in the Georgia Basin by collecting birds during the early winter and again in the later winter at contaminated and reference sites. Carcasses underwent complete necropsy, and tissues were collected for histology, biomarkers and contaminant analysis. Hepatic EROD activity was induced in scoters collected from the harbour compared to scoters from the reference site. Over winter, the EROD activity increased significantly in scoters from the harbour whereas levels in scoters from the reference site remained constant. This response may have been induced by exposure to PAHs as a PAH-conjugated metabolite was detected in bile. Levels of chlorinated hydrocarbons and metals (Pb, Hg, Se, Cu, Zn, Cd) in scoters were minimal. Scoters wintering in the harbour had approximately 10-fold more butyltins than scoters from the reference site. Body condition of surf scoters declined significantly over the winter at both reference and contaminated sites. Further work is needed to assess if endocrine-disrupting substance exposure on the wintering grounds is contributing to population declines recorded on breeding grounds.

10AM2001 S8-404 oral

NEW-ERA ENVIRONMENTAL CONTAMINANTS: WHAT DO WE KNOW?

Michael G. Ikonomou

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In the past several years a substantial body of research has pointed out the hazards posed to wildlife and human health by synthetic endocrine-disrupting chemicals (EDCs). Broadly defined, EDCs are synthetic and/or natural agents present in the environment that interfere in some way with normal endocrine function. A number of industrial, municipal, agricultural, and natural compounds have been shown or are suspected to be estrogenic. Such compounds include polychlorinated dioxins, furans (PCDD/F) and biphenyls (PCBs); selected pesticides (DDT, methoxychlor, kepone); brominated flame retardants (PBDEs); non-ionic surfactants such as nonylphenol (NP) and biodegradation products of alkylphenol ethoxylates (APEOs); other industrial chemicals such as phthalates and bisphenol-A, as well as natural and synthetic estrogens (17b-estradiol, diethylstilbesterol, b-sitosterol and flavones).

Although there is a large body of scientific literature associated with the fate, distribution, toxicity and endocrine effects of classical organic contaminants such as PCDD/Fs, PCBs, DDT etc. there is limited information on the fate and distribution of "new era" environmental contaminants of industrial origin such as the PBDEs, APEOs and the phthalate esters. These chemicals are produced in mega-ton quantities each year and they are found in all environmental compartments. However, in order to accurately determine their environmental concentrations novel non-conventional analytical methodologies have been developed. This talk will provide an overview on the challenges associated in measuring these three classes of contaminants in environmental samples and will also present data showing their spatial and temporal distribution in the marine and freshwater environment.

10AM2001 S8-189 oral

LONG-RANGE ATMOSPHERIC TRANSPORT OF POLLUTANTS ACROSS THE PACIFIC: AN OVERVIEW OF CURRENT KNOWLEDGE

Dan Jaffe, Heather Price, Anna McClintick, Peter Weiss, Eric Prestbo and Ian McKendry

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We first identified long-range transport of pollutants from Asia to North America in 1997 based on springtime observations at the Cheeka Peak Observatory on the western tip of Washington state, combined with meteorological indicators. By adding vertical profiles of the key species to our surface observations and using several transport models to help interpret the data, we now know that most of the direct transport occurs in the free troposphere, between about 2-6 km above sea level. Subsequently the pollutants can get mixed into the boundary layer and impact the surface concentrations. The transport occurs both during occasional episodes, which have substantially elevated concentrations, as well as via a steady enhancement of the background concentrations. Compounds which we have detected to date include CO, O_3, nitrogen oxides, sulfur oxides, heavy metals, non-methane hydrocarbons, soot and mineral aerosol. The sources for these compounds include industrial emissions, deserts and occasionally biomass burning from the Eurasian continent. While we have learned a great deal on this phenomenon in the past few years there is still much we don't know. For example very little is known about possible transport of toxic constituents, such as persistent organic compounds and mercury. Also, we know very little about the deposition and uptake of these materials in marine and terrestrial ecosystems. While uptake of the toxic compounds can have negative consequences for marine ecosystems, it is also possible that deposition of mineral dust could be an important source for key elements in the North Pacific ecosystems.

10AM2001 S8-135 poster

POSSIBLE IMPACT OF HEAVY METALS ON MARINE ENVIRONMENT FROM OFFSHORE DRILLING

Igor E. Kochergin[1], Tatyana A. Gavrilova[1], Alexander A. Bogdanovsky[1] and Viktor F. Putov[2]

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One of the most dangerous impacts on marine environment during offshore drilling is caused by drilling wastes (mud, cuttings, produced waters, etc) discharges into the sea. Possible entering of heavy metals into marine environment and their fate there (dispersion and bottom sedimentation) is analyzed in this report.

Entering of heavy metals into the sea with cuttings and produced waters can be explained by their high concentration in nature. When water-base drilling mud is discharged, heavy metals may come with drilling chemicals. For example, the main components like barite and bentonite have more ions of Cu, Cd, Pb, Zn, Ba, etc. than bottom sediments. During drilling operations some heavy metals contained in chemicals become dissolved. When drilling mud is discharged, most metal compounds contained in suspended matters fall to the bottom but some of them still stay in sea water. Drilling mud was specially examined to determine the degree of metal compounds (Fe, Mn, Cu, Ni, Cd, Pb, Zn, As and Ba) conversion to the dissolved state. Experiments have shown that dissolution depends on various factors and metal properties. The highest dissolution is typical for Cd, Ni and Pb and the lowest – for Ba, Fe and Mn.

Numerical modeling of discharges fate considering the metals content in suspended and dissolved phases was carried out to determine scale and intensity of heavy metals impact on marine environment. Solid phase is characterized by a higher concentration of metals in bottom sediments. Concentration of dissolved metals is rapidly decreasing when they are mixed with water and maximum permissible concentration is met at a short distance. Monitoring results also confirm anthropogenic impact of metals on sea bottom and actually zero impact on the sea water quality in the drilling area.

10AM2001 S8-016 invited

EMERGING ISSUES: DANGER OR OPPORTUNITY?

Robbie W. Macdonald and Richard F. Addison

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In Chinese it is said that a crisis provides a danger that may be turned into an opportunity. Increasing human population in general, and accelerated encroachment of human activities on aquatic environments in particular undoubtedly pose a danger to coastal oceans which, if unchecked, will lead to crisis. A fundamental conflict arises from the expectation that the sea will continue to provide increasing amounts of food and recreation while, at the same time, provide an unlimited capacity to accept waste products of human activities. The dangers seem clear: loadings of classical toxic chemicals (industrial chemicals, pesticides, metals, PAH); loadings by "new" chemicals (ethoxylates, pharmaceuticals, pesticide substitutes); loadings by nutrients and micro-organisms; alteration of the hydrological cycle (damming or diversion of rivers); selective and massive withdrawal of ecosystem components (fish, shellfish; shrimp); introduction of exotic species (green crab, zebra mussel); aquaculture; cumulative impacts (construction, diversion, dumping, dredging, bottom trawling, long-range transport) and; climate change (temperature, hydrology). These dangers, which collectively threaten aquatic habitat and biodiversity, provide the opportunity to learn, to mobilize action and, in a few cases, to convert a stress into an advantage. Specific dangers that provide no apparent opportunities (e.g., PCDD/Fs and PCBs) suggest that we need strongly to pursue mitigative measures – the sooner the better. Opportunities, on the other hand, imply that adaptation might be a successful response. A clear message has emerged from our unintentional "experiment" to release megatonne quantities of organochlorine compounds to the environment: source control works.

10AM2001 S8-300 poster

EXPLORING LOW FREQUENCY VARIABILITY OF MARICULTURE PRODUCTION

María Verónica Morales-Zárate and Salvador E. Lluch-Cota
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During the last decade, mariculture production has been constantly increasing and many coastal countries are considering it as one of the few new potential sources for food in the following decades. However, it still faces a number of problems, such as access to technology and financial resources in the poor countries, environmental impacts, and diseases. Furthermore, a large proportion of the mariculture production is based on extensive techniques, meaning production still depends on availability of seeds (larvae), reproductive animals, food from the environment, etc. which in turn are closely related to the environment.

In this work, we show a few selected time series of aquaculture production from different regions of the world and compare them to catch series and environmental proxies. Results suggests that food security planning based on aquaculture should learn from the experience in fisheries science and realise that environment has the potential to strongly affect natural biomass levels, and that research at global and regional scales is needed to evaluate and characterize this potential.

10AM2001 S8-061 poster

OIL DRILLING FAULTS ANALYSIS: INSIGHT FROM AMCAD

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The oil production platform Molikpaq has been installed (52°42'55N, 143°33'59E) and one appraisal well (52°54'39N, 143°29'36E) was drilled in 1998. During the platform installation more than 1000.000 tons of bottom sediments were dredged and relocated. Drilling of appraisal well led to the discharge of approximately 1000 tons of drilling mud and cuttings to the sea.

To carry out damage assessment the approximation method for classification and analysis of data (AMCAD) has been employed. The analysis of physical properties of seawater and bottom sediments demonstrated that ecological consequences of Molikpaq installation are not too dangerous to impact marine organisms.

10AM2001 S8-062 poster

NUMERICAL MODELING OF THE OIL SPILL SPREADING

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The purpose of this study is to assess the evolution of boundaries of vortex patch, which, we assume involve the oil in the case of oil spill damage. Assuming that vorticity is distributed piecewisely constant, time evolution of a vortex patch is calculated using a contour dynamics model. The initial state has been proposed as unstable vortex with arbitrary boundary, and the process of its deformation has been examined. For understanding the deformation and mixing processes of the vortex patch itself and the surrounding regions streamfunctions and its evolution have been computed.

The possibilities of further development of this model for the tasks of oil spill in the ocean are discussed.

10AM2001 S8-266 oral

PACIFIC MARINE MAMMALS AS SENTINELS OF LOCAL AND TRANS-PACIFIC CONTAMINATION BY PERSISTENT ORGANIC POLLUTANTS (POPS)

Peter S. Ross

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Many marine mammal species occupy high trophic levels in the world's oceans, and are therefore vulnerable to accumulating the fat-soluble Persistent Organic Pollutants (POPs). These include many chemicals (e.g. PCBs, DDT) that have been banned from use in industrialized nations, but continue to be used in many developing nations. They also include "new" replacement chemicals with similar properties (e.g. PBDEs, PCNs), which represent emerging issues. Marine mammals represent the "ultimate receptors" for these chemicals in the world's oceans, and can serve as valuable "sentinels" for food chain contamination. Our recent finding that NE Pacific killer whales (*Orcinus orca*) represent the most contaminated marine mammals in the world suggest that this region is far from pristine. A food chain approach to evaluating the accumulation of POPs in food chains in British Columbia and Washington State suggests that a combination of local and offshore sources exist for contaminants in these killer whales. Local sources include industrial chemical "hotspots" in Puget Sound, while offshore sources largely reflect the atmospheric transport and deposition of POPs, probably of Asian origin, into the North Pacific. While the UNEP global convention to phase out the 12 priority POPs will help to reduce the atmospheric delivery of these chemicals to remote regions, further research will be needed to more fully understand the risk that unregulated POPs present to wildlife and to humans inhabiting the North Pacific environment.

10AM2001 S8-292 oral

THE GREATER VANCOUVER REGIONAL DISTRICT (GVRD) PLANNING FOR THE FUTURE: A SCIENCE-BASED RECEIVING ENVIRONMENT APPROACH TO MUNICIPAL WASTEWATER MANAGEMENT

Albert van Roodselaar[1] and Stan Bertold[2]

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The GVRD provides cost-effective utility services such as water, sewerage and drainage, and solid waste management to its 21 member municipalities and one electoral area. The GVRD owns and operates five wastewater treatment plants (WWTPs) that discharge primary and secondary treated wastewater that ultimately flows into Georgia Strait. Long-range planning for wastewater services is addressed through the GVRD's Liquid Waste Management Plan. The Plan outlines the preferred approach of the GVRD and its municipalities to manage its liquid waste discharges on a science-based monitoring approach, rather than the common prescriptive technology-based approach. Under this preferred approach, the need for actions that might include facility-upgrading programs is based on scientific evaluation, which considers water use and water quality objectives as well as other criteria and measures performance against receiving environment benchmarks. This evaluation utilizes a 'triggering' mechanism, which integrates various components: monitoring, water quality objectives, risk assessment, cost/benefit analysis, intergovernmental agency consultation, and actions.

The GVRD has conducted numerous investigations to characterize WWTP discharges and conditions in the receiving environment. Phthalate esters, nonylphenol and its ethoxylates were the most abundant organic contaminants found in wastewater discharges. Acute toxicity identification evaluations on discharges indicated toxicity has been due to non-persistent substances, un-ionized ammonia and anionic surfactants. Numerical modelling was utilized to forecast the dilution and dispersion of the effluent plume and its solids. Three excellent and 8 good quality tracers of sewage solids deposition were determined: nonylphenol, coprostanol, fecal coliforms; epicoprostanol, cholestanol, cadmium, NP1EO, cholesterol, mercury, silver, and p,p'-DDE. As well, key benthic infaunal indicators are being developed include Species Richness, Adult Infaunal Composition, Swartz's Dominance Index, Crustacean Abundance, and Ophiuroid Abundance. Fish health is monitored. Statistical tools such as bootstrapping are used to check the power and confidence of hypothesis-based monitoring findings. The effect of municipal WWTP discharges on the receiving environment is addressed relative to natural and other anthropogenic influences.

10AM2001 S8-040 poster

MARINE ECOSYSTEM PROTECTION IN CHINA

Jihui Yan

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The ecological system along China's coastal area is diversified, including typical mangrove ecosystem, coral reef ecosystem, estuary ecosystem and bay ecosystem. As the coastal area is highly populated and economically developed, the ecosystems there encounter great pressure and have degraded seriously due to irrational exploitation and environmental deterioration. The deterioration of the coastal ecosystem has seriously reduced its role in coastal disaster mitigation, resource conservation and environmental purification, and even has caused negative impacts on local climate. In this paper, the status of the ecosystem in the coastal area of China is described, and policies and measures to protect and restore the marine ecological environment are presented. International cooperation for coastal ecosystem protection is also discussed.

10AM2001 S8-417 poster

ATMOSPHERIC FLUX OF PAHS AND ORGANOCHLORINES TO THE SOUTHEASTERN YELLOW SEA: RESULTS BASED ON SHIPBOARD AEROSOL COLLECTION DURING 2000-2001

Dong-Beom Yang, Jun Yu, Yong Hyun Jin, Kyung Tae Kim, Suk Hyun Kim, Deok Soo Moon and Gi-Hoon Hong

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Shipboard aerosol sampling was made during 2000-2001 in the southeastern Yellow Sea. Atmospheric concentrations and deposition fluxes of polycyclic aromatic hydrocarbons (PAHs) and organochlorine pesticides were studied. PAH concentration in the atmospheric aerosol showed seasonal variation. Mean total PAH concentrations in the aerosol collected in September 2000 (2.4ng m^{-3}) were double those in June 2000 (1.2ng m^{-3}). Our PAH values are comparable to background air concentrations in inland areas of the World. γ-HCH concentrations in aerosol were in the range 7.2-99.3pg m^{-3}. The mean dry deposition fluxes were 107μgm^{-2} yr^{-1} for total PAH, with individual compounds varying from <1 (anthracene) to 25μg m^{-2} yr^{-1} (pyrene). Wet deposition flux of total PAH by particle scavenging was estimated at 180μg m^{-2} yr^{-1}. Dry deposition flux of γ-HCH was calculated to be 2315ng m^{-2} yr^{-1} in the southeastern Yellow Sea. All PCB congeners were below measurable levels in the region.

10AM2001 S8-125 oral

ENVIRONMENTAL ISSUES ALONG CHINESE COAST -- TAKING PEARL RIVER ESTUARY AS AN EXAMPLE

Mingjiang Zhou and Jay-Chung Chen

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This paper summarized the update information on environmental issues along Chinese coast. Generally speaking, much more attention has recently been paid on Eutrophication, Harmful Algal Blooms, Oxygen Deficiency, Pesticides, Detergent and Oil Spill as environmental problems in Chinese Waters. The Pearl River Estuary located in southern part of Chinese coast, an area reflecting quick economy development and its potential impact on the aquatic environment. Several specific environmental problems and phenomena in the estuary will be discussed: the role of phosphorus cycling in "Eutrophication", the effects of water stratification and bottom sediment consumption on "Oxygen deficiency", and variety issue related to "Harmful Algal Blooms" in Hong Kong and adjacent waters.

10AM2001 S8-336 oral

ECOSYSTEM CHANGES IN BOHAI SEA IN THE LAST TWO DECADES

Mingyuan Zhu and Ruixiang Li

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Bohai Sea is an inland sea in North China with an area of 77,284 km^2 and average depth of 18 m. It is rich in living marine resources and petroleum oil. It is an important fishing ground in North China as many fish and shrimp spawn and grow here.

There are three provinces and one Municipality along the coast of Bohai Sea. Since 1980s, industry, fishery, mariculture and urbanization has been developing quickly here. The significant changes of Bohai Sea ecosystem have been observed. It includes the increase of land source pollution, eutrophication and HAB events, the loss of habitat, the decrease of fresh water input, the decline of fisheries resources. Several projects such as Coastal Resource Conservation and Environmental Management Project supported by Asia Development Bank and The Bohai Sea Environmental Management Project supported by GEF/UNDP as well as a domestic Comprehensive Management Project have been carried out or initiated for resource and environment protection.

S9 MEQ/BIO/POC Topic Session
Physical, chemical and biological interactions during harmful algal blooms

Convenors: Hak-Gyoon Kim (Korea), F.J.R. (Max) Taylor (Canada) and Vera L. Trainer (U.S.A.)
Thursday, October 11, 2001 13:30-17:30

Physical processes play vital roles in the coastal environments in which HABs develop. The degree of vertical mixing strongly determines whether diatoms or flagellates will predominate. The former is favoured by high surface nutrients resulting from upwelling and small-scale turbulence. The latter can exploit stratification with low surface nutrients and a relatively shallow nutricline. Blooms are frequently advected by along-shore buoyant plumes from seed sites and frontal aggregations are common. The nature of the light regime is also a critical factor. The goal of this session will be to foster co-operation between physical and biological oceanographers.

Invited speakers:

Barbara M. Hickey (University of Washington, U.S.A.) - Biological/physical connections of harmful algal blooms in the eastern Pacific Ocean

Hee-Dong Jeong (NFRDI, Korea) - The prediction and movement of the harmful algal blooms in Korean waters

10AM2001 S9-420 poster

ECOHAB WEST COAST- OUR FIRST FIVE YEARS

Carol Auer
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Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) is a national research program, funded since 1997, studying HABs in the coastal waters of the U.S. Five Federal agencies currently collaborate to sponsor ECOHAB including the National Oceanic and Atmospheric Administration, National Science Foundation, U.S. Environmental Protection Agency, Office of Naval Research, and National Aeronautics and Space Administration. ECOHAB provides research support through open competitions and peer review. A primary goal of HAB research is to develop a predictive capability based on an understanding of how physical and biological processes interact to promote bloom development, affect bloom dominance, and contribute to bloom maintenance or decline. Knowing the causes of these blooms will lead to identifying means to prevent them. This effort will also develop forecast models that can alert managers to conditions favorable for bloom development and enable rapid response by monitoring agencies, health departments, and fisheries interests.

Since ECOHAB's inception, eight research projects have been funded on the West Coast of the United States all studying either the dinoflagellate *Alexandrium* spp. or the diatom *Pseudo-nitzschia* spp. *Alexandrium* produces saxitoxin, the causes of Paralytic Shellfish Poisoning (PSP) and *Pseudo-nitzschia* produces domoic acid, the cause of Amnesic Shellfish Poisoning (ASP). Here we present a summary of the projects funded by ECOHAB on the West Coast of the US including some preliminary findings.

10AM2001 S9-411 oral

STUDY OF *Alexandrium tamarense* BLOOM DYNAMICS IN THE ST. LAWRENCE ESTUARY (CANADA): A MODELING APPROACH

Juliette Fauchot, Maurice Levasseur, François J. Saucier, Suzanne Roy and Alain Vézina
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Toxic dinoflagellate blooms are greatly influenced by their physical environment, and hence climate forcing (e.g. precipitation, wind conditions). Biological factors, such as the spatial distribution and germination rates of resting cysts, the growth rate and vertical migrations of vegetative cells, also play a significant role on the development, maintenance and dissipation of these blooms. Exactly how these different physical and biological factors affect the dynamics of blooms of the PSP producer *Alexandrium tamarense* in the St. Lawrence Estuary (SLE) is still not well understood. The recent development of climatically driven circulation models for coastal areas and their coupling with appropriate biological models offer the opportunity to test hypotheses linking bloom dynamics with particular climatic, hydrodynamic and biological conditions. To explore the causes of a *A. tamarense* red tide observed in 1998 in the SLE, we used a Regional Ocean Model that reproduces the three-dimensional water circulation under atmospheric, hydrological and oceanic forcings. In the two scenarios tested, the initial spatial distribution of *A. tamarense* vegetative cells was based on the known spatial distribution of resting cysts in the sediments of the SLE and a 20% germination rate. First, vegetative cells were followed as passive Eulerian tracers in order to determine if the distribution of cysts, the timing of germination, and advection in the SLE could explain the general distribution of *A. tamarense* cells during the red-tide. Second, a growth rate of 0.5 division per day was set for vegetative cells to verify if cellular growth can account for the *A. tamarense* abundance observed during the red tide. Our preliminary results highlight the potential of this approach to understand and eventually predict toxic blooms in coastal waters.

10AM2001 S9-012 invited

BIOLOGICAL/PHYSICAL CONNECTIONS OF HARMFUL ALGAL BLOOMS IN THE EASTERN PACIFIC OCEAN

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The oceanography of the U.S. West coast is dominated by the California Current System, a system of currents with strong interannual, seasonal and several day scale variabilities. The wind-driven upwelling of nutrients from deeper layers fuels coastal productivity, resulting in both a strong seasonal cycle and several day fluctuations that mimic changes in the wind direction and, hence, upwelling. During an upwelling event, phytoplankton respond to the infusion of nutrients near the coast and this "bloom" is moved offshore, continuing to grow while depleting the nutrient supply. When winds reverse, the bloom moves back toward shore where it can contact the coast or enter coastal estuaries. In several regions where large coastal promontories occur, phytoplankton are swept offshore and southward by the meandering jets and/or eddies that form where the coastal jets detach from the shelf. In other regions, retention may occur and these regions appear to be associated with higher levels of domoic acid (DA). For example, off the Washington/British Columbia coast a semi-permanent eddy develops seaward of the Strait of Juan de Fuca and this eddy frequently contains higher levels of DA than elsewhere along the coast. During some years the eddy appears to move southward in prolonged upwelling events and then onshore during the first major storm of the fall season, causing high levels of DA in razor clams on Washington's coastal beaches and immediate closure of coastal clamming beaches, often for the entire season. High levels of DA are generally associated with high cell numbers of *Pseudo-nitzschia* (generally *P. pseudodelicatissima*) both offshore and near coastal beaches.

10AM2001 S9-015 invited

THE PREDICTION AND MOVEMENT OF THE HARMFUL ALGAL BLOOMS IN KOREAN WATERS

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Recent harmful algal blooms (HABs) represent a significant and expanding threat to fisheries resources and human health in Korea. From our regular monitoring since 1981, we proved that the nature of dinoflagellate blooms have changed over the last two decades. Their outbreaks were rare during the 1980s, but they became frequent and persistent during the 1990s. In the light of spatial distribution, it mainly occurred in the South Sea of Korea during 1980s. But in recent years, they became widespread encompassing entire southern coast and some part of eastern and western coast of Korean peninsula. HABs had been occurred mostly in mid-summer and lasted more or less one week during 1980s, but became persistent more than two weeks since 1990s. In particular, the bloom of *Cochlodinium polykrikoides* have been persisted nearly two months since 1995.

In this study, the relationship between the blooming of *C. Polykrikoides* and environmental parameters records collected at our regular monitoring stations on the South Sea of Korea since 1981 have been examined to predict the HABs. Even though we can find the presence and persistence of *C. polykrikoides* in the lower (20°C) or higher(28°C) water temperature, their outbreaks were mainly associated with temperature of 25-26° and salinity of 32.0-32.5psu.

The numerical simulations using Lagrangian method were also done to predict the movement of *C. polykrikoides*' blooming in the South Sea of Korea. It simulated well the short-term movement of the HABs to apply for the practical purposes.

10AM2001 S9-385 poster

A WAY OF SPORIFEROUS TISSUE DISPOSITION ON THALLUSES OF *Laminaria japonica* AS A FEATURE OF GROWTH CONDITIONS

Tatiana N. Krupnova

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The study of brown seaweed *Laminaria japonica* Aresch sporification dynamics in long-period 1975 -2001 years was carried out. It was determined, that a way of sporiferous tissue disposition on thalluses of Laminaria cannot be a systematic feature. The laying periodicity of sporiferous tissue on one or both sides of a thallus depends on contents of biogenic elements, in particular, on quantity of nitrogen in growth places of the seaweed and it is manifestation of morphophysiological plasticity have been response of different ecologic condition of inhabiting.

Thus, in stable flow of Liman Current the speed of sporification is high and it occupies the both side of the plate. While Liman current flow is broken by the income of warm waters which is poor with biogens the speed is decreasing and sporiferous tissue is only on side of the plate. We revealed the quantity parameters of extreme concentration of nitrates that causes the decreasing of sporification speed.

10AM2001 S9-387 poster

INFLUENCE OF HYDROLOGICAL CONDITIONS ON PRODUCT OF *Laminaria japonica arech.* IN NORTH-WESTERN PART OF THE SEA JAPAN

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Laminaria japonica is a species of boreal group An optimal condition for its growth is water temperature not higher than 16-18°C, good water exchange with flow speed not less than 30-40 m/sec, high biogen content of nitrates not less than 15-20 Mkg/l. The Liman Current in north-western part of the sea meet all this conditions. Because of this *Laminaria* has a stable productivity. But in the years when according to some reasons occurs the weakening of the current flow it follows by the change of *Laminaria* kelp status.

Thus, as a result of late coming of the phenologic autumn in northern Primorie region in 2000 a high water temperature stayed till middle of November. Such warming results. Such warming results in all-round destruction both first-year thalluses and mother thalluses with reproductive tissue. It results almost in full absence of second year thulluses on 2001 and decreasing of productivity of population in general. The destruction of more temperature-tolerated second year thulluses was not so considerable.

Till the decreasing of water temperature to favourable for sporification mother thulluses lost up to 2/3 of its plate square. It results in considerable decreasing of zoosporus seed amount. It lead to decreasing of first year thulluses outspread on 2001 and will lead to decreasing of productivity on 2002.

Such a situation is explained by the coming of warm water mass coused by delay of shift from southern winds to winter-type coastal ones, that in its turn was induced by the global athmosphere phenomena.

10AM2001 S9-218 oral

EFFECTS OF OILS AND CHEMICAL DISPERSANTS ON GROWTH OF HARMFUL DINOFLAGELLATE *Cochlodinium polykrikoides*

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The bioassay and toxicity tests were conducted to investigate the effects of various concentrations of Kuwait oil, Arab oil, Bunker-C, diesel oil, kerosene, oil spill dispersants and mixtures of oil and dispersant on growth of the harmful alga *Cochlodinium polykrikoides*. Growth of *C. polykrikoides* treated with higher concentrations (≥50 ppm) was found to decline markedly 4-10 days after the addition of oils used in this study compared with the

control, whereas ≤1 ppm had no significant effect on growth. Similarly, growth was inhibited when the cells were exposed to higher concentrations in dispersants (≥50 ppm), but they exhibited similar growth across the range of less than 1 ppm. In 10 days after the cells were exposed to higher concentrations mixtures of oil and dispersant (≥50 ppm), *C. polykrikoides* was almost died regardless of types of oils and dispersants. However, lower concentrations (≤1 ppm) did not play a role in critical toxicity concentration for suppressing the growth of *C. polykrikoides*. These results suggest that higher concentrations of oils, dispersants and even mixtures make a serious impact of *C. polykrikoides*, whereas the cells were not associated with toxicity, with lower concentrations.

10AM2001 S9-221 oral

EVIDENCE OF TOXIN PRODUCTION BY THE OCEANIC DIATOM, *Pseudo-nitzschia* DURING Fe STIMULATED GROWTH IN AN HNLC REGION

Adrian **Marchetti**, Paul J. Harrison and Vera L. Trainer

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The importance of iron (Fe) in regulating ocean primary productivity has gained wide acceptance over the last decade. Recent evidence has shown that iron fertilization in vast regions of the world's oceans has resulted in increased productivity and algal blooms. This has sparked the notion that anthropogenic iron additions could be a possible solution in combating the recent increase in atmospheric carbon dioxide.

Experiments in the Subarctic Pacific Ocean suggest that pennate diatoms may become the dominant primary producer after an iron addition. These oceanic pennate diatoms of the genus *Pseudo-nitzschia* have rarely been studied and very little information is known about their physiology and ecology. Research on similar coastal varieties of this group has implicated various species of *Pseudo-nitzschia* to harmful algal blooms. Their production of the glutamate analog, domoic acid which is a neurotoxin and produces amnesic shellfish poisoning, has been documented in coastal waters world-wide. Preliminary experiments in the Subarctic Pacific, at Ocean Station Papa, have confirmed the production of domoic acid by *Pseudo-nitzschia* spp. that dominate the phytoplankton community with the addition of iron. Future research goals will be to determine the conditions associated with the production of domoic acid by these diatoms as well as the possible role this toxin may serve. Such a study will allow for a better understanding of the effects of iron addition to open-ocean environments and provide some insight into the possible implications of shifting the phytoplankton community to pennate diatoms during large-scale iron fertilization experiments in the North Pacific.

10AM2001 S9-308 oral

MARINE BIOTOXINS IN MEXICO

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We wish to present a summary of 12 years of work assessing the risk of human poisoning by consumption of marine organisms obtained at the Pacific coast and Gulf of California in Mexico. In spite of having over 18,400 miles of coastline, seafood consumption among the Mexican population is relatively low. Yet, for the past 25 years over 500 cases of hospitalization and more than 20 fatalities have been reported by health authorities. Such record however, is certainly underestimated because many cases are erroneously mistaken and/or attributed to various infectious agents other than marine toxins. We will show evidence for the occurrence of TTX, PSP, ASP, DSP and CTX in the Pacific and Gulf of California, Mexico. We will present data with regard the level toxicity and its composition in mollusks and fish, and examples of the ecological impacts of marine toxins manifested as massive killings of seabirds and sea mammals. We discuss the properties of the first toxic dinoflalgellate isolated and cultured in Mexico (*Prorocentrum lima*), which adds to the controversial issue of "ciguatera" risk in the Gulf of California. Finally, we will show some preliminary evidences linking frequency and dynamics of harmful algal outbreaks to some regional environmental proxies.

10AM2001 S9-383 oral

RELATIONS BETWEEN DEVIATIONS FROM THE AVERAGE YEAR VALUES OF SURFACE WATER TEMPERATURE AND HAB OCCURRENCES IN THE PACIFIC CENTRAL AMERICAN COASTAL LME

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The Pacific Central American Coastal LME (PCAC-LME) have been and still are impacted by the flourishing of microalgal populations known as Harmful Algal Blooms (HABs). In spite of the piling of effects on the human health, the economic activities and the environment, there is still a lack of information available on the subject. This does not allow to clearly establish whether anthropogenic or natural phenomena, or both, are the major driving forces of this apparent increase on occurrences. The augmented use of coastal zones for human activities is also paralleled by increased awareness of global climate changes; thus, discriminating both effects is not an easy task. The long term data sets available for reduced regions, as well as some sporadic observations during notorious blooms, allowed us to compare the climate regimes, geographical conditions, nutrient availability (including eutrophication) and opceanographical parameters that promotes or allow to HAB development and maintenance, making evident major changes in the biodiversity and biogeography of HAB organisms. Factors affected are the number of events, the area covered, the duration and frequency, the number of species blooming and the appereance of not previously reported harmful taxa. HAB have been recognized, to widespread to areas previously unaffected. The organisms that have caused recent episodes of HABs are among others *Gymnodinium catenatum*, *Pyrodinium bahamense* var. *compressum*, *Pseudonitzchia australis* and recently *Cochlodinium* cf. *catenatum*. Sea surface temperature seems to be the factor more clearly related to this dynamic phenomena, while, up to date is not posible to weight its contribution.

10AM2001 S9-412 oral

IRON REGULATION OF DOMOIC ACID PRODUCTION BY TOXIGENIC *Pseudo-nitzschia* spp.

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Marine diatoms of the genus *Pseudo-nitzschia* only recently were recognized to produce domoic acid (DA), a potent neurotoxin responsible for amnesic shellfish poisoning in humans and capable of causing large scale mortalities of marine mammals and birds. Like all other marine toxins, the physiological role of DA in these algae has remained obscure. Recent evidence shows that DA, a small tricarboxylic amino acid, forms stable complexes with iron indicating that its function may be linked to iron metabolism. Our findings show that dissolved DA in the medium enhances iron uptake by *Pseudo-nitzschia multiseries*, and that DA production by cells growing in log phase is substantially higher under iron stress with all of the added chelator being released to the medium. Field experiments conducted during the large toxic *Pseudo-nitzschia australis* bloom in Monterey Bay, CA in 1998 showed that these cells were more easily starved for Fe compared to non-toxic diatoms. Moreover, artificially induced iron stress in natural population cultures caused a 95% decrease in the cellular DA content of cells. These findings are the first to indicate that the primary physiological function for DA is to facilitate iron uptake, and that iron stress may be responsible for the widely variable cellular toxicity of Pseudo-nitzschia blooms in coastal waters.

10AM2001 S9-056

THE ROLE OF PHYSICAL, CHEMICAL AND BIOLOGICAL FACTORS IN HAB FORMATION -- EXPERIMENTAL STUDY USING MONO AND MIXED CULTURES OF THREE HAB SPECIES

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Three important HAB species Dinoflagellate *Alexandrium tamarense*, Raphidophyte *Heterosigma akashiwo*, and Diatom *Skeletonema costatum* were chosen in the study to explore the role of some physical, chemical and biological factors in HAB formation. 3-factor experiments have been used to study the combined effects of temperature (12, 19, 25, 32°C), irradiance (0.02, 0.08, 0.3, 1.6×10^{16} quanta.sec^{-1}.cm^{-2}) and salinity (10, 18, 25, 30, 35‰) on the growth of each species. The growth of these three important HAB species in mixed cultures in different nutrient conditions (+Si/-Si, N:P=5/25) and under different salinities (10, 18, 25, 30, 35‰) and temperatures (19, 25°C) was also studied. The community structure changes were examined during the experiments. The results of mono-culture showed that the optimal growth condition for *A. tamarense* was at 19°C, 30‰ and 1.6×10^{16} quanta.sec^{-1}.cm^{-2}; for *H. akashiwo*, 25°C, 10-35‰ and 1.6×10^{16} quanta.sec^{-1}.cm^{-2}; and for *S. costatum*, 25°C, 18-35‰ and 1.6×10^{16} quanta.sec^{-1}.cm^{-2} respectively. Combining with the results of mixed culture, the role of the physical, chemical and biological factors in HAB formation were discussed.

10AM2001 S9-064 oral

STUDY ON THE HAB BIOLOGICAL MODEL IN CHINA

Mingyuan Zhu, Fangli Qiao, Ruixiang Li and Shang Chen

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As an abnormal event in the sea, the occurrence of Harmful Algal Blooms has recently increased in the coastal water of the world. It impacts seriously on the marine environment and resources and great attention has been paid to it. There have been many studies on the formation and process of HAB. One aspect of the studies is to develop HAB models. Since Kierstead and Slobodkin gave a model of bloom formation in 1953, there are several kinds of models, such as aggregated models (Wyatt and Horwood 1973, Truscott 1995), multispecies models (Ebenhoh 1987, Montealege 1995), models with simple physics (Kiestead and Slobodkin 1953, Franks 1997) and models with detailed physics (Kishi and Ikeda 1986, Yanagi et al 1995). Mesocosm experiment is developed in late 1960s to study the biological process in the sea. By mesocosm experiment, one can obtain data of population growth of plankton and develop biological model of HAB organism.

In this paper, the results from mesocosm experiment carried out in the area out of Yangtze River Estuary were presented. The results showed that in outside of Yangtze River Estuary, phosphate is relatively the limiting factor, compared with nitrogen for the growth of phytoplankton. A N-P-Z model was used to simulate the change of phytoplankton biomass and the preliminary estimated threshold values of nitrogen and phosphate concentration for HAB occurrence are 4.5 μmol/l and 1.0 μmol/l respectively in this area.

S10 CCCC Topic Session
A decade of variability in the physical and biological components of the Bering Sea ecosystem: 1991-2001

Convenors: Suam Kim (Korea), Allen Macklin (U.S.A.), Vladimir I. Radchenko (Russia) and Sei-ichi Saitoh (Japan)
Tuesday, October 9, 2001 08:30-17:30

There is widespread recognition that significant changes occurred in the marine ecosystem over the last decade, possibly due to shifts in the Pacific Decadal Oscillation and Arctic Oscillation, and influences of El Niño-La Niña. The character of the Bering Sea seasonal ice pack has changed recently from the "warm" phase that persisted since the regime shift of the late 1970s to one that exhibits rapid buildup in winter but earlier retreat in spring. Vast colonies of coccolithophores began appearing on the Bering Sea shelf in the summer of 1997 and have recurred each summer since. Salmon stocks recruited in much lower numbers in the last few years than were forecast. Pollock distribution and abundance have varied with fluctuations in sea ice. Shifts have also been observed in crab, seabird, and marine mammal populations. This half-day session will examine the nature of climate changes in the Bering Sea over the past decade and the effects of these changes on the ecosystem.

Invited speakers:

George L. Hunt (UC at Irvine, U.S.A.) - Climate change and the control of energy flow in the eastern Bering Sea

Vladimir I. Radchenko (SakhNIRO, Russia) - The western Bering Sea: changes in physical environment and pollock stocks

Akihiro Shiomoto (National Research Institute of Far Sea Fisheries, Japan) - Interannual variation in phytoplankton biomass in the Bering Sea basin in the 1990s

Kozo Takahashi (Kyushu University, Japan) - Temporal flux changes of shell-bearing plankton particles in the Bering Sea during the last ten years since 1990

Selected papers from this session (oral and posters) will be published in a special issue of *Progress in Oceanography*. If review and final revision are completed by March 1, 2002, publication might be scheduled before PICES XI, in October 2002.

10AM2001 S10-211 oral

COMPARISONS OF FOOD WEB MODELS AND FIELD DIET STUDIES FOR MAJOR FISH SPECIES IN THE EASTERN BERING SEA DURING THE 1990S—IMPLICATIONS FOR TOP-DOWN VS. BOTTOM-UP CONTROL

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Dynamic food web models rely on strong assumptions about the nature of top-down and bottom-up control acting between species in marine ecosystems. Measuring prey or predator interactions is a major challenge facing modelers attempting to build predictive or explanatory models that encompass ecosystem-wide shifts in resident biota. Recent variation in eastern Bering Sea fish, crab, seabird and mammal populations are a case in point: are changes traceable to a few key species exerting both top-down and bottom-up pressure, or do links between climate and fish act on a species-by-species basis? In order to answer this question, models predicting temporal changes in predator/prey relationships must be compared with empirical data on changing diets.

Fish food habits studies performed in the eastern Bering Sea shelf by the Alaska Fisheries Science Center during the 1980s and 1990s have resulted in one of the most extensive existing databases on large marine ecosystem predator/prey dynamics. In addition, this area has been subject to a range of modeling efforts, including whole-ecosystem biotic models containing species ranging from plankton to carnivorous mammals. In this study, we analyze the dietary predictions made by these models under differing hypotheses of top-down and bottom-up control with observed shifts in the diet and population structure of multiple species throughout the ecosystem. This comparison is both an attempt to clarify both the usefulness of these models in predicting ecosystem changes, and an attempt to examine the structure of species interactions in the Bering Sea as a whole.

10AM2001 S10-169 oral

ECOSYSTEM ANALYSIS OF THE PRIBILOF ARCHIPELAGO DURING THE DECADE OF 1990-2000

Lorenzo Ciannelli, R.C. Francis, R.D. Brodeur and B. Robson

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The biological features of the water adjacent the Pribilof Islands are distinct from the rest of the Bering Sea. The Pribilof Islands are located at the shelf edge of the Bering Sea and are populated by species from both the shelf and the adjacent mesopelagic oceanic ecosystems. The Pribilof Islands also host the largest Bering Sea colonies of northern fur seals, kittiwakes and murres. These apex predators feed on species belonging to both the mesopelagic and the shelf communities, and constitute a link among the two. Our objective was to build a mass-balance ecosystem model representative of the area around the Pribilof Islands during the decade of 1990-2000. A primary objective of this study was to synthesize the abundance and trophic relationships of the dominant groups residing in the study region. Moreover, the model was used to define the boundaries of the Pribilof ecosystem based on the energetic requirements of the apex predators, such as sea birds and marine mammals. We compared the magnitude of the various sources of predation on age-0 walleye pollock, a central forage species in this system. We linked the Pribilof model to the rest of the Bering Sea system, by comparing results from our model with an already existing Bering Sea model. Finally, we speculate on what the relative contribution of the Pribilof Islands age-0 pollock were to Bering Sea adult pollock recruitment during this time period.

10AM2001 S10-293 oral

TRAWL SURVEY CATCH IN THE SOUTHEAST BERING SEA: 1960-2000

M. Elizabeth Conners, Anne B. Hollowed and Eric Brown

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A retrospective study looks at 40 years of bottom trawl surveys in the eastern and southeast Bering Sea. Groundfish surveys conducted in the 1960s and 70s by the IPHC and in the 80s and 90s by NMFS are used to create a continuous time series of catch data, in order to examine decadal-scale variation in demersal species. The study uses a mesoscale spatial resolution, using selected study areas of 13,100-58,500 km^2. Three areas of slightly different habitat are examined: the shelf north of Unimak Island, inner Bristol Bay, and an area near the Pribilof Islands. For each of these study areas, we generate time series based on the geometric mean of catch-per-unit-effort (CPUE) from summer survey hauls. These time series are examined in comparison with hypothesized regime shifts and decadal-scale variation in climate indices.

Trawl catches north of Unimak and in Bristol Bay exhibit a major shift in catch rate and species composition beginning in the early 1980s. The catch of walleye pollock increases more than fourfold in these areas over a 2-year time span, and substantial increases are seen in catches of Pacific cod and flatfish. Through the 1980s and 1990s, the catch of commercial crab species declines but catch of other benthic invertebrates increases dramatically. Similar patterns are seen in the area near the Pribilofs, but the sudden increase in catch occurs 4-5 years later than at the southern sites. We examine a variety of mechanisms and hypotheses that might account for recent changes.

10AM2001 S10-323 poster

VARIATIONS IN ZOOPLANKTON DISTRIBUTION AND ABUNDANCE ON THE INNER SHELF OF THE SOUTHEAST BERING SEA RELATIVE TO CLIMATE EXTREMES

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Zooplankton samples were collected at four locations in and around the Inner Front of the southeast Bering Sea shelf during spring and fall of 1997 through 1999. Spring samples were collected during late May and early June, at the end of the spring bloom when the seasonal thermocline was beginning to develop. Conditions during June 1997 were unusually calm and warm. Zooplankton on the inner shelf was dominated by neretic species (*Calanus marshallae*, *Pseudocalanus* spp.). During the stormier spring of 1998, zooplankton on the inner shelf were again dominated by neretic zooplankton, however, advected oceanic zooplankton dominated the biomass at the stratified side of the Inner Front. The winter of 1998-1999 was characterized by extensive ice cover, which resulted in lower bottom water temperatures in 1999 than observed in earlier years. The distribution of early copepodite stages of *Calanus marshallae* were more abundant in warmer water while copepodites V preferred well stratified waters. *Pseudocalanus* spp. distribution was correlated to warmer water temperatures but was unaffected by water column structure. In general, calanoid densities on the inner shelf during 1997 through 1999 were higher by one to two orders of magnitude than were observed in the early 1980s. Population differences of such a magnitude suggests that oceanographic conditions on the southeast Bering Sea shelf may have changed between the early 1980s and the late 1990s.

10AM2001 S10-130 poster

FOOD HABITS OF SOCKEYE, CHUM, AND PINK SALMON FROM THE CENTRAL BERING SEA, 1991-2000

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Sockeye, chum, and pink salmon food habits data collected from the central Bering Sea near 180° in 1991-2000 were examined. Prey weight and prey composition were analyzed with respect to physical conditions, and phytoplankton, zooplankton, and salmon abundance. Results indicate large interannual differences in prey weight of salmon in the Bering Sea. Zooplankton abundance was correlated with the weight of amphipods in sockeye, pteropods in pink, and copepods in chum salmon stomachs. In this area of the Bering Sea, there is a strong odd-year dominance cycle in pink salmon abundance, which fluctuates fifty-fold between odd and even years. Sockeye, pink, and chum salmon food habits included less high calorie prey organisms when pink salmon were abundant, suggesting that prey competition among pink salmon and between pink salmon, sockeye, and chum salmon can be observed in the food habits of these fishes. The smaller proportion of amphipods and copepods in salmon of large body size suggest shifts in the food habits as fish grow. The central Bering Sea is an important feeding area for sockeye, pink, and chum salmon because they feed on an abundance of small fish and squid that appear to be common in the area.

10AM2001 S10-265 poster

INTERDECADAL AND MESOSCALE TIME-SPATIAL VARIABILITY IN THE PHYSICAL AND BIOGEOCHEMICAL COMPONENTS OF THE BERING SEA ECOSYSTEM: THE ANADYR GULF

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Over the shelf, nutrient concentrations are governed by rates of biological uptake and remineralisation, by physical structural fronts that retard cross-shelf flow of nutrient-enriched basin waters (perhaps the oldest in the world [Coachman et al., 1999]), and by countvailing physical features that distribute the basin waters to the shelf [Luchin et al., 1999; Springer, 1999; Whitledge and Luchin, 1999]. Interannual variability in nutrient flux over the shelf as well as the annual amount of annual production over the shelf is related to frequency of storms [Stabeno et al., 1999; Reed and Stabeno, 1999; Overland et al., 2000].

In this paper we examine mesoscale temporal and spatial chemical and sedimentation variability in the Anadyr Gulf which is forced by both physics and biology. The Anadyr Gulf is the most extreme example on the northern shelf where Anadyr water originates at depth along the shelf edge and is thus highly enriched in nutrients, creates a chemostat-like environment that fuels levels of primary production of world record productions (Mc Roy et al., 1987; Springer and McRoy, 1993). We present the oceanographic data obtained before (1992) and after (2000) the 1989-99 winter when contrasting conditions in the Bering Sea were detected (Hunt et al., 1999). A system analysis for meteorological, water masses parameters, and current data is applied to understand better linkage between occurred changes in the marine ecosystems and atmospheric circulation patterns over the last decade.

10AM2001 S10-170 oral

MODERN AND PALEOCEANOGRAPHIC INDICATORS OF ECOLOGICAL CHANGES IN THE BERING SEA

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Changes in primary productivity probably play a key role in determining the structure and biomass yield of the Bering Sea ecosystem. During the extreme warm periods of recent years, high ocean temperatures may result in strong stratification of the water column that would reduce nutrient cycling and reduce productivity. Long-term records of changes in the Bering Sea and the biota are being reconstructed from proxy data in sediment cores, marine mammal bones, whale baleen and other sources. The record of carbon isotope ratios in recent sediments from Skan Bay, Unalaska in the Bering Sea track zooplankton biomass, as well as carbon isotope ratios from bowhead whale baleen and Steller sea lion bone collagen (Hirons et al. 2001; Schell 2000; Sugimoto and Tadokoro 1997). All three sources were cited as evidence for recent declines in the carrying capacity of the Bering Sea and northeastern Pacific Ocean. The apparent declines in primary productivity in the past century is reflected in the carbon isotopes from skeletal remains of Steller sea lions found in archaeological sites around the Kodiak archipelago and Aleutian Islands. These data provide evidence that productivity changes impact upper trophic level organisms and may contribute to their population declines in the region.

10AM2001 S10-014 invited

CLIMATE CHANGE AND THE CONTROL OF ENERGY FLOW IN THE EASTERN BERING SEA

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We examine how coupling of physical and biological processes facilitates the production and transfer of energy to upper trophic-level species in the southeastern Bering Sea. During the 1990s, the Bering Sea experienced variability in the marine climate that was as great or greater than previous extremes recorded since the early 1970s. For example, in 1998, ice cover was minimal in extent and retreated early, but in 1999, it was unusually great and long-lasting. Likewise in 1997, sea surface temperatures were unusually high during spring and summer, whereas in 1999, temperatures in spring and summer were unusually low. Associated with the warm, nutrient-depleted upper mixed layer in 1997, the first documented bloom of the coccolithophore, *Emiliania huxleyi*, turned much of the surface waters of the middle domain a milky green color. This bloom has now recurred each year, suggesting that a new pathway for energy flux in the Bering Sea has become established. Data from a biophysical mooring deployed in the middle domain has shown the relationship between the timing of ice retreat and the occurrence of ice-edge vs. open-water spring phytoplankton blooms. When sea-ice remains until late March, an ice-edge bloom results, whereas if ice retreats prior to mid-March, an open water bloom occurs in May or June, depending upon when the thermocline sets up. The timing of the bloom and the temperature of the water in which it occurs may have a significant impact on the fate of the production, and its ability to support a pelagic food web, including juvenile pollock.

10AM2001 S10-117 poster

SPATIAL AND TEMPORAL PATTERNS OF SHEARWATER USE OF THE SOUTHEASTERN BERING SEA

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Millions of short-tailed shearwaters (*Puffinus tenuirostris*) migrate yearly from breeding colonies in Tasmania to the North Pacific Ocean between spring (May) and fall (September). During the summer - fall of 1997, an estimated 600,000 short-tailed shearwaters starved in the Bering Sea. We used standard population sampling techniques to estimate the abundance of live shearwaters and floating shearwater carcasses within three study areas in the southeastern Bering Sea during May - June and July - September of 1997, 1998 and 1999. We employed these data to assess changes in short-tailed shearwater populations before and after the 1997 die-off, and to evaluate background mortality levels during years when a large-scale die-off did not occur (1998 and 1999). Our observations suggest that a significant mortality event of unusual extent and magnitude occurred during the summer-fall of 1997, when an estimated 95,000 carcasses (7% of the total live and dead population surveyed) were afloat within our survey grids. Analyses of vessel-based surveys revealed significant changes in shearwater dispersion during 1997-1999. Springtime shearwater abundance was highest during 1997, before the mortality event, and declined thereafter. During summer - fall, shearwaters were most numerous in 1998, and decreased substantially during 1999. Additionally, significant statistical interaction terms between years and study grids suggest that shearwater densities do not fluctuate coherently across the southeastern Bering Sea. Knowledge of shearwater dispersion can provide information on the spatial and temporal availability of their preferred prey. In turn, these fluctuations are indicative of interannual and longer-term changes in the structure of the Bering Sea marine food web.

10AM2001 S10-283 oral

TEMPORAL AND SPATIAL VARIABILITY OF COCCOLITHOPHORE BLOOMS IN EASTERN BERING SEA SHELF

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During the late summer of 1997, for the first time ever recorded, most of the continental shelf of the eastern Bering Sea was covered by aquamarine waters, resulting from massive bloom of coccolithophores. Since then, coccolithophores bloom is not unusual but common in the southeastern Bering Sea.

Our objectives of this study are, to determine threshold value of SeaWiFS coccolithophore algorithm in Bering Sea, comparison with satellite observation and ship optical observation, and to analyze variability of temporal and spatial coccolithophore bloom in 2000 using SeaWiFS images.

We carried out bio-optical measurement using T/S *Oshoro-maru* to observe coccolithophore blooms of *Emiliania huxleyi* in late July 2000, in Bering Sea Shelf. The bio-optical feature observed by ship is different from CZCS standard NASA mask algorithm. Thus we defined new threshold value from optical observation and applied this to time series SeaWiFS images. Coccolithophore bloom began in February along ice edge. Ice melt start at the same time, then expanded to northward. A peak occurred in April. After May, June, July, August tended to decrease the area, but the area increased again in September. Then coccolithophore bloom distributed at the depth from 40m to 80m in the southeastern Bering Sea shelf as like "Coccolith Wall", and did not expand more than 80m depth. Coccolithophore bloom area has relatively low chlorophyll *a* concentration in comparison with spring bloom region observed by SeaWiFS images.

10AM2001 S10-321 poster

PRIMARY PRODUCTIVITY AND PHYTOPLANKTON BIOMASS IN THE SOUTHEASTERN BERING SEA IN SUMMER 2000

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Primary productivity was measured using ^{13}C uptake method during a summer cruise (late July-early August 2000) in the southeastern Bering Sea, on board the training ship *Oshoro-Maru*. The discrete primary productivity estimates were integrated for the water column within the euphotic zone. The study area was divided into four oceanographic domains: the coastal shelf, the central shelf, the outer shelf and the oceanic domains. Primary productivity was higher in the outer shelf and oceanic domains (497 and 420 mg C m^{-2} day^{-1}) than in the coastal shelf and central shelf domains (143 and 296 mg C m^{-2} day^{-1}). Similar pattern was observed in the chlorophyll a standing stock with 25.8, 32.2, 46.0 and 48.6 mg m^{-2} respectively at the coastal shelf, the central shelf, the outer shelf and the oceanic domains. Coccolithophore bloom was noticed in the coastal shelf domain. Silicate concentrations in the upper layer of the water column were lower in the coastal shelf and central shelf domains than in the outer shelf and oceanic domains. Low concentration in the coastal shelf can be attributed to exhaustion of silicate in this domain. Based on our results, silicate was found to be a key controlling factor for varied phytoplankton species composition as well as phytoplankton productivity and biomass in different oceanographic domains.

10AM2001 S10-209 oral

INTERANNUAL VARIABILITY IN STOCK ABUNDANCE AND BODY SIZE OF PACIFIC SALMON IN THE CENTRAL BERING SEA

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Variability in catch-per-unit-effort (CPUE) and mean body size was examined for pink, chum and sockeye salmon collected with research gillnets in the central Bering Sea in July from 1972 to 2000. CPUEs of three species showed significant increasing trends with large interannual variability. Pink salmon showed higher CPUE in odd years than in even years, and particularly increased in odd years from 1989. CPUEs of chum and sockeye salmon were higher during 1979-1984 and 1992-1998, but lower during 1985-1991. Chum salmon also showed odd/even year fluctuations, which was out of phase with pink salmon, but sockeye salmon did not show such fluctuations. Body size of pink salmon showed a significant decreasing trend, and chum and sockeye salmon also showed significant decreasing trends at ocean age 3 and older ages, but not at ocean age 2. Significant negative relationships between CPUE and body size were found within species, but not between different species. The effect of Aleutian Low Pressure index on CPUE and body size was examined, but no correlation was found. These results indicate that Pacific salmon in the Bering Sea in the 1990s was characterized by higher stock abundance and strong intraspecific density dependent growth.

10AM2001 S10-210 poster

DISTRIBUTION OF FORAGING SHEARWATERS WITH RESPECT TO THE INNER FRONT OF THE SOUTHEASTERN BERING SEA

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The inner front is a structural front, which separates the well-mixed coastal domain from the two-layered middle domain of the southeastern Bering Sea and has been hypothesized to be an important foraging area for short-tailed shearwaters (*Puffinus tenuirostris*). To test this hypothesis, we surveyed the spring and fall distribution of short-tailed shearwaters in the vicinity of the inner front at several locations in 1997, 1998 and 1999. We predicted that shearwater distribution in the southeastern Being Sea was the result of shearwaters being attracted to the front where euphausiids aggregated to forage on phytoplankton stocks throughout the summer. We found that euphausiids were not more abundant at the front than elsewhere in our study areas. Nevertheless, in 1997 and 1999 foraging shearwaters were more abundant than expected by chance in frontal areas than elsewhere along the transects. In 1998, foraging shearwaters were more abundant than expected by chance inshore of the frontal zone. Shearwater diets varied among years. We hypothesize that interannual differences in hydrographic structure and the abundance of different prey species influenced foraging locations in shearwaters.

10AM2001 S10-095 poster

CURRENTS NEAR THE INNER FRONT OF THE SOUTHEASTERN BERING SEA

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As part of the Inner Front Predators (NSF) program approximately 30 moorings were deployed along the inner front of the southeastern Bering Sea during 1997, 1998 and 1999. Instrumentation on the moorings included current meters, thermistors, conductivity sensors, fluorometers and meteorological sensors. During spring and summer, the inner front is a structure front that separates the well-mixed coastal zone from the two-layered middle shelf. Our measurements show large variability in currents and water properties in the vicinity of the front on tidal, seasonal and interannual scales. Establishment of the front, its structure and position are largely determined by atmospheric forcing and by storm events that increase mixing and deepen the thermocline. Using a simple nudging scheme, the data from the array of moorings and surveys at Nunivak Island have been assimilated into a primitive equation model (Regional Oceanographic Modeling Scheme) in order to examine frontal dynamics.

10AM2001 S10-297 oral

INTERANNUAL VARIATIONS IN THE ZOOPLANKTON COMMUNITY IN THE BERING SEA DURING THE MID 1990S

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Mesozooplankton community in the Bering Sea was investigated to figure out interannual variation in relation to oceanographic condition. Surveys were conducted in late June - early July 1994 and 1995. Zooplankton were collected obliquely using a Bongo net with 60 cm mouth fitted with 333μm mesh from the depth of *ca.* 200 m to surface, and seawater properties such as temperature and salinity were measured with CTD. There was a big difference in seawater temperature between 1994 and 1995. In summer 1995, sea surface temperature (SST) ranged 7.3-12.4°C, while that in summer 1994 was 5.3-8.7°C, and temperature difference was also found in water depth down to 300 m. Thermocline was formed at the layer of 30-50 m in 1994, but 20-30 m in 1995. Also, salinity in 1995 was relatively low compared to 1994, and halocline appeared at the layer of 20-30 m in

1994, while it didn't seem to appear in 1995 at the upper layer. Eighteen zooplankton groups including ichthyoplankton were identified during study period, and interannual variations in abundance and species composition were noticed. Zooplankton abundance was *ca.* 4 times higher in 1995 than that in 1994. Copepods and euphausiids were predominant in both years. However, especially in 1995, appendicularians appeared abundant. Higher zooplankton abundance in 1995 might be caused by abnormal oceanic conditions such as warm seawater temperature and low salinity.

10AM2001 S10-298 poster

SEASONAL SUCCESSION IN ZOOPLANKTON COMMUNITY IN THE BERING SEA IN 1994

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Seasonal changes in zooplankton community in the Bering Sea were investigated with samples collected in spring-fall 1994. Surveys were conducted in April, June-July, and September 1994. Zooplankton were collected using a Bongo net with 60 cm mouth fitted with 333μm mesh, and a net was towed obliquely from about 200 m to surface in most stations. Seawater properties such as temperature and salinity were measured with CTD. In general, species composition of zooplankton didn't show a large seasonal variation except some copepods, and a large peak in zooplankton abundance appeared in September and a small peak in April. Copepodites developed and grew after spring reproduction, so that copepod abundance increased to the maximum in summer and autumn. Of copepods, *Eucalanus bungi bungi*, *Calanus pacifica*, *Neocalanus cristatus* and *Metridia pacifica* exhibited a strong seasonal variation in quantity depending on copepodite stages. Adult and copepodite 4-5stages were dominant in spring but it decreased dramatically in summer. Young copepodites, such as copepodite 1-3 stages showed a high quantity in summer, but they were replaced by copepodite 3-5 stages in autumn. From these results, it is concluded that copepodites are very important to determine seasonal zooplankton abundance in the Bering Sea.

10AM2001 S10-389 poster

STOCK-RECRUITMENT RELATIONSHIPS FOR ALASKAN CRAB STOCKS

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Stock–recruitment (S–R) relationships have important implications for harvest strategies but are difficult to develop for crab stocks because crabs lack retainable hard body parts, like scales, to age them. Moreover, lack of sufficient knowledge about complex reproductive biology complicates estimation of effective spawning biomass. To evaluate harvest strategies, we developed S–R relationships for three major crab stocks in Alaska: Bristol Bay red king crab, *Paralithodes camtschaticus*, Bristol Bay Tanner crab, *Chionoecetes bairdi*, and eastern Bering Sea snow crab, *C. opilio*. We estimated recruitment from length-based models based on growth data for recruitment age, and effective spawning biomass from male and female abundance, male fertilization capability, sex ratio, size and shell structures of males, molting period duration of the female population, and duration of male attendance during mating. For all three stocks, a Ricker-type model fits the observations better than a Beverton-Holt model, and an autocorrelated or general Ricker model has a better fit than an ordinary Ricker model. For both Tanner and snow crab stocks, recruits are not strongly associated with effective spawning biomass and much variation of recruitment can be explained by autocorrelation or cycle; thus, environmental factors are likely to play a very important role in recruitment success. Weak recruitment is associated with extremely small spawning biomass and strong recruitment is produced by intermediate spawning biomass for the Bristol Bay red king crab stock, suggesting possible density-dependent effects.

10AM2001 S10-418 poster

TRENDS IN OCEAN CONDITIONS AND NEW PRODUCTION ON THE SHELF OF THE SOUTHEAST BERING SEA OVER THE PAST 20 YEARS

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We used the 1979-1999 time series of physical and chemical data collected by researchers on board the cruises of the *Oshoro Maru* in the Bering Sea to determine trends in ocean conditions on the outer shelf. Temperature in the surface and deep layers show an increasing trend for the period. Salinity shows a slight decreasing trend in surface waters but little or no change in deeper layers. Integrated values of major nutrients in the upper layer all show a slight decreasing trend whereas the trend is opposite in the lower layer. We determined the seasonal change in Nitrate+Nitrite concentrations in combination with diffusive resupply, estimated by the model of Walsh & McRoy 1986, to calculate a mean value of new production for each year. Estimated new production over this period ranges from 0.6 to 1.2 gC m^{-2} d^{-1} for the spring season with a mean of 0.9.

10AM2001 S10-207 oral

INTERANNUAL TO MULTIDECADAL CHANGES OF TEMPERATURES IN THE BERING SEA

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The surface temperature data (1922-1999) in the Bering Sea are analyzed in order to clarify the influences of the Pacific Decadal Oscillation (PDO) and Arctic Oscillation (AO) and to know the 1990s' situation of the Bering Sea with respect to the 20th century changes of the sea. A wavelet analysis indicates that the Bering Sea exhibited a pentadecadal (about 50 year period) oscillation in winter, spring and autumn seasons. The 20-year oscillation was almost absent or relatively weak in the western Bering Sea (50-60N, 160E-180), and hence clear regime shifts were not observed. On the other hand, in the eastern Bering Sea, prominent shifts were observed in the end 1940s and mid 1970s accompanied by the bidecadal signatures, consistent with the previous regime shift studies.

Another interesting feature of the SST field is the existence of the quasi-decadal oscillation. The quasi-decadal signal has been coherent with the changes of the AO after 1960. However, the quasi-decadal oscillation of the western Bering Sea SST limited temporally not only after 1960 as the AO did, but occurred through the record.

The situation of the Bering Sea in the 1990s can be interpreted as follows; the SSTs were generally warm in the last 20 years due to the positive phase of the PDO on the 50-year time scale. The marked cold anomalies around 1990 and following warming from 1990 to late 1990s were likely to be resulted from both of the changes of the polar vortex and Aleutian low. The analyses of subsurface temperatures will be also presented.

10AM2001 S10-284 poster

BERING SEA EDDY IN THE "GREEN BELT"

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The Bering Sea is well known as highly productive marginal sea. Especially, there are lots of important physical and biological factors for high productivity along the continental shelf edge so called "GREEN BELT" in the Bering Sea (Springer et al 1996). Our objectives of this study are, to make clear the formation of the eddy in the Bering slope current and to estimate eddy's effect on primary production. Final goal is to estimate of regional and temporal variability of primary production by physical processes in the Green Belt. We carried out "Simultaneous" Eddy observation by using the T/S *Oshoro-maru* and TOPEX/ERS2 data from CCAR Altimeter Data Archive Home Page (http: //www-ccar.colorado.edu/research/topex/html/topex.html) in summer 2000. High Chlorophyll-a concentration occurs under the thermocline of this eddy. This suggests that nutrient supply from the subsurface layer to euphotic zone, which is due to upwelling in the center of cyclonic eddy, then maintained high phytoplankton abundance. Another High chlorophyll-a concentration occurs between shelf edge and this eddy. This might be due to convergent between cyclonic eddy flow and Bering Slope Current transported nutrients into shelf edge. Low nitrate at shelf edge is correspond to high chlorophyll *a* concentration layer. It was depleted for primary production in the shelf edge.

10AM2001 S10-311 oral

PRELIMINARY ESTIMATES OF CETACEAN ABUNDANCE ON THE CENTRAL AND EASTERN BERING SEA SHELF WITH OBSERVATIONS OF OCEANOGRAPHIC AND PREY ASSOCIATIONS

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Vessel surveys for cetaceans were conducted in association with a groundfish stock assessment survey in the central Bering Sea from 5 July through 5 August 1999 and in the eastern Bering Sea from 12 June through 3 July 2000. In both years, the survey was conducted from the NOAA ship *Miller Freeman* using line-transect methodology with 25x binoculars. Survey effort totaled 2,391 km and 2,598 km, respectively. The most common mysticete and odontocete in both regions was the fin whale and the Dall's porpoise. Abundance estimates were made for fin whales, Dall's porpoise, and harbor porpoise in both regions. For the central Bering Sea (1999) estimates were: 4,951 fin whales (CV=0.29), 36,851 Dall's porpoise (CV=0.21) and 7,631 harbor porpoise (CV=0.32). Other cetacean sightings included three sei whales, 12 humpback whales, 25 minke whales, one gray whale, six killer whales, and one North Pacific right whale. Abundance estimates in the eastern Bering Sea (2000) were: 481 fin whales (CV=0.31), 6,343 Dall's porpoise (0.26), and 1,662 harbor porpoise (CV=0.22). Additional sightings included two sei whales, five humpback whales, 34 minke whales, 11 gray whale, one Baird's beaked whale, 12 killer whales, and one Pacific whitesided dolphin. Distribution of some species appeared to be associated with oceanographic or prey features. Fin whales, found throughout the Bering Sea shelf, were clustered along the 200m and 50m isobath, where fish and invertebrate species were aggregated. Dall's porpoise and harbor porpoise were primarily distributed on opposite sides of the 75m isobath (with Dall's in deeper water).

10AM2001 S10-230 poster

ANALYSIS OF THE WATER CIRCULATION IN THE KOMANDOR-KAMCHATKA REGION BY THE TYPES OF THE ATMOSPHERIC CIRCULATION

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The presented studies of seasonal variability of waters circulation in the Kamchatka and the Near Straits carried out with concern to the predominant types of atmospheric circulation on the basis of monitoring mathematical model. That has allowed find out some peculiarities of water exchange through the straits at different types of synoptic situation typical for a certain season.

The integral flux values corresponding to the Bering Sea waters flow out and the Pacific water supply in the straits for each possible scheme was obtained. It is traced seasonal variability of water circulation intensification in the straits.

In the Kamchatka Strait it is observed the predominant flow out of the Bering Sea with the Kamchatka current under the «north-western» type of atmospheric circulation (a stable transfer of air masses mainly from the north-east, east to the south-west and south). That was as well as during the synoptic situation «cyclones over the ocean» (over the Komandor-Kamchatka area a transportation of the masses from the east takes place) in fall and winter period. The predominant supply of the Pacific Ocean water is observed only with the «okhotsk-aleutian» type of atmospheric circulation (the southern and southeastern wind are predominates in this area) in spring period.

In the Near Strait the predominant flow in of the Pacific Ocean waters is observed with the «north-western» type of the atmospheric circulation in summer period. Well enough expressed two-way scheme of the water circulation is formed with the standard synoptic situation «cyclones over the ocean» in winter and fall seasons. With the «okhotsk-aleutian» standard synoptic situations in spring and summer period the circulation in the straits is represented by the flows of non-uniform direction, which are conditioned by the «close package» of the vortex formations of various sign.

The obtained results can be used for developing the forecasts of hydrological conditions in the given area.

10AM2001 S10-085 poster

COMPOSITION, STRUCTURE AND PRESENT STATE OF BUCCINIDAE MOLLUSCS OF OLYUTORSKY BAY, BERING SEA

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Buccinidae molluscs distribution in Olyutorsky Bay, Bering Sea was investigated by bottom trawl survey had been carried out at isobaths 25-450 m in the fall of 2000 with 150 trawl stations. The molluscs had mosaic distribution; their biomass density changed from 0.5 to 300 kg/km^2 with predominance of densities 10-20 kg/km^2. The main concentrations were found westward from 168°E at the depths 80-190 m. In total, 14 species of Buccinidae from 4 subfamilies were identified. Subfamily Neptuninae was the main one among them; its share of total biomass was up to 84%. *Neptunea pribiloffensis*, *N. ventricosa*, and *N. heros* were the most numerous species of this subfamily which formed about 90% of Neptuninae biomass. Subfamily Ancictrolepininae formed 8.1% of total Buccinidae biomass, subfamily Volutopciinae - 6.9% (but *Volutopsius castaneus* was the most numerous species, besides of Neptuninae species), subfamily Buccininae - 1.1%. The core of catches (80% and more) of molluscs was formed by specimens of commercial size with the height of their shells > 110 mm. Total biomass of Buccinidae molluscs in Olyutorsky Bay was calculated by the method of Tissen's polygons and estimated as about 1,000 tons if coefficient of trawl catch efficiency was 0.5. Present species composition and spatial distribution of Buccinidae molluscs have some differences in compare with data of 1980s, although their taxonomic ratio almost has no change.

10AM2001 S10-140 poster

THE RISE AND FALL OF ZOOPLANKTON POPULATIONS IN RECENT DECADES ON THE SE BERING SEA SHELF - BOTTOM-UP AND TOP-DOWN CONTROL OF TWO COPEPOD GENERA

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A synthesis of results from current (SEBSCC) and historical (PROBES, *Oshoro Maru*) Bering Sea research points to two conflicting facts - shelf zooplankton biomass exhibits no decadal trend, but springtime abundance of two copepod genera, *Calanus* and *Pseudocalanus*, have recently increased relative to the early 1980s. Egg production rates by *Calanus* were not appreciably affected by spring environmental conditions, but *Pseudocalanus* egg production and development, which are much more responsive to changes in temperature, may have been affected. During three climatologically different years (1995-1997), *Calanus* that survived to spring were those whose molt to the copepodite stage was nearly coincident with the spring phytoplankton bloom. The timing of the spring bloom was significantly altered by the presence of sea ice. This suggests that bottom up control of *Calanus* operated on survivorship rather than birth rates and *Pseudocalanus* populations were controlled by both.

Evidence for top down control of the population dynamics of these two genera was visible in the covariance among their abundances and that of their predators. There was no relationship between the interannual (and longer period) fluctuations of *Calanus* and *Pseudocalanus* and the recent population explosion of Scyphomedusae. There is a strong negative relationship between the abundances of these two species and juvenile fish (age-0 pollock, *Theragra chalcogramma)*. Our observations point to multiple, rather than single sources of population control of SE Bering Sea plankton populations. Multiple sources of population control are probably the rule, rather than the exception, and provide valuable insight into how ecosystems operate.

10AM2001 S10-226 oral

LONG-TERM FLUCTUATIONS IN THE PELAGIC COMMUNITY OF THE WESTERN BERING SEA

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A dynamic type of relationship characterizes the pelagic ecosystem of the Western Bering Sea, where planktivorous animals actively compete with one each other for common resources. Pelagic community of the area is a subject to cyclic (with a 30-40-years interval) succession of the two dominant species - walleye pollock and herring. The walleye pollock biomass increases 3-5 times at the warm periods, and herring - 5-10 times at reasonably cold ones. At the transitional periods, when both species stocks-size are not big, capelin biomass grows to one order. The pelagic fish total biomass at the periods of one of the species dominating are 2-3 times more than at the transitional ones. There is a close linear relationship between a general stock of planktivorous fish and zooplankton biomass. The pelagic fish food base state depends in its turn on the sea ice conditions in winter months and the water temperature in summer months.

A regular reconstruction of the pelagic biota happened at the last decade of the 20th century. For some time until 1994 walleye pollock held a leading position in biomass, but after appearance of a herring very strong generation in 1993, walleye pollock part decreased to half and even less of the total stock of all pelagic fish species. Since 1994 herring has been absolutely dominant species of the community. Capelin reproduction has considerably increased as well.

10AM2001 S10-262 poster

SURFACE HEAT FLUXES AND SEA ICE VARIATIONS OF THE BERING SEA IN THE 1990S

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Surface heat fluxes are very important factors because, through those processes, ocean and atmosphere system interact each other and they are changed finally. Therefore heat fluxes can be used as indicators of climate variability. During the regime shift in the 1976/77, latent heat fluxes in the Bering Sea were increased rapidly which is more distinct that the signal of sea surface temperature. To see the climate variability during a last decade, we calculated surface heat fluxes from the ocean-atmosphere variables retrieved from the Comprehensive Ocean-Atmosphere Data Sets, and analyze the seasonal, interannual variability during a last decade. Analyses on the satellite observed SST and sea ice from GISST data are also conducted for the consideration of the effects of variation of surface heat exchange. Latent heat release from the ocean is gradually decreasing after mid-1980s, so the Bering Sea gets more heat from the atmosphere. SST is also increased. Ice cover is gradually decreased except for the 1995/96 winter.

10AM2001 S10-026 invited

THE WESTERN BERING SEA: CHANGES IN PHYSICAL ENVIRONMENT AND POLLOCK STOCKS

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Dynamics of determinative physical factors are analyzed: climatic changeability, water exchange with the Pacific Ocean, ice conditions, and water temperature. Since second half of 1990s, seasonal atmospheric processes developed like to pattern inherent for "cold decades" of 1960s - 1970s above the western Bering Sea. Cold season duration grew. The water exchange dynamics differ by lower periodicity: from 6 to 12 years. Pacific water inflow in the Bering Sea decreased in early 1990s but trend to increase evinced in last years. Icing is determined as by air temperature as by wind strength and duration. Ice conditions changed with the frequency of 2-4 years. However, longer periods could be selected with relatively high and low winter ice covering. Determinative effect of winter season conditions on the Bering Sea oceanography regime is confirmed.

Changeability of regarded factors is not uniform through the Bering Sea region. Consequently, walleye pollock abundance and distribution have dissimilar dynamics in the western and eastern Bering Sea. Walleye pollock is more thermophilic species in comparison with herring and Polar cod. In the eastern Bering Sea, "summer cold pool" distribution determines southward shift of Polar cod aggregations in years of severe ice conditions. Age-1 pollock occur in the middle and outer shelf (Wyllie-Echeverria, Ohtani, 1999). Close situation was observed in the western Bering Sea in 2000. Polar cod demonstrated a significant southwards expansion and even possibility of spawn in the Karaginsky Bay.

10AM2001 S10-208 poster

EFFECTS OF HIGH AMMONIUM CONCENTRATIONS ON NITRATE UPTAKE RATES AND ITS IMPLICATIONS IN THE SOUTHEASTERN BERING SEA SHELF ECOSYSTEM

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During June and August 2000, we investigated the effects of high ammonium concentrations on nitrate uptake rates in the southeastern Bering Sea shelf waters. Nitrate uptake rates using $^{15}N\text{-}NO_3^-$ isotope were measured at 4 different nutrient treatments; an ambient condition, a high nitrate condition (ambient condition + 16.81 uM nitrate), a high ammonium condition (ambient condition + 4.2uM ammonium), and a high nitrate and ammonium condition (ambient condition +16.81 uM nitrate + 4.2uM ammonium).

Comparison between an ambient condition and an experimental high ammonium condition showed a decrease of nitrate specific uptake in the high ammonium condition. Average ammonium inhibitions on nitrate specific

uptake rates ranged from 25.5-84.1% decrease. The nitrate specific uptake rates, however, were not completely inhibited by the high ammonium concentrations (4.2 uM ammonium). Effects of the high nitrate concentrations on nitrate specific uptake rates exhibited distinctively different responses between June and August cruises. Nitrate specific uptake rates increased at higher light levels (12-100% surface of surface light) and decreased at lower light levels (1-5% of surface light) in the middle domain of the southeastern Bering Sea shelf during June, 2000. However, during August, 2000, nitrate specific uptake rates were low at the surface (12-100% surface light) and increased at the lower light intensity (1-5% of surface light).

The results from this study suggests that the ammonium inhibition of nitrate uptake rates may play a very important role in the southeastern Bering Sea shelf ecosystem because high ammonium concentrations are often observed in this region. Ammonium inhibition may explain the low nitrate uptake rates observed during May 1998 when nitrate concentrations were high.

10AM2001 S10-236 oral

TEMPORAL AND SPATIAL VARIABILITY OF SPRING BLOOMS IN THE BERING SEA DURING 1997-1999 - APPROACH USING SATELLITE MULTI-SENSOR REMOTE SENSING

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The Bering Sea is well known as highly productive marginal sea all over the world. Our objectives of this study are to clarify the interannual variability of primary productivity of the Bering Sea and to understand the mechanism of spatial variability of high productivity using satellite multi-sensor remote sensing.

We applied multi-sensor remote sensing data sets including ocean color (OCTS and SeaWiFS), sea surface temperature (AVHRR), sea surface height (TOPEX/Poseidon) and sea ice (SSM/I) to understand complexity of Bering Sea ecosystem. We attempt to calculate primary productivity by VGPM Model (Behrenfeld and Falkowski, 1997) using satellite chlorophyll *a* and SST data sets.

Phytoplankton biomass depend on the timing of sea ice melting and tend to increase when there is a delay. Wind stress is most important factor to control spring bloom. In 1997 and 1998, east-west distribution of phytoplankton biomass show the seesaw pattern, high in west and low in east or low in west and high in east. The most important effect to this seesaw phenomena is due to distribution of Aleutian Low in related to El Niño-La Niña phenomena. In La Niña period Aleutian Low shift to west and in El Niño period it shift to east, then weak wind stress promote development of stratification and enhancement of spring bloom.

10AM2001 S10-107 poster

AN ENDURING COCCOLITHOPHORE BLOOM IN THE BERING SEA

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Every summer since 1997, a bloom of the coccolithophore *Emiliana huxleyi* has covered a large part of the eastern Bering Sea shelf ($2x10^5$ km^2 in September 1997). On clear days, the bloom is clearly visible in SeaWiFS satellite images as a bright turquoise patch. Smaller blooms may have been detected in Coastal Zone Color Scanner images from 1979-1981, but none have been as large or as long-lasting as the present bloom. Coccolithophores are present in samples we have taken in the Bering Sea in January and February, but a major expansion in their concentration generally occurs in early summer. *In situ* samples taken in the summers of 1997 and 1998 showed that from 8 to 95% of the phytoplankton in the area covered by the bloom were *Emiliania huxleyi*.

The core of the coccolithophore bloom covers the shelf southwest of Nunivak Island, while its northern extent varies from year to year. For example, in 1998 and 1999, tendrils of the bloom were visible in eastern Bering Strait, while in 2000 an extensive bloom occupied the region south and southwest of St. Lawrence Island. Both the timing of the onset of bloom and the variability in its shape and extent are related to atmospheric forcing and its effect on currents.

10AM2001 S10-353 oral

THE DECADAL CHANGES OF THE MESOPELAGIC FISHES ABUNDANCE IN THE WESTERN BERING SEA

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There are about 10 common mesopelagic fishes in the Western Bering Sea. However, only 2 of them -northern smoothtongue *Leuroglossus schmidti* and lanternfish *Stenobrachius leucopsarus* are most abundant from epipelagial to bathypelagial. The distribution patterns of these species have both similar and different aspects. Similarly, that both species abundance increase from deep-sea area to continental slope and relative biomass proliferates from epipelagial to mesopelagial. The difference is that lanternfish is more abundant in offshore area than northern smoothtongue. Both species migrate in the upper layer during nighttime for feeding and, for one's turn use as a prey for salmons, pollock and others. High level of the mesopelagic fishes biomass was fixed in late 1980s. Midwater fishes abundance reduced in 1990s. Analogous changes of the zooplankton biomass were observed in this time. A shift of the dominant species of nekton and plankton communities was recorded. However the evident changes of the mesopelagic fishes feeding habit were not marked. The distribution patterns of midwater fishes are not stable. Year-to-year fluctuations of the total biomass and distribution patterns have a close relation with annual changes of the water circulation. It is a possible that all mesopelagic fishes spawn only in the Subarctic North Pacific Ocean and Bering Sea is a feeding area for theme. The current system is main mechanism for the distribution pattern formation.

10AM2001 S10-324 oral

CHANGES IN THE BERING SEA ATMOSPHERE ICE-WATER SYSTEM IN THE SECOND HALF OF THE TWENTIETH CENTURY

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In this report we examine the long-range, decadal, and interannual variability in the oceanographic regime of the Bering Sea in the second half of the twentieth century using the largest T-S (and dissolved oxygen) data base, containing about 60,000 stations, with a particular eye toward change in ice-regime and atmospheric processes over the Bering Sea and Western Arctic.

The concept of a highly productive habitat, or Green Belt, along the continental shelf is based upon fragmentary observations of a variety of physical and biological features (Springer et al., 1996). We therefore also consider significant differences in physical processes at the shelf edge and extreme hydrological situations after anomalous "cold" and "warm" winters. Here we identify long-range variability in the Bering Sea that is induced by changes in the atmospheric circulation patterns. We demonstrate that the ice-regime is an important parameter of the Bering Sea System, which influences the thermohaline regime and primary production. Change in the ice-condition is only an effect of change in atmospheric processes, which are the driving factor for the Bering Sea System. The effects of climate changes on the marine ecosystem over the past decades is examined.

10AM2001 S10-111 poster

SOME SIGNIFICANT CHANGES IN THE BERING ECOSYSTEM

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As you may be aware, the number of sea otters has dramatically declined during the last five years in some parts of the Northern Pacific. At this time, we can foresee a really catastrophical reduction in the population of sea otters near the Aleutian Islands. They seem to disappear for unknown reasons. This situation makes it crucial to get and keep current observations of the population of sea otters near the Commander. The same situation is occurring with Steller Sea Lions and some other species which are in the top level of the feeding chain.

Here is the report from the local office Fish and Wildlife Service on the Commander Islands about whales (written by head of office Mr. Vladimir Fomin):
In 2000 on the Commander fond on the beach five dead whales:
On the Medniy Island - 3 - all Right Whale
On the Bering Islands - 2 - (1 - Right whale; 1- Cuvier's Beaked Whale)

All these facts clearly display that something is drastically wrong with the natural functions in the whole ecosystem of the Bering Sea. As you know, this process may be most typical mark for the present condition of Beringia Ecosystem, because the sea otter itself is a keystone of that. That is why in meantime very important to organize on the Commander a very careful monitoring of the sea otter's population by field expeditions all year's around. Also, all those activities could be improving the situation with poaching of the sea otters on the Bering Islands. For the time being the Commander Nature Preserve do not have enough money for protection of the sea otter and in recent years about 200-300 animals (may be more) have been taken by poachers. The prize of the sea otter's skins on the black market in Petropavlovsk-Kamchatskiy could be around US$500-1200. Most of the skins going by illegal way to China and South Korea. (This unofficial evidence was taken by me from business minded people in Moscow and Petropavlovsk-Kamchatka).

10AM2001 S10-264 poster

SUMMER CHARACTERISTICS OF ZOOPLANKTON COMMUNITY SOUTH OF ST. LAWRENCE ISLAND, NORTHERN BERING SEA SHELF

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A neritic polynya is formed to the south of St. Lawrence Island, which lies approximately in the center of the northern Bering Sea shelf. Within the polynya, cold and saline water accumulates near bottom in winter and persists even during the summer.

Abundance and community structure of zooplankton were investigated in late July from 1990 to 1997. Samples were obtained using vertical hauls from near the bottom to the surface with a NORPAC net (45 cm in diameter, 0.33 mm). Between 1994 and 1997, stratified samples from above and below the pycnocline were also obtained, using a closing type of the NORPAC net (fitted with 0.10 mm mesh cloth).

Three water types were distinguished in the study area. In general, zooplankton was more abundant below the pycnocline than above it in the Bering Shelf Water and the Anadyr Water. On the contrary, zooplankton was abundant above the pycnocline rather than below it in the Alaskan Coastal Water. While copepods predominated in the whole water column, the zooplankton community in the study area was characterized by high dominancy of appendicularians (mostly *Oikopleura vanhoeffeni*). The mean abundance of *Oikopleura vanhoeffeni* widely varied interannually. However, there was no clear relationship between their abundance and temperature.

10AM2001 S10-363 poster

ORGANIC CARBON CYCLES IN THE BERING SEA AND WESTERN ARCTIC OCEAN

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The Arctic Ocean cruises of R/V *Mirai* (JAMSTEC) were conducted in the Bering Sea and Chukchi Sea (MR99-K05; Sept. 11 - Oct. 6, 1999, and MR00-K06; Aug. 22 - Oct. 3, 2000). The high primary productivity in the eastern and northern Bering Sea is reportedly due to the large nutrients supply on account of upwelling and turbulence mixing and river discharge. Bering Sea water (heat and high nutrients) can affect on the physical and biogeochemical processes in the western Arctic. We found that the out flowing dense water (cold halocline water) in the Barrow Canyon in the eastern Chukchi Sea contains high Chl. *a* and total organic carbon (particulate and dissolved) content, suggesting an enormous biological CO2 pump works in the northern Bering Sea and Chukchi Sea shelf. The extremely high organic content of surface sediment (2.73%) in the Barrow Canyon also may be explained by a large biological pump in the shelf and transportation through the water flow. On the other hand, alkenone concentration was detectable within upper12cm depth of sediment core in northern Bering Sea (total core length is 21cm), suggesting that coccolithpores (*Emiliania huxlei*) appeared recently, which is possibly related to the increased sea water temperature in the Bering Sea.

Production rates of lipid compounds such as fatty acids and alkenone are determined by using13C-GCMS technique, to understand dynamics of geochemical biomarkers in the surface water of Bering Sea (during *Emiliania huxlei* blooming) and Chukchi Sea. Turn over rates of individual fatty acid and C_{37} alkenone based on the production rate and concentration of each biomarker in particulate matter are various in the surface water of eastern Bering Sea shelf and in eastern Chukchi Sea and Canada Basin (alkenone was detected only in the Bering Sea). It strongly suggests that individual lipid compounds have the different stability in the water column. In addition, these results can be applied for the interpretation of marine paleoproductivity change and terrestrial input of organic matter by comparing with the records of sediment core which is associated with climate change in the Arctic region.

10AM2001 S10-031 invited

INTERANNUAL VARIATION IN PHYTOPLANKTON BIOMASS IN THE BERING SEA BASIN IN THE 1990S

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Surface chlorophyll *a* (Chl *a*) concentrations were measured at seven stations located at every 1° between 52°30'N and 58°30'N along 179°30'W, late in June from 1991 through 1999. Surface Chl *a* concentrations at the same locations were estimated from SeaWiFS data during mid June through mid July 2000. All of the surface Chl *a* concentration data (n=75) were statistically tested for year-to-year and station-to-station variations. No significant variation was noticed from both analyses. Moreover, there was no significant difference in the Chl *a* concentrations, between the years during ten years of investigation.

Based on the time series of monthly Chl *a* concentrations from 1998 through 2000 by SeaWiFS, maximum Chl *a* concentrations were observed during May-June along our sampling transect. By using the shipboard data during 1993-1995, surface Chl *a* concentration was found to be in good agreement with Chl *a* standing stock integrated over the upper 100m of the water column. Thus the surface Chl *a* concentration was considered as an index for analysis of the interannual variation in phytoplankton biomass in the Bering Sea basin. Our result indicated no significant interannual variation in phytoplankton biomass in the Bering Sea during 1990s.

10AM2001 S10-216 poster

TEMPORAL AND SPATIAL VARIABILITY IN LIPID FLUXES OVER THE SOUTHEASTERN BERING SEA SHELF, 1997-2000

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The lipid composition of sinking particulate matter at two sites over the southeastern Bering Sea shelf was investigated using sediment traps deployed between 1997-2000. The traps were moored at M2 (56°53', 164°02'W) at 35 meters and M3 (56°04', 166°20'W) at 70 meters. Lipid fluxes varied spatially, the flux into the shallower middle shelf (M2) trap being greater than the flux into the deeper outer shelf (M3) trap. Seasonal variations in fluxes were also noted, with maximum fluxes at both sites occurring usually during spring and fall blooms and minimum fluxes occurring in winter. Temporal changes between years included a decrease in saturated acids such as 14:0, and an increase in 18 PUFAs and 20 PUFAs.

The fatty acid composition of lipids at M2 during spring bloom pulses consisted of the diatom biomarkers 16:1 (n-7), the polyunsaturates 16:4 (n-1), 20:5 (n-3), with a smaller concentration of saturated fatty acids such as 14:0 and 16:0. Polyunsaturated fatty acids believed to be flagellate biomarkers, 18:2 (n-6), 18:3 (n-6), 20:4 (n-6) and 22:6 (n-3), were present in samples also. Lipid fluxes from the M2 fall blooms reflected diatom and flagellate inputs, in addition to the euphausid biomakers, 14:0, 16:0, 18:0, 18:1 (n-7) and 18:1 (n-9), and the calanoid copepod lipids 20:1 (n-9) and 22:1 (n-11). Numerous zooplankton fecal pellets were found in fall samples. The odd-chain and branched-chain fatty acids 15:0 and 17:0, bacterial indicators, were also present.

Fluxes at M3 were lower and generally contained fewer phytoplankton and a larger ratio of intact zooplankton fecal pellets. The same fatty acids were found during bloom periods as those found at M2, although 20:1 (n-9) and 22:1 (n-11) concentrations were significantly higher at M3.

Fatty alcohols phytol, 16:0, 18:0, 20:1 and 22:1 were dominant in samples throughout the study. Cholesterol was the main sterol, especially in samples containing flagellates. Other sterols found were 24-methylcholesta-5,22E-dien-3β-ol and cholesta-5,22E-dien-3β-ol.

10AM2001 S10-375 oral

DECADE OF CHANGE OVER THE SOUTHEASTERN BERING SEA SHELF

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The Bering Sea is characterized by large year-to-year variability, which can obscure longer-term climate changes. This was true of the 1990s, which featured large fluctuations in parameters such as sea surface temperature and ice extent. Among the decadal shifts in the 1990s was a systematic move toward an earlier spring transition. Since the mid-to-late 1980s, the period of May through mid-June has been characterized by an increased rate of warming (from 5°C/100 days to 7°C/100days). In addition, April temperatures at 850 hPa for the 1990s were significantly warmer than for previous decade. A primary objective of our analysis is to determine the relative contributions of anomalous horizontal advection of heat by the ocean versus anomalous heating by the atmosphere to the observed warming during the 1990s. The causes and effects of such warming are difficult to identify, but the extensive measurements from both ships and moorings collected during the 1990s permit us to examine changes in the physical environment of the southeastern Bering Sea during the 1990s.

10AM2001 S10-405 poster

WHEN PUSH COMES TO SHOVE: CONTRAST IN ZOOPLANKTON DEPLETION IN HIGH AND LOW JUVENILE POLLOCK ABUNDANCE YEARS BASED ON ACOUSTIC AND MODELING EVIDENCE NEAR THE PRIBILOF ISLANDS, ALASKA

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Acoustic surveys in the neighborhood of the Pribilof Islands, AK, provided an opportunity to examine the abundance and distribution of a pelagic predator, juvenile walleye pollock, and their zooplankton prey. Image processing methods were used on acoustic backscatter data at 38 and 120 kHz to identify schools of fish in this major pollock nursery area and distinguish them from patches of zooplankton (predominately euphausiids, which are large enough to reflect sound at the study frequencies). We compared fish and plankton biomass distribution for both August and September 1996 and 1997 surveys, the highest and lowest abundance years for pollock during 6 consecutive years of acoustic surveys. We found that there was a significant drop in zooplankton abundance on each of 4 study transects between August and September 1996, with the change in abundance being proportional to the relative abundance of pollock schools on the transects. In contrast, conditions in 1997 did not show any significant drop in zooplankton abundance between August and September surveys. These results suggest that zooplankton abundance was seriously depleted by the major pelagic zooplankton predator in this area in 1996, but was hardly affected in 1997. A pollock energetics model, using the abundance in each distinguishable habitat region, computed from acoustic abundance, and diet data from trawl-caught pollock, projected the consumption of zooplankton between August and September in both years. Results of these simulation runs were compared with observed abundance differences.

10AM2001 S10-033 invited

TEMPORAL FLUX CHANGE OF SHELL-BEARING PLANKTON PARTICLES IN THE BERING SEA DURING THE LAST TEN YEARS SINCE 1990

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Because of its considerable high biological productivity, it is of interest to study efficiency of biological pump in the Bering Sea for the global climate change. This requires extensive time-series flux studies on quality and quantity of plankton community. Station AB (53.5°N, 177°W; water depth: 3788 m; trap depth: 3198 m) in the Aleutian Basin of the Bering Seas was chosen for collecting long time-series particle flux data. A time-series sediment trap was deployed at 600 m above the sea-floor for eleven consecutive years thus far and currently on-going. Considerable changes both in quality and quantity of temporal fluxes have been observed.

The mean opal contribution to total mass flux was 66%, which was significantly high. This mainly stems from an extensive production of diatoms. *Neodenticula seminae*, a chain forming pennate diatom, dominates the flux assemblages, contributing 82% mean of total diatoms. The remainder of the assemblage is comprised of forty centric and eight pennate species. Second to diatoms in opal contribution, highly diversified radiolarian flux assemblages with 113 species were observed. The top five species in shell flux number includes: *Peridium* sp., *Phormacantha* spp., *Stylochlamydium venustum, Pseudodictyophimus gracilipes,* and *ceratospyris borealis.*

Calcium carbonate fluxes contributed 14% mean in total mass fluxes, which are mainly comprised of coccolithophores and planktic foraminifers since pteropods' mass flux is negligible in $CaCO_3$. *Coccolithus pelagicus,* a large-sized cold water coccolithophore taxon, dominates in the $CaCO_3$ contribution, whereas *Emiliania huxleyi,* a small-sized cosmopolitan coccolithophore, does occur on the same order of magnitude as the former. The planktic foraminifer assemblages are comprised of *Globigerina bulloides, Neogloboquadrina pachyderma, Globigerina quinqueloba,* and *Globigerinita glutinata.*

10AM2001 S10-414 poster

EFFECTS OF WATER TEMPERATURE AND WIND ON RECRUITMENT OF TANNER CRABS IN BRISTOL BAY, ALASKA

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We investigated five hypotheses on recruitment mechanisms for commercially exploited Tanner crabs, *Chionoecetes bairdi*, in Bristol Bay, Alaska, through correlation analysis, exploratory graphics, and multivariate regression modeling. Recruitment was estimated by Zheng et al. (1998) length-based analysis of assessment survey and commercial catch data. Recruitment estimates were positively correlated with bottom temperatures during gonadal development and egg incubation, and with sea surface temperatures and northeasterly winds during the pelagic larval period in spring. No relationships were found between recruitment estimates and winds from other directions nor predator abundance. Anomalously cold bottom temperatures may adversely affect the Tanner crab reproductive cycle, winds from the northeast may promote coastal upwelling while advecting larvae to regions of fine sediments favorable for survival upon settling, and warm sea surface temperatures promote growth and reproduction of small-bodied copepods, the preferred food of crab larvae. Correlations among the physical variables and uncertainty about time lags from crab spawning to recruitment confound conclusive interpretation of underlying cause and effect mechanisms.

10AM2001 S10-206 oral

CHANGES IN CARBON FLOW ON THE SOUTHEAST BERING SEA SHELF: IMPORTANCE OF LARGE WHALES DURING THE LATE 1990S

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During the mid-1970s, the food web of the middle shelf of the southeast Bering Sea was described as primarily a benthic system, in which most of the primary production was largely ungrazed and sank to the sea floor, supporting high benthic biomass. Results from line-transect surveys of cetaceans conducted during the late 1990s, however, suggest that the flow of carbon on the southeast middle shelf has altered. Stratified density and abundance estimates of cetacean species for the summers of 1997 and 1999 show the ecological importance of the two dominant large whale species, fin whales *Balaenoptera physalus* and humpback whales *Megaptera novaeangliae*, as top trophic predators on the middle shelf of the southeast Bering Sea. During 1997, 65% of fin whales and 76% of humpback whales occurred in the southeast central middle shelf (50-100 m isobaths; 163.7W - 168.1W). During 1999, 79% of fin whales occupied the southeast central middle shelf domain. Over a four-month feeding season in 1997, fin whales (of total abundance N = 794, 43.3% C.V.) consumed an estimated 95,300 - 267,000 metric tons (mt) of prey on the southeast shelf and slope. For the same region and period, humpback whales (N = 1730, 53.1% C.V.) consumed an additional 169,000 - 457,000 mt of prey. During 1999, fin whales (N = 1184, 44.8% C.V.) consumed an estimated 138,000 - 398,000 mt of prey on the shelf, slope, and basin-edge regions. In contrast to the middle shelf preference shown by fin whales, Dall's porpoise *Phocoenoides dalli*, were more numerous (N = 27,268 (28.2% C.V.) in 1997 and N = 32,303 (21.0% C.V.) in 1999) in the outer shelf, slope, and basin-edge regions, where they consumed approximately 49,000 - 58,100 mt of prey. These results redefine the important ecological roles of large whales on the shelf during the late 1990s in terms of predation, carbon sequestration and export, respiration, and recycling in the shelf system.

10AM2001 S10-364 poster

ASSESSMENT OF MACROSCALE CONNECTION IN THE ATMOSPHERE - SEA ICE COVER SYSTEM

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On the base of all available data sets and reanalyzed historical ice-cover data in Far-Eastern seas (the Sea of Okhotsk and Bering Sea) and macrosynoptic circulation over the Amerasian sector of Northern Hemisphere for the period 1929-2000 the relationship into the atmosphere- ice cover system has been estimated.

Square of sea-ice covering Okhotsk and Bering seas and Siberian High and Aleutian Low parameters are used for study. Spectral analyze of all investigating parameters shown the main quasiperiodic part in ice formation and atmospheric processes. There are 2-3, 7-8, 11 and 21-22 years periods in variability of ice cover and atmosphere processes. The maximum change is obtained for 7-8 frequency connected with global change in ice conditions in the Far-Eastern Sea. Asynchronous change between atmosphere processes and ice cover is obtained with time lag 7 years. Assessment of ice cover variability is agreed with recent change in ice cover in the Bering and Okhotsk seas: the shift in ice conditions from low ice cover in the 1991-1997 to hard ice cover in the 1998-1999.

10AM2001 S10-133 poster

TEMPORAL PATTERNS IN THE AT-SEA ABUNDANCE AND DISTRIBUTION OF MARINE BIRDS AROUND THE PRIBILOF ISLANDS, 1975-1999

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Evidence suggests there have been major changes in the Bering Sea over recent decades, including shifts in the abundance of marine birds nesting on the Pribilof Islands, Alaska. We hypothesized that at-sea surveys of marine birds foraging near the islands would reflect changes in abundance on the islands. In addition, we hypothesized that changes in the local distribution of seabirds would indicate shifts in the distribution or availability of their prey. Therefore, we conducted at-sea surveys near the Pribilof Islands during 1975-79, 1987-88, and 1994-1999. We found that the at-sea abundance of murres (*Uria* spp.) and puffins (*Fratercula* spp.) decreased across decades, whereas kittiwakes (*Rissa* spp.) declined between the 1970s and 1980s, but then increased in the 1990s. At-sea abundance of murres did not reflect long-term trends in murres nesting on the islands, whereas the at-sea abundance of kittiwakes was similar to that for nesting kittiwakes. We suggest that, over time, murres have shifted their foraging distribution outside our sampling area. In contrast to decadal-scale changes in numbers, changes in densities of marine birds relative to their use of waters north of St. Paul Island (primarily water from the middle domain), between St. Paul and St. George Islands (mixed middle and outer domain waters), and south of St. George Island (outer domain water) were apparent only at an annual scale. Our results suggest that the distribution of murres near the Pribilof Islands is influenced annually by short-term shifts in the distribution of forage fish, while murre abundance is influenced by decadal-scale declines in prey abundance.

10AM2001 S10-380 poster

ANALYSIS OF THE REASONS OF ABNORMAL DISSEMINATION OF ICE IN THE BERING SEA

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Ice cover of the seas is a product of mutual relation of the atmosphere and hydroshpere and ice itself have influence on atmosphere and hydroshpere. Us result of they very complicate mutual relation is specific type of ice cover. Analysis of the reasons of forming one or another type of ice shows, that it is not always possible to find the source which is most important. In that situation dissemination of the ice on the sea is abnormal. This work shows versatile analysis of all abnormal things in dissemination of the ice cover including extreme situation.

10AM2001 S10-259 poster

FLATFISH RECRUITMENT RESPONSE TO DECADAL CLIMATIC VARIABILITY AND OCEAN CONDITIONS IN THE EASTERN BERING SEA

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Temporal trends in flatfish production in the Eastern Bering Sea are consistent with the hypothesis that decadal scale climate variability influences marine survival during the early life history period. Five species of Bering Sea shelf flatfish (yellowfin sole, rock sole, flathead sole, Alaska plaice and arrowtooth flounder) exhibited increases in production (recruitment) from 1970-1990. During the same period, Greenland turbot exhibited a marked decline in production. These biomass increases were the result of consecutive years of strong recruitment which occurred for each species over a 5-7 year interval in the time period examined. For two species, yellowfin sole and Alaska plaice, the consecutive strong recruitment occurred during the period from the late 1960s through the mid 1970s, associated with the cooler climatic period in the North Pacific Ocean. For flathead sole, arrowtooth flounder and rock sole the consecutive strong year-classes were evident from the 10 year period spanning the late 1970s the late 1980s, the warm climate period. This analysis provides a more detailed examination of the statistical relationship between ocean forcing and flatfish production in the Eastern Bering Sea.

We statistically evaluate the role of ocean forcing on flatfish production using two analysis approaches. First we perform a statistical comparison of temporal patterns of flatfish production, the arctic oscillation and the Pacific decadal oscillation. Previous studies have shown that shifts in production of Greenland turbot and Arrowtooth flounder coincided with the climate shift in 1976/77. This time series is updated to include temporal patterns before and after the 1988/89 period. The second analysis approach explores the relationship between flatfish production, flatfish condition (weight at age and length at age) and time series of key oceanographic variables. The oceanographic variables include the areal extent of the cold pool, seasonal bottom temperature, sea ice extent, and wind driven transport (based on the OSCURS model). Time series are selected to temporally and spatially coincide with conditions present just before spawning to settlement.

10AM2001 S10-391 oral

THE INTERANNUAL VARIABILITY OF BIOLOGICAL CHARACTERISTICS OF WALLEYE POLLOCK IN THE ALEUTIAN BASIN IN THE 1990s

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Distributions and biological characteristics of pelagic walleye pollock, *Theragra chalcogramma*, were examined in order to elucidate significant changes in one of the important key species in the Aleutian Basin ecosystem over the last decade. Historical data obtained between 1989 and 1999 by research vessels (Japan Fisheries Agency) were used to analyze the distributions, size compositions, length-age relationships, spawning activities, and growth. In this area, commercial catch showed a peak in the late 1980s, and it rapidly decrease in the early 1990s. Acoustic survey results showed a clear shrinkage of summer distribution between end of 1980s and early 1990s, showing good accordance with commercial fisheries catch history. Spawning pollock survey revealed that the spawning biomass had been decreasing, and the spawning ground shifted from the Bogoslof Island area to the Four Mountains Island area in the early 1990s. Age compositions showed 1978 year class was the most dominant until 1993, it was replaced by the 1989 year class in the mid 1990s. At the same time, length at age became larger, and the average length of spawning pollock increased from 480mm in 1989 to 560mm in 1999. Over the last decade, historical strong 1978 year class disappeared, and significant changes in the biomass, horizontal distribution, size composition, growth, and spawning period were observed in the Aleutian Basin pollock stock.

10AM2001 S10-171 poster

COCCOLITHOPHORES IN THE BERING SEA

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Field work in the Bering Sea during the period of 1997-1999 documented a coccolithophore bloom, of unusually large proportions and unusual persistence. The abundance of the *Emiliana huxleyi* cells varied around the southeastern Bering Sea from a few cells/ml to well over 5000 cell/ml, measured during the fall cruise of 1998. Abundances were lowest near the Alaska Peninsula and increased northward. The percent composition also varied from almost none to over 90% of the phytoplankton community. Total community cell concentrations ranged from a 10s of cells to over 15,000 cells/ml.

Evidence for the overwintering of *E. huxleyi* comes from the *in situ* samples. During the winter of 1997-98, unfortunately, no *in situ* samples were collected. Water samples collected during a February 1999 cruise, however, contained intact *E. huxleyi* cells with chloroplasts. Although the cell counts were low (192-960 cells/liter), the fact that they were present in February indicates that the cells never sank out of the water column, and likely survived the winter. Initial observations of the bloom came during an El Niño year. Temperatures were warm for the region, but conditions returned to more normal conditions in later years.

S11 CCCC/GLOBEC Topic Session Results of GLOBEC and GLOBEC-like programs (with emphasis on a possible 1999 regime shift)

Co-sponsored by GLOBEC
Convenors: Makoto Kashiwai (Japan) and David W. Welch (Canada)
Wednesday, October 10, 2001 08:30-12:30

There is widespread evidence for a large change in the physics and biology of the North Pacific in 1998/99, which has been suggested to represent a switch in the PDO to its opposite state. The purpose of this session will be to provide a forum for a review of the observational evidence contrasting conditions before and after the 1998-99 winter, and for developing an understanding of how this impacts the upper trophic levels of the ecosystem. As PICES is now discussing the development of an ecosystem report on the status of the North Pacific Ocean, the data that would be generated from this session could provide the basis for an initial report on this topic. Such a report would be of widespread interest within the PICES region, and would also position PICES to play a significant role in other international programs.

Invited speakers:

P. Christopher Reid (SAHFOS, UK) - The North Atlantic: evidence for a change in ocean climate in recent years

Franklin B. Schwing (Pacific Fisheries Environmental Lab., NOAA/NMFS, U.S.A.) - The 1998 regime shift in the North Pacific: physical mechanisms and ecological consequences

10AM2001 S11-395 poster

COMPARATIVE REPRODUCTIVE PERFORMANCE AND NESTLING DIET OF CASSIN'S AUKLET BREEDING IN TWO DISTINCT OCEANOGRAPHIC DOMAINS OFF BRITISH COLUMBIA

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The planktivorous seabird, Cassin's Auklet (*Ptychoramphus aleuticus)* breed on Triangle Island (50°52'N 129°05'W), in the coastal upwelling domain, and on Frederick Island (53°56' N, 133°11' W) in the coastal downwelling domain of British Columbia, Canada. Measures of breeding performance (e.g., chick growth rate) exhibited significant differences in the 1990s (1994-1998) despite strong similarities in the early 1980s (1981, 1982). The Triangle Island breeding population performed very poorly, particularly in 1996 and 1998, in contrast to consistently strong nestling performance on Frederick Island. In 1999, ocean temperatures cooled significantly and reproductive performance on Triangle Island was the strongest of the decade, similar to the historical values. In 2000 the growth rates of nestlings on both colonies were similarly high. The nestling diet is composed largely of copepods (*Neocalanus cristatus*) and euphausiids (*Thysanoessa inspinata, T. spinifera & Euphausia pacifica*) with fish contributing substantially in some years at Triangle Island. The copepod *N. cristatus*, however, is the single most important prey item at both colonies. In years when spring was early and warm nestling growth at Triangle Island was significantly reduced. *N. cristatus* contributed less to the diet overall in warmer years, and was scarce or absent late in chick-rearing. The degree to which the seabird breeding season overlaps temporally with the peak availability of copepods in surface waters appears to be reduced in years with warm, early spring. Copepods also varied between years at Frederick Island, but were replaced in the nestling diet by prey of higher energy density (Euphausiids).

10AM2001 S11-374 poster

YEAR-TO-YEAR DYNAMICS OF COPEPODA; CALANOIDA IN EPIPELAGIC LAYER OF THE OKHOTSK SEA AND THE KURIL REGION OF THE PACIFIC OCEAN

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The data were analyzed on zooplankton distribution in the upper 200 m layer of the Okhotsk Sea and the Kuril region of the Pacific Ocean (41-52°N, 144-159°E) obtained in summer of three years with different hydrological regime: 1991 (warm), 1993 (cold), and 1995 (transition type of regime). Biomass distribution and age structure of mass species of Copepoda are presented. The range of Copepoda biomass in the Okhotsk Sea was 700-1500 mg/m^3 and in the Pacific Ocean - 900-1300 mg/m^3. The highest their abundance in the epipelagic layer of the Okhotsk Sea was observed in the transition year (1995) but in the Pacific Ocean - in the warm year (1991). Besides, ratio of the main species and groups of zooplankton was different.

Distribution of mass Copepoda species was different in dependence on thermal regime, as well. Distribution of *Neocalanus cristatus*, *N.plumchrus*, *Eucalanus bungii* and *Metridia pacifica* was influenced by water exchange between the Sea and the Ocean. The densest concentrations of Copepoda were found in frontal zones and in proper oceanic waters. The highest abundance of *Calanus glacialis* and *Metridia okhotensis* was noted in the Okhotsk Sea. Abundance of small size Copepoda as *Oithona similis* and *Pseudocalanus minutus* was higher in the Kuril region of the Pacific Ocean.

10AM2001 S11-139 poster

MESOSCALE AND FINE-SCALE DISTRIBUTION OF JUVENILE SALMON AND ASSOCIATED BIOTA OFF OREGON AND NORTHERN CALIFORNIA

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Information is summarized on juvenile salmon distribution, size, condition, growth, stock origin, and species and environmental associations from the first year (June and August 2000) GLOBEC cruises with particular emphasis on differences related to the regions north and south of Cape Blanco off Southern Oregon. Juvenile salmon were found primarily in cooler water inside of the 200 m isobath. Juvenile salmon were more abundant during the July-August cruise as compared to the June cruise and were distributed northward from Cape Blanco. There were distinct differences in distribution patterns between salmon species with chinook found close inshore in cooler water all along the coast. Coho salmon were rarely found south of Cape Blanco. The nekton assemblages differed significantly between cruises. June samples were dominated by juveniles of rockfishes, rex sole, and sablefish, which were almost completely absent in August. The forage fish community during June was comprised of herring and whitebait smelt north of Cape Blanco and surf smelt south of Cape Blanco. The August fish community was dominated by sardines. Potential salmon predators were rare in June, however jack mackerel were very abundant in August. Both cruises were similar in diversity of the nekton community. Significant differences in growth and condition of juvenile salmon indicate different oceanographic environments north and south of Cape Blanco. The condition index was higher in juvenile yearling chinook salmon to the south of Cape Blanco whereas condition was higher in juvenile coho to the north. Genetic mixed stock analysis indicated that during June most of the chinook salmon in our sample originated from rivers along the central coast of Oregon. In August, chinook salmon sampled south of Cape Blanco were largely from southern Oregon and northern California while north of Cape Blanco, most chinook salmon were from Central California.

10AM2001 S11-228 poster

ON PINK SALMON (*Oncorhynchus gorbuscha*) NUMBER INFLUENCE ON ASIAN SOCKEYE (*Oncorhynchus nerka*)

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Sockeye reproduction in Asia is practically completely concentrated in Kamchatka. A total number of the mature part of the Asian Sockeye (the Ozernaya River, the Kamchatka River, minor Asian stocks) grew almost twice in 1985-2000 in comparison with the previous period of 1970–1984.

In 1957–1983 a high number of Pink salmon (dominating generations) by odd years was observed simultaneously at both coasts. In even years the number of Pink salmon of the both coasts was considerably lower. Due to overflow of the spawning grounds almost the whole generation of Pink salmon of the Western Kamchatka of 1983 died.

As a result starting 1985 and till now in all odd years the number of Pink salmon at the North-East Kamchatka became much higher than that at the Western Kamchatka. In its turn in even years starting 1986 and till now they observe a bigger number of Pink salmon at the Western Kamchatka and a lower – at the Eastern Kamchatka.

Changes of roll-down dynamics and Pink salmon 0+ number of the both coasts as a whole changed food relations of Pink salmon and Sockeye in the sea, especially at the primary stages of the marine period of life. These species are food rivals during the marine period of life.

A historical fact of the Western Kamchatka Pink salmon dominating generations' shift from odd to even years, and the coincident with this event increase of the Asian Sockeye stocks may be a basis for researches of this area Sockeye number by separate periods.

10AM2001 S11-333 oral

STUDY ON ANNUAL VARIATION OF BIOMASS OF ZOOPLANKTON IN THE EAST CHINA SEA

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This paper deals with annual variation of biomass from 1950s to 1990s in the East China Sea. The analyzing result shows that annual mean biomass of zooplankton is 156 mg/m^3 appeared in 1959. Since the 1970s, mean biomass of zooplankton was decreasing to 125mg/m^3. In 1981, mean biomass of season of zooplankton only was 64mg/m^3 and the mean biomass in the end of 1990's was only 40.9mg/m^3 which obviously showed that biomass was sharply decreasing in the East China Sea.

Key species of zooplankton are *Calanus sinicus* Brodsky, *Euphausia pacifica* Hansen, *Pseudeuphansia sinica* Wang et Chen, *Sagitta enflata* Grassi, *Euchaeta concinna* Dana and *Themisto gracilipes* Noman etc. The quantitative fluctuation and distribution of key species are close related to water temperature, salinity and currents. Distribution of biomass of zooplankton and key species are closely related to locations of major fisheries grounds of mackerel and hairtail fishes, and temperature, runoff etc..

10AM2001 S11-116 poster

BIO-PHYSICAL TRANSPORT MODELLING OF THE GROWTH AND SURVIVAL OF THE PLANKTONIC STAGES OF MACKEREL (*Scomber scombrus*) IN THE EASTERN NORTH ATLANTIC

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As part of a multi-national European project (SEAMAR), an individual-based bio-physical transport modelling scheme has been developed for simulating the growth and survival of the planktonic stages of mackerel (*Scomber scombrus*) in the shelf-edge and adjacent waters of the eastern North Atlantic. A circulation model provides input to a transport model incorporating the vertical distribution of eggs and larvae. Growth of larvae and post-larvae is parameterized in terms of temperature and food availability. Food availability is modelled from satellite-derived sea surface temperature and colour (chlorophyll) data via copepod egg production rates. Mortality is modelled as a function of larval length and growth rate. Model simulations have been run for various climatological scenarios as well as using actual annual meteorological data for comparison and validation against survey data and recruit distributions. The results are discussed in relation to the validity of the parameterizations, recent inter-annual variability and the predictive capability of such modelling schemes.

10AM2001 S11-006 poster

LOW FREQUENCY PYCNOCLINE DEPTH VARIABILITY AT STATION P IN THE NORTHEAST PACIFIC

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Low frequency variability of the depth of the main pycnocline at Ocean Weather Station P and over the northeast Pacific is examined in terms of the response of the Hasselmann (1976) stochastic climate model to local Ekman pumping. The model is forced with monthly wind stress curl anomalies derived from the NCEP reanalysis for the period 1948-2000. An empirical orthogonal function analysis shows that the leading mode of the response bears the signature of the Pacific (inter) Decadal Oscillation (PDO), while the associated principal component captures the 'regime shift' of 1976/77. A direct comparison is made between pycnocline displacement anomalies hindcast from the model and anomalies in the depth of the main pycnocline at Station P (215E, 50N) observed over a 43 year period. The comparison shows that good agreement is maintained over the length of the timeseries, with the PDO mode contributing importantly to the observed variability. Insofar as Station P is representative, the results suggest that variability of the upper ocean density field on interannual to interdecadal time scales over the northeast Pacific occurs largely in response to local Ekman pumping.

10AM2001 S11-351 poster

YEAR-TO-YEAR VARIABILITY OF PLANKTON IN THE NORTHWESTERN PART OF THE JAPAN SEA

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The material for the study was collected by Juday plankton net in the upper 200 m layer in 1985-1998. In spring the total biomass of zooplankton was twice higher in conditions of "cool years" (1988 & 1996), than in "warm years" (1989-1994), while the ratio of dominant groups didn't vary. In relatively "cool" springs both a number of cold-water species of copepods and euphausiids and a total biomass of plankton in deep-water area is increased in 2.6 times. In relatively "warm" springs, the biomass of wide-boreal species as *Euphausia pacifica* is increased in 2.4 times. The phytoplankton concentration was also twice higher in the "cool years". In summer the total biomass of zooplankton in years with different type of thermal mode had equal meanings, but, as against the spring period, the ratio of the basic groups of plankton sharply differs. The biomass of copepods in the "cold years" was in 1.5 times lower, than in "warm years", but the biomass of hyperiids and euphausiids was higher in 1.3 and in 2.5 times accordingly. So, the deflection of environmental conditions from climatic state renders effect on reproduction of plankton invertebrates according to their ecology. Interannual changes in quantity and structure of plankton have been revealed, which are a part of epipelagic ecosystem reconstruction. After exclusion from ichthyocenosis the highest-power herbivorous consumer has caused by sardine declining, the share of predatory chaetognatha species is increased by three times. Japanese common squid, despite of its high stock in recent years, has not replaced the sardine in a trophic pyramid: in summer period the squid consumes the plankton invertebrates in 17.5 times lesser than sardine had consumed in the times of its high stock.

10AM2001 S11-146 poster

THE RECENT NORTHWEST BAITFISH BOOM AND INCREASED SALMON OCEAN SURVIVAL

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Historical datasets indicate that Northwest baitfish (e.g., Pacific herring, northern anchovy, Pacific sardine, and smelt) abundance has fluctuated widely over the last 50 years. Salmon ocean survival has also fluctuated widely since records began. Since 1999 we have noted a marked increase in the number of baitfish off Washington and Oregon. This increase appears to be related to decreasing ocean temperatures, changing zooplankton species and abundance, and decreased predator abundance. We hypothesize that baitfish abundance directly affects salmon ocean survival by acting as "alternative prey" for predators and thus decreasing predation rates.

10AM2001 S11-153 poster

VARIABILITY IN LENGTH AND INTENSITY OF EUPHAUSIID SPAWNING OFF CENTRAL OREGON, 1996-2001

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Through high-frequency (biweekly) sampling, along a transect line off Newport, Oregon (latitude 44° 40' N), we are able to track the duration and intensity of the euphausiid spawning season. Our sampling consists of vertical and oblique plankton tows, CTD casts, and collection of water for chlorophyll *a* and nutrient analysis. The density of euphausiid eggs in our samples is highly variable spatially and temporally. However, we see the most striking differences in egg densities and length of the spawning season, when we compare apparent spawning before and after 1999. 1996 and 1997 were characterized by one large, late summer peak in egg density. 1998 followed this pattern for our offshore station, but with eggs nearly absent at our inshore stations. Starting in

1999, we saw multiple peaks in egg density starting in spring and lasting through early fall. Egg densities during these peaks reached record levels in 2000 with densities five times higher than the 1996-1998 peaks. 2001 is continuing with this trend with peaks starting in late February. Peaks in egg densities are often associated with phytoplankton blooms, but interannual changes in chlorophyll *a* concentration cannot explain the dramatic changes seen in 1999. Peaks in egg densities often follow upwelling events, but it is not yet clear whether this connection is due to changes in advection or changes in upwelling induced productivity.

10AM2001 S11-306 poster

ZONAL DISTRIBUTION AND COMMUNITY STRUCTURE OF EUPHAUSIID ON THE COASTAL SHELF OFF CENTRAL OREGON, DURING 1970-1972: A MULTIVARIATE APPROACH

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Community structure and inshore-offshore zonal distribution of euphausiids off the central Oregon, USA (Newport Hydrographic line, 44° 40'N) was examined from oceanographic surveys from January 1970 through July 1972. The community variables were related to monthly changes in temperature, salinity, upwelling index, and regional ocean circulation. Multivariate analysis was done to identify strongest environmental gradients that influence the temporal and spatial changes in the euphausiid community structure. Eleven euphausiid species were found associated to this upwelling ecosystem with a β-diversity of 5.2. The main reproductive area where egg and nauplii were mainly distributed was nearshore (< 10 nautical miles from the coast during summer). The euphausiid community assemblage in the Oregon upwelling region is separated in two groups: neritic and oceanic assemblages by strong longitudinal gradient indicated by the distance from the coast (limit is about 25 nautical miles offshore). Other variables like time of sampling (D/N), sea surface temperature, and seasonality are secondary variables to separate these two assemblages. The dominant species *Euphausia pacifica* and *Thysanoessa spinifera* have a strong life-stage segregation within the Oregon upwelling region where early larvae stages inhabits in different environmental conditions than juvenile and adults stages. High densities of larvae and juveniles of *T. spinifera* also were found nearshore but older stages were mainly recorded offshore (10 to 60 nm from the coast). *Euphausia pacifica* was found relatively homogeneously distributed in shelf and offshore waters but were recorded chiefly inshore in mid-summer and offshore the rest of the year. Four species can be considered as good indicator species for offshore environment of the Oregon upwelling region: *Tessarabrachion oculatus*, *Thysanoessa longipes*, *Thysanoessa gregaria*, and *Nematoscelis difficilis* featured by temperatures larger than 10°C. Our data support the hypothesis there are strong inshore-offshore segregation in species distributions suggesting active maintenance strategies of these euphausiids within this upwelling region.

10AM2001 S11-079 poster

DECADAL VARIABILITY ON THE STOMACH CONTENTS AND THE GROWTH RATE OF WALLEYE POLLOCK OFF THE PACIFIC COAST OF EASTERN HOKKAIDO, JAPAN

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"Pacific stock" of Japan is the most abundant walleye pollock stock in Japan. Environmental change in the North Pacific might affect the biological characteristics of the "Pacific stock". We examined annual changes of the stomach contents in spring and the growth rate of walleye pollock off the Pacific coast of eastern Hokkaido, from 1984 to 1999.

The appearance rate of Euphausiacea in the pollock stomach contents was high from 1984 to 1988, and whereas the rate of Copepoda was high after 1989. After 1998, the appearance rates of Euphausiacea and the rate of Copepoda were both high together, but the amount of stomach contents was smaller than that before 1998. Fish had significantly larger length-at-ages in the 1990s compared to the 1980s. The possibility was suggested that the

interannual growth variability was affected by the phase change of phase of planktonic biota might be changed took place in 1989 and 1998. The observed higher growth rates in 1990s were resulted from the higher growth in their younger ages with utilizing abundant Copepoda in the environment. We thought that the environment, which Copepoda was abundant, was a good feeding environment for young pollock. The annual variability of the growth rate of young pollock would be left as a difference of the averaged body length when the fish had grown. We propose the following hypothesis.

In 1984-1988: the environment of rich Euphausiacea and poor Copepoda --> the growth rate of young pollock was low --> the body length of adult fish was small.

In 1989-1997: the environment of poor Euphausiacea and rich Copepoda --> the growth rate of young pollock was high --> the body length of adult fish was large.

After 1998: the new phase of feeding environment for pollock was started.

10AM2001 S11-322 poster

INCREASE IN BODY SIZE WITH DECREASE IN POPULATION SIZE OF CHUM SALMON RETURNING TO HOKKAIDO, JAPAN, SINCE THE LATE 1990s

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In Japan, almost all the chum salmon are produced by the hatchery programs. Population size of Hokkaido chum salmon increased exponentially from early 1980s to early 1990s because of favorable oceanic conditions and successful hatchery technology. Body size of adult chum salmon returning to Hokkaido decreased during the same period. Several hypotheses regarding the cause of this decrease in body size have been proposed such as changes of sea surface temperature and salinity, fishing pressure, global warming, and population density-dependent effect. Since recent climate regime shift in late 1990s, however, this population size has shifted a decrease trend. On the other hand, body size of adult chum salmon in Hokkaido has increased again since 1995. A significant negative relationship between the population size of the Hokkaido chum salmon and annual mean fork length of age-4 adult chum salmon returning to 11 rivers was observed in Hokkaido ($r=-0.865$, $P<0.001$). Our results suggest that somatic growth of Hokkaido chum salmon might relate with the population density-dependent effect.

10AM2001 S11-299 poster

INTERANNUAL AND SEASONAL VARIATIONS IN OCEANOGRAPHIC CONDITION AND ZOOPLANKTON COMMUNITY IN THE EASTERN AREA OF THE YELLOW SEA

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Interannual and seasonal variations in zooplankton biomass and composition of major zooplankton groups, such as copepods, amphipods, chaetognaths and euphausiids, were studied with focusing on climate changes in the eastern area of Yellow Sea. This study dealt with data set of zooplankton biomass, abundance of major zooplankton groups and sea surface temperature obtained over 1965-1999.

The bimonthly regular oceanographic survey on the Korean waters had begun from 1965 by National Fisheries Research and Development Institute. The zooplankton was vertically collected with Norpac net (mouth size: 0.45 m and mesh size: 0.33 mm) from bottom to surface. Zooplankton biomass was calculated based on the wet weight of zooplankton smaller than 3 cm in body size. Major four zooplankton groups were counted over 1978-1999. Sea water temperature was estimated using a thermometer and CTD (Seabird 19) on the standard depths. The studying area was divided into five sub-areas, coastal area, central area, Chin-do area, southwest area and southeast area, based on the physical and biological characteristics. Anomalies of sea surface temperature (SST) showed steadily positive value after late 1980s or early 1990s in February and December except some special years. In contrast, SST seriously fluctuated in August depending on year-to-year.

Zooplankton biomass has increased since late 1980s with three times of large peak in 1991, 1993 and 1997-1998. The zooplankton biomasses of coastal and southwest areas were importantly contributed to determine the mean zooplankton biomass in the whole West Sea of Korea. Zooplankton biomass exhibited seasonal variation with a large peak in June and a small peak in October in the whole West Sea of Korea in conjunction with area variations. In the coastal area, zooplankton showed a large peak in June in contrast with a large peak in April in the southwest area.

Of four major zooplankton groups, copepods were predominated and slightly increased from middle 1980s to late 1990s. After copepods, chaetognaths occupied high position in abundance. Copepods showed similar seasonal variation with zooplankton biomass while the other groups didn't. Chaetognaths appeared abundantly in August after copepod's peak and amphipods and euphausiids showed peak in August and June, respectively. From these, it is assumed that copepods are closely related to chaetognaths as a prey and a predator. It is concluded that the increasing trend of zooplankton biomass after late 1980s is resulted from the warmer winter after late 1980s.

10AM2001 S11-279 poster

NEW ERA OF PACIFIC SALMON EXISTENCE IN THE NORTHWEST PACIFIC

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In the first half of the 1990s the abundance of Pacific salmon was at a high level. This is explained by both favorable oceanographic conditions and advances in artificial propagation. Chum salmon released from Japanese farms constituted the base of propagated juveniles. Chum salmon became the main food consumer in the North Pacific. Under the conditions of a high density they consumed mainly the low caloric food. This resulted in slower growth rates, decreased fecundity and increased age of maturation. Moreover, consumption of this food led to appearance of a large number of individuals with flabby muscles. In the second half of 1990s the situation changed. Chum salmon CPUEs decreased. They began to use energetically valuable food. As a result, the age of maturation decreased, the individuals with flabby muscles almost disappeared. The cause of these changes was a constant tendency toward cooling since the mid-1990s, which resulted in decrease in salmon survival during the first years of marine period of life. As a result, the density of concentrations decreased, and competition for food and space weakened. Sockeye salmon were also affected by changes in oceanographic conditions. The low temperature in Pacific waters off Kamchatka in spring, 1999 and 2000, led to shift in the main migration routes to the south at 2-4° latitude. They migrated into the Sea of Okhotsk with a delay of two weeks. It seems that the cold regime will be favorable for northern stocks of chum and sockeye salmons and unfavorable for Japanese chum salmon.

10AM2001 S11-134 oral

SOME EVIDENCE OF REGIME SHIFT IN THE NORTHWEST PACIFIC DURING 1998/1999

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This paper deals with those changes, which occurred in the Far East Seas and adjacent Pacific waters since 1998. It synthesizes the results of laboratory research and observational data collected as a part of the program on monitoring of climatic variations and their impact on ecosystems in various fishing areas of the world ocean. In 1998/1999 the cold regime was established in the upper layers of the Sea of Okhotsk and Pacific waters off East Kamchatka and the Kuril Islands, though the tendency toward cooling appeared there since 1995-1996. During this period (1995-2001) there was a steady increase in duration of ice period in the region and the later retreat of ice margin. At the same time, the rates of spring-summer warming in the surface layers accelerated in some areas by a factor of 5-7. The volume transport of cyclonic circulation in the Sea of Okhotsk increased by a factor of 3 compared with the mid-1990s (warm regime). As a result, in contrast to the surface layer the warm regime was established in the intermediate layer of 500-1000 m. The transport of Kamchatka current in the 0-1500 m during summer, 2000 was at a low level of about 2 Sv while during the period of intensive water exchange it might be

10-15 Sv. In June 2000 about 70% of aquatory occupied by the Cold Intermediate Layer of Pacific waters off Southeast Kamchatka and the Northern Kuril Islands had the negative temperatures with the minimum value of -1.21°C, which was never registered before. The changes in hydrographic conditions resulted in some biological consequences. Number of species captured in this area in 1999 decreased essentially compared to 1995-1998 (from about 260 to about 150) mainly due to disappearance of heat-loving species such deep-sea sole, slime flounder, Korean flounder, threadfin hakeling. Since 1998 the catch rates of Pacific Ocean perch decreased, while those of Atka mackerel, Kamchatka flounder, Pacific halibut increased. This may be an evidence for ecosystem changes on the western boundary of Western Subarctic Gyre. Migration routes and dates of salmon approaching the coasts of East Kamchatka also changed in 1998/99. For example, because of low water temperatures in Pacific waters off Kamchatka in spring, 1999-2000, migration routes of sockeye salmon shifted to the south at 2-4° latitude following the displacement of zone with the optimal temperatures. The new interesting data regarding the links between climatic variations in different regions of the Northern Hemisphere are also presented in the paper for possible discussion.

10AM2001 S11-346 poster

GLOBAL WARMING AND ENSO IN THE KELP FOREST ECOSYSTEMS OF BAJA CALIFORNIA, MEXICO: BIOLOGICAL INDICATORS OF CLIMATE CHANGE IN BIOGEOGRAPHIC TRANSITION ZONES

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The effects of short-term perturbations or long-term environmental shifts (e.g., climate change) on ecosystems are likely to be magnified in biogeographic transition zones. Species with their ditributional limits occurring in these biogeographic transition zones can often be used as biological indicators of ecosystem response to climate change. The giant kelp ecosystem, *Macrocystis pyrifera*, is an ideal example as: 1) it is an important ecological and economic temperate ecosystem, 2) it has its southern limit in the Northern Hemisphere in a biogeographic transition zone in the Mexican Pacific between a warm temperate and subtropical region, and 3) it shows a direct response, both immediate and long-term, to Pacific warming. Data will be presented showing habitat loss (regional extinction covering almost one third of the ecosystem habitat in the Northern Hemisphere) over the past 75 years, its association with inter-decadal warming events in the Pacific, and the sensitive balance that climate change upsets in this ecosystem. Life history strategies for survival in spite of the strong selective pressures of warmer temperatures and reduced nutrients at the subtropical range of this temperate ecosystem will be presented, suggesting the existence of a stress tolerant microscopic seed bank.

10AM2001 S11-074 poster

DECADAL VARIABILITY OF NORTH PACIFIC CENTRAL MODE WATER

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A climatic regime shift in the winter of 1976/77 had significant impacts on fish production, heat fluxes, SST, and wind stress patterns. After the winter of 1976/77, the central North Pacific SST became colder and the band of westerly winds between 20°N and 45°N became stronger. These conditions remained until the winter of 1988/89 when they switched back to a state similar to that before 1977. An isopycnal model forced with wind stress and heat fluxes from 1965 through 1993 was used to examine the effects of variable atmospheric forcing on the ventilation of the North Pacific. The climate shift had significant effects on the formation rates and locations, and properties of the central mode water (CMW) formed in the model.

The PDO and the AO indices both changed sign in 1976/77. To better understand the influence of these variability patterns on changes in mode water formation, regressions between these indices and various model variables were calculated. Positive PDO and negative AO are both associated with enhanced low pressure over

the North Pacific subpolar gyre and strengthened westerly winds over a zonal band from 30°N to 50°N. A positive state for the PDO is associated with deeper model mixed layers, increased formation of denser CMW layers, thicker layer 12 (the densest CMW layer), and an anticyclonic layer 12 circulation anomaly. On the other hand, while the AO is associated with layer 11 and layer 12 thickness anomalies, it has no associated mixed layer depth or formation signatures.

10AM2001 S11-241 oral

POSSIBLE 1998/99 REGIME SHIFT AND THEIR IMPACTS ON MARINE ECOSYSTEM AND FISHERIES RESOURCES IN THE YELLOW SEA OFF KOREA

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Climate change of the North Pacific occurred in 1976 and 1988/89 had affected the dynamics of the marine ecosystem and fisheries resources in Korean waters (Zhang et al., 2000). There was a switch in the Pacific Decadal Oscillation (PDO) to its negative state in 1998/99, suggested another regime shift in the North Pacific. Characterized as an abnormally cold year in the Yellow Sea off Korea, the monthly sea surface temperature (SST) anomaly changed to negative state after December 1999 and sustained to April 2001. There were biological evidences that the Kuroshio Current introduced to the Yellow Sea off Korea in the late 1990s. Based upon these results with primary production and fisheries resources data in the Yellow Sea off Korea, the relationship between the climate-driven oceanic changes and changes in fisheries resources are discussed with emphasis on a possible 1999 regime shift.

10AM2001 S11-204 oral

EFFECTS OF LARGE-SCALE CLIMATE VARIABILITY ON THE LOWER TROPHIC ECOSYSTEMS OF THE WESTERN SUBTROPICAL PACIFIC AND OYASHIO WATERS: COMPARISON OF POSSIBLE LINKING MECHANISMS AND BIOLOGICAL RESPONSES

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Considerable evidence has suggested that basin-wide changes on different time scales in North Pacific oceanic ecosystems may be linked to large-scale climate variability. In order to improve our understanding on the linkages between the large-scale climate variability and the regional oceanic ecosystem responses, particularly of the lower trophic levels in the subtropical and subarctic Pacific, historical oceanographic and atmospheric data of the two different biogeochemical regimes in the western North Pacific spanning from 1950 to 2000 were examined and compared. Our results clearly showed that large changes in the lower trophic level environments of both regimes observed on interannual and decadal time scales are closely related to large-scale climate variability. In both regimes, deeper winter mixed layers occurred from the mid 1970s to the mid 1980s was synchronous with a decade-long intensification of the wintertime Aleutian Low pressure system in the North Pacific. These led to a sizeable increase in mixed-layer nitrate concentrations. However, the lower trophic levels in both regimes appeared to respond differently, despite similar responses of oceanic physical environments to this decadal climate variability. In the western subtropical Pacific water, springtime phytoplankton and mesozooplankton biomass gradually increased during the mid 1970s to the mid 1980s. In contrast, those in the Oyashio water sharply declined in the same period. The possible mechanisms whereby a large-scale climatic variability causes similar responses in physical environments but different responses in the lower trophic level ecosystems in each regime will be further discussed.

10AM2001 S11-286 oral

LONG-TERM EMPIRICAL FORECASTING OF INTERANNUAL CHANGE AT THE CALIFORNIA CURRENT SYSTEM

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At their first meeting, the Living Marine Resources Panel of the Global Ocean Observing System (LMR-GOOS) decided to conduct a series of retrospective experiments with the purpose of examining whether ocean changes could have been forecasted on the basis of present knowledge. This presentation deals with the results of such an experiment for the California Current System. Three main frequencies of interannual variation were found: the high, mostly related to El Niño events (3-7 yrs), bidecadal (~20 yrs) and low, basically regarded as regime (~50-70 yrs). Of these, we found no support for forecasting the low frequency, whereas empirical relations were developed for the other two that would have yielded reasonable predictions.

10AM2001 S11-201 poster

EMPIRICAL EVIDENCE FOR A LATE 1990'S NORTH PACIFIC REGIME SHIFT

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A cursory review of Pacific climate and ecosystem data from the past few years suggests to some that we have witnessed a regime shift sometime in the late 1990's. In an earlier study, we assembled 100 environmental time series, 31 climatic and 69 biological, to determine if there was evidence for common regime signals in the 1965-1997 period of record. That analysis reproduced previously documented features of the 1977 regime shift, and identified a 1989 shift in some components of the North Pacific ecosystem. Here we report on an analysis of the same 100 environmental time series, updated through present (where possible). Our aim is to characterize recent changes in Pacific climate and marine ecosystems in the context of regime changes documented for the past few decades.

10AM2001 S11-198 poster

PREDICTING CLIMATE CHANGES OF THE WESTERN NORTH PACIFIC OCEAN

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Skillful climate predictions at lead times of a few years have been a goal of climate research because they hold great potential benefit for managing natural resources as well as mitigating adverse climate impacts. Here, we show that wintertime sea-surface temperature (SST) anomalies in the confluence region of the Kuroshio-Oyashio currents in the western North Pacific can be skillfully predicted at unprecedented lead times of up to three years. The predictions are based on the history of the wind stress over the North Pacific and oceanic Rossby wave dynamics. This oceanic predictability is of great interest because the oceanic ecosystem in the KOE region is of vital importance in sustaining the productive oceanic fisheries industries of the northwest Pacific.

10AM2001 S11-203 poster

EFFECTS OF COASTAL SEA SURFACE TEMPERATURES ON SURVIVAL RATES OF SOCKEYE, PINK, AND CHUM SALMON STOCKS FROM WASHINGTON, BRITISH COLUMBIA, AND ALASKA

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Survival rates of Pacific salmon show positive covariation primarily at regional spatial scales (e.g. a few hundred kilometers), presumably due to shared regional-scale variability in environmental processes. Specifically, coastal ocean temperatures during early marine life correlate with survival rates across numerous salmon stocks and may be useful predictors of recruitment. We used regional averages of coastal sea surface temperature (SST), a large-scale climate index (Pacific Decadal Oscillation (PDO)), and dummy variables allowing for regime shifts in 1976/77 and 1988/89 to investigate the relative utility of large-scale versus regional-scale processes for predicting salmon recruitment. We fit a generalized Ricker model with environmental variables (SST, PDO, and regime shift) across 120 stocks of sockeye, pink, and chum salmon. For each species, we fit a mixed-effects model simultaneously to all stocks to improve parameter estimates. Models that included regional measures of SST provided better fits than models including the PDO or regime shifts. However, the best model for sockeye salmon stocks in Alaska included SST and an increase in survival rate (regime shift) after 1976. There was no evidence for a shift in survival rates after 1988. For all three species, coastal SST had a positive effect on survival rates in Alaska. In contrast, survival rates of sockeye and pink salmon stocks in Washington and British Columbia were reduced during warm years. Our results suggest that estimating regional SST effects across multiple stocks improves the precision of parameter estimates, and that such effects are better predictors of recruitment than a large-scale climate index.

10AM2001 S11-356 poster

REASONS FOR ABNORMAL ICE COVER IN THE OKHOTSK SEA

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In the present paper features of the atmospheric circulation near the eastern coast of Asia during abnormal ice processes in the Okhotsk Sea from 1950-2001 are investigated. In the paper the data on a geopotential H500 by 19 aerological stations, located on the perimeter of the Japan Sea, the Okhotsk Sea and Kuril patch were used. For an abnormal ice definition of the Okhotsk Sea the data on the ice cover from 1928-2001 were used. The materials of Okhotsk Sea satellite IR- and TV- images, collected in TINRO-Center, for period 1977-2001 were analyzed. In extreme ice years (1967, 1978-1979, 1983, 2000 and 2001) the area with low values of H500 is above the Okhotsk Sea, the anomalies reached a minus 10 dam. In little ice years (1976, 1984, 1991, 1996 and 1997) above the Okhotsk Sea the area of minimum altitudes shifts and the field of high pressure dominates. The anomalies amount 6-11 dam. Such circulating conditions (they are typical for the 90s) promote an off-flow of warm Pacific air masses to the Okhotsk Sea, what is one of reasons for anomaly low ice of the sea. The extreme ice conditions in the Okhotsk Sea are determined by intensity of a troposphere polar whirlwind above Okhotsk Sea water area. A trajectory and a cyclone depth entering the Bering Sea depend on this polar whirlwind. The off-flow of cold arctic air implements by the periphery of these cyclones. These processes cause weakening of inflow of warm waters into the Okhotsk Sea through Kuril Straits. In extreme warm winters the troposphere whirlwind weakens and shifts to continental regions. As a result cyclone trajectories, entering the Okhotsk Sea, has been changed. An inflow of the warm air in a rear area comes into the sea. These processes promote strengthening the advection of warm waters in the Okhotsk Sea through Kuril Straits.

10AM2001 S11-331 poster

COASTAL UPWELLING IN THE JAPAN SEA: ESTIMATION OF WIND-DRIVEN TRANSPORT OF ZOOPLANKTON

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Zooplankton species abundance in the upper 100 m layer and environmental parameters was measured twice with 17 days interval at the stations of the section along 133°40′ E normal to Primorye coast (north-western Japan Sea) in 14 and 31 of October 2000 (r/v *Professor Gagarinsky*). Upwelling event happened in the period between observations that revealed in abrupt cooling and salting of surface and subsurface layers at the shelf. Stormy north, northwest wind in the rear of cyclone passed over the area in October 24-26 is supposed as possible reason of the upwelling. It caused water transport in surface layer directed off shore that was estimated by heat balance method as 60,000 m^3 per each 1 meter of coastline.

In the same period, certain mass species of zooplankton had change of their abundance with different values at the shelf (width 12-miles, depth <200 m) and in deep-water area, besides of general decreasing of their number because of mortality and sinking usual for fall season. The difference was supposed to be caused by wind-driven transport of the animals off the shore during upwelling. There was not so considerable difference outside of upwelling area. After exclusion of withdrawal contribution caused by mortality and sinking (estimated as 0-14% per day for different species), the advective exchange between the shelf, slope, and deep-water zones was calculated. The transport of all mass species with exclusion of *Calanus pacificus* was directed off the shore, that is why their abundance decreased in the shelf zone and increased or less decreased in the slope zone. The most prominent taking out of shelf zone was found for *Oithona brevicornis* (73% of initial number) and *Oithona similis* (67%). Note, that *O. brevicornis* is neritic species and usually is not abundant outside the shelf, but after upwelling its concentration in the slope zone became twice higher than in the shelf zone. Other species (*Pseudocalanus newmani*, *Metridia pacifica*, *Themisto japonica*) were taken out of the shelf in less degree estimated as 20-40%. On the contrary, small amount (about 7% of initial number) of *C. pacificus* was transported from the deep-water zone to shelf zone across the slope, obviously by compensatory shoreward flow in deep layer. Transport of plankton from the slope zone to deep-water zone was considerably lower than from the shelf to the slope zone.

The influence of upwelling on certain zooplankton species is to depend on depth of their habitation. *O. similis* and *O. brevicornis* are expected to concentrate just at the sea surface. Taking into account their initial abundance, the estimated huge transport was possible if the whole their stock was concentrated in the upper 5 m layer. Lower shares of the taken out *P. newmani*, *M. pacifica*, and *T. japonica* corresponded to 1/3, 1/4, and 1/5 of their stocks in the upper 5 m layer. *C. pacificus* lived in subsurface layer and was not caught up by surface current but was partly transported by opposite deep flow.

It is curious that some active vertical migrants as *T. japonica* and *M. pacifica* were transported by surface drift current. Their night/day ratio of abundance in the upper 100 m layer in the period of investigation were estimated as 2.2-5.2, so they had to concentrate at the sea surface at night to be transported in significant quantity.

Thus, wind-induced upwelling causes the significant change of zooplankton composition with heightening the share of large-size habitants of deeps in shelf zone.

10AM2001 S11-205 poster

A LARGE SHIFT IN THE SURVIVAL RATE OF JAPANESE SAND EEL (*Ammodytes personatus*) IN ISE BAY BETWEEN 1998 AND 1999 IN RELATION TO COPEPOD COMPOSITION

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The environmental factors affecting year-to-year variation in survival rate of larval Japanese sand eel were investigated in winter in Ise Bay, an estuary located off the central part of the Pacific coast of Japan, from 1995 to 2000. There was a large shift in the larval survival rate, a ratio of eggs to the recruits with body size at the

first capture (around 35mm in body length), between 1998 and 1999. The rate exceeded 2% in 1999, whereas was around 0.2% before the year. Year-to-year variation in the survival index, the ratio of the recruits to the adults also showed a similar trend as the survival rate. In addition to the shift between 1998 and 1999, shifts in the survival index were also found between 1988 and 1989 and between 1992 and 1993 since 1981. The survival rate from 1995 to 2000 was positively related with biomass of copepodites (including adult stage) of *Paracalanus* sp. ($r=0.985$) and *Acartia omorii* ($r=0.854$) in February, and the two species has dominated in copepod biomass in February since 1999. It is considered that not only biomass but also copepod composition probably influenced the survival shift between 1998 and 1999.

10AM2001 S11-347 poster

ENVIRONMENTAL CONDITIONS, SPAWNING STOCK, AND PACIFIC SARDINE RECRUITMENT IN THE GULF OF CALIFORNIA

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In the Gulf of California an important fishery of small pelagic fish exist, which contributes around 20% of the total catches of Mexico, besides being a very important generating source of employments for the region. Historically, the Pacific sardine (*Sardinops sagax*) it has been the most important species, contributing 92% of the annual total catches of clupeoides of the Gulf. From the beginning of the fishery, this resource has presented extremely marked changes in its distribution and abundance. In particular, this species showed a high variability between 1978 and 1997, period in that the catches were increased of around 40,000 tons up to 292,000 tons then fell to less than 8,000 tons, and again in 1997 the catches had increased to 215,000 tons. Considering this great variability, the relationship between environmental conditions, spawning stock and the Pacific sardine recruitment was investigated. The results of the historical analysis (1971/72 to 1996/97) indicated that the sardine population was increased from early 1970s until a maximum by the middle of the 80s, falling at very low levels in 1990/91 and being increased to near values to the historical maximum in the 1996/97 season. The relationship among the recruitment, the biomass spawning and the environmental variables was nonlinear, in dome shaped. The variance explained for the recruitment by the two better models was of 59% and 52%; the first one includes to the biomass spawning, temperature (with delay) and upwellings (with delay), and the second only included environmental variables. These results indicate that the Pacific sardine recruitment responds to the climatic variability, in a nonlinear way, and they show how this data can be used for predicting the Pacific sardine recruitment success. A simulation model had a good adjustment to the historical catches series, and it is expected that it provides a clear idea of the behaviour of the catches, in the short term.

10AM2001 S11-302 oral

UPPER TROPHIC LEVEL SURPRISES OFF B.C. DURING THE 1990S AND THEIR PHYSICAL AND BIOLOGICAL OCEANOGRAPHIC DRIVERS: GLOBAL CHANGES IN ACTION?

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During the 1990s, atypical species distributions, changes in community composition, and changes in survival were observed for many high trophic level fishes and seabirds off the west coast of British Columbia. These include changes in the growth and survival of seabird chicks, increased abundances of warm water pelagic fishes such as Pacific hake, sardine and chub mackerel, and decreases in the populations of cold water pelagic fishes such as several species of salmon. Much of the 1990s were unusually warm off BC, which ended rather abruptly in 1999 with a return to conditions typical of the 1960s and early 1970s. We provide a synthesis of Canadian GLOBEC studies off the west coast of Canada during the 1990s and examine in detail the physical and biological oceanographic changes and their consequences for higher trophic levels. We also examine whether these oceanographic changes are consistent with a period of extended El Niño events, whether the biological changes

simply represent latitudinal shifts in zoogeographic distributions, or whether they may provide a glimpse into potential marine ecosystem changes in the NE Pacific that may result from continued global warming.

10AM2001 S11-200 oral

THE 1998/99 REGIME SHIFT IN THE NORTHERN CALIFORNIA CURRENT: WHAT ARE THE COPEPODS TELLING US?

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Hydrographic data and nutrient, chlorophyll and zooplankton samples have been collected biweekly at several hydrographic stations off Newport Oregon (latitude 44° 40'N) from May 1996 through present. We presented evidence at the March 2000 "Beyond El Niño" meeting that a change in copepod community structure occurred in 1999 whereby the copepod community switched from one dominated by subtropical species to one dominated by subarctic species. We now have two more years of data. Cluster analysis shows that the shift to a cold water subarctic community began in April 1999. Although the shift to a "cold water" community began at that time, there was no apparent change in ocean productivity until one year later – large increases in copepod biomass (a proxy for an increase in ecosystem productivity) did not begin to occur until summer 2000. Oceanographic conditions observed to date in 2001 suggest that the summer of 2001 is likely to be the third in a row characterized by dominance of subarctic species and the second in a row of very high copepod biomass. This suggests firstly that the seven year "warm period" of 1992-1998 has ended and secondly that we have entered a new "cool productive period". Off central Oregon, this new period is characterized by an increase in the length of the coastal upwelling season, an increase in copepod biomass (factor of 2.5x higher), an increase in the length of the spawning season of euphausiids, increased spawning biomass of anchovies and smelts, and increased survival of coho salmon.

10AM2001 S11-027 invited

THE NORTH ATLANTIC: EVIDENCE FOR A CHANGE IN OCEAN CLIMATE IN RECENT YEARS

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The Continuous Plankton Recorder (CPR) survey has operated over an extensive region of the North Atlantic between 37° and 64°N each month from January 1946 to the present. Phytoplankton and zooplankton are identified into ~400 taxonomic categories and the resulting database contains more than 2 million data points. Results from the survey document long term trends and step-wise changes. Some of the changes are evident on both sides of the North Atlantic, such as a large increase in the season length and level of Phytoplankton Colour (a visual index of chlorophyll) around the mid 1980s. Other patterns of change are more regionally defined. A change in the North Sea circa 1988 has been described as a regime shift as it is seen in phytoplankton, zooplankton, fish and benthos as well as physico/chemical determinands. This event, which suggests that the North Sea has become more productive in the last decade, coincides with the most consistent period of a strongly positive North Atlantic Oscillation (NAO) index since records began. Other relationships between CPR plankton and the NAO as well as the Gulf Stream Index suggest that plankton can integrate hydrometeorological signals. The patterns seen in the plankton fit well observed hydrographic changes evident in the northern North Atlantic and Nordic seas and may be providing the first evidence of an effect, at an ocean basin scale, of global warming.

10AM2001 S11-287 poster

OBSERVATIONS ON POSSIBLE EGG MASSES OF THE SQUID, *Todarodes pacificus* IN THE SEA OF JAPAN

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Ommastrephid squids generally produce large numbers of small eggs encapsulated in gelatinous masses. No egg masses have been observed in the natural habitat, but they are thought to occur within the pycnocline, based laboratory observations on spawning of captive squid. MOCNESS (Multiple Opening Closing Net and Environmental Sampling System) and an ROV (Remotely Operated Vehicle) were used to examine the distribution of egg masses and paralarvae of *Todarodes pacificus* in the Sea of Japan near the Oki Islands, a known spawning ground of this species. The objective of this study is to examine how environmental processes affect to the recruitment of *T. pacificus*. The MOCNESS was used to sample at 21 stations through 5 depth layers between 0-100 m depth. Hatchlings occurred in the surface layer (0-25 m depth) and larger paralarvae were distributed through a wide depth range. The ROV was used at 7 stations to search for egg masses near the pycnocline (70-120 m depth). Gelatinous structures resembling egg masses were observed at two stations in the Tsushima Current along the continental shelf off the Oki Islands. They occurred within the pycnocline (75 and 95 m depth, respectively), where temperatures were about 18°C, and the sigma-T value was 24.5. Temperatures in the pycnocline are suitable for embryonic development, and the risk of predation and mechanical damage to egg masses is presumably lower than at the surface. Upon hatching, paralarvae may rise to the surface layer, where they would be carried into the convergent frontal zone in the Tsushima Current.

10AM2001 S11-030 invited

THE 1998/99 REGIME SHIFT IN THE NORTH PACIFIC: PHYSICAL MECHANISMS AND ECOLOGICAL CONSEQUENCES

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In recent years, researchers trying to document and understand how climate variability impacts north Pacific marine ecosystems have witnessed exceptional environmental extremes. One of the strongest El Niño events on record in 1995-96 was followed by a strong La Niña in 1997. The transition between these events was possibly the most dramatic and rapid episode of climate change in modern times. For example, ocean temperatures off central California fell by nearly 10°C in less than two years.

Within the context of these El Niño and La Niña events, a longer term climate shift in late 1998 or early 1999 produced striking anomalies in environmental conditions. These seem to have translated into substantial alterations in marine populations at all trophic levels. As with many oceanic changes, reports of shifts in living marine resources first drew attention to this period as a regime shift.

Atmospheric and oceanic anomalies prior to and during this regime shift will be described, with an eye toward how this particular period might be similar to, and differ from, other major El Niño and La Niña events, and previous documented regime shifts. Possible forcings and mechanisms responsible for this shift, and their geographic sources, will be discussed. Another focus will be on biological changes in the north Pacific in 1998 that may be related to this regime shift. At a minimum, we have learned that marine ecosystems can respond to environmental change in a surprisingly swift and dramatic way.

10AM2001 S11-393 poster

OCEAN CLIMATE CHANGE OFF OREGON?

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Motivated by the possibility of long-term climate change, we began measuring the current, temperature and salinity off Newport, Oregon on a seasonal basis in July 1997 as part of GLOBEC. Temperature and salinity are measured to a maximum depth of 1000 meters at 12 locations along 44°6 N between the coast and 85 nautical miles offshore, and currents are measured to 400 meters acoustically. Temperature and salinity measurements were made regularly along this line from 1961 to 1971; these past data show the seasonal cycle clearly. Recent observations can be compared with the seasonal means from 1961-1971 for evidence of climate change. Although current measurements were not made in 1961-1971, the alongshore (north-south) component of the geostrophic current can be calculated.

The largest interannual variability is El Niño and the strongest Niños in a century were in 1997-8 and 1982-3. Between July 1997 and September 1998, Oregon coastal waters were significantly warmer than the averages for 1961-1971. Since November 1998, water temperatures off Oregon have not been significantly different from the corresponding seasonal averages for the decade of 1961-1971, which was during a cool phase of the Pacific Decadal Oscillation (PDO) that dominated the Northeast Pacific from 1947 to 1976. Our present monitoring study began in 1997 at the onset of El Niño, during a warm phase of the PDO that ended with the 1999 La Niña (the cold opposite of El Niño). Are we now in a cool PDO phase?

10AM2001 S11-067 poster

COLLAPSE OF PACIFIC HERRING STOCK IN PRINCE WILLIAM SOUND, ALASKA

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The three dominant pelagic biomasses were observed in Prince William Sound throughout the 1990s: walleye pollock, Pacific herring and calanoid copepods. Annual monitoring of these dominant biomasses is part of a GLOBEC-like nowcast-forecast program to assess natural resources at risk to oil spills. We now have eight years of herring biomass assessments where the annual survey was repeated several times to yield a high level of precision. Historically, preseason estimates of herring biomass in PWS were made by combining a number of indirect and direct observations into an age-based population model and assuming constant natural mortality. However, since 1993 we have observed highly variable natural mortality. Thus, it is not surprising that we found several fold errors in these preseason estimates. During this period the population has experienced two major declines, outbreaks of disease and high winter predation. The total adult herring population 2001 is only a fraction of the commercial harvest in 1992. Several factors have contributed to the decline. Since we began winter measurements, the major impact has been overwinter predation by marine mammals, especially Steller sea lions and humpback whales. The current adult population size is comparable to estimates of annual removals by marine mammals from only a few years ago. Continued decline is likely, and may have serious consequences for the Prince William Sound ecosystem.

10AM2001 S11-066 poster

NOWCAST-FORECASTING IN PRINCE WILLIAM SOUND, ALASKA: A MULTI-FREQUENCY APPROACH TO SYNOPTICALLY ASSESSING SPRING COPEPOD PREY AND FISH PREDATOR DENSITIES

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A GLOBEC-like program of nowcast-forecasting is ongoing in Prince William Sound (PWS), Alaska. A Princeton Ocean Model serves as the foundation of the comprehensive physical observation and prediction effort, while acoustical survey techniques to measure dominant plankton and fish populations are the focus of the biological observation and developing predictive efforts. Initially, we used three high frequencies (420, 720 and

1000 kHz) to measure spring zooplankton, but the short detection ranges of the two higher frequencies was too limiting. Since 2000, we have used 38, 120 and 420 kHz and make synoptic measures of both fish and zooplankton. The monitoring focuses on the late-April through May period. This period encompasses the spring bloom and is dominated by large-bodied calanoid copepods. The acoustic techniques have been able to document many features of the zooplankton population distribution and abundance. Early distributions appear to be highly correlated with deep overwintering areas of PWS, whereas the population distribution later in the season appears to be affected by physical forcing. Comparison of the population distribution of copepods between 2000 and 2001 is of interest since the weather patterns, hence forcing conditions, were quite different between years. Among the interesting features that have been noted are direct observations of the impact of fish grazing on zooplankton patches. Synoptic measures of the calanoid copepods, fish predators and marine conditions are important for determining the early marine survival of pink salmon fry.

10AM2001 S11-078 oral

DECADAL-SCALE VARIATION IN THE ABUNDANCE OF PACIFIC SAURY (*Cololabis saira*) AND ITS RESPONSE TO SEA SURFACE TEMPERATURE IN THE NORTHWESTERN PACIFIC DURING THE LAST HALF CENTURY

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Pacific saury (*Cololabis saira*) is widely distributed in the northwestern Pacific, and exhibit large interannual variations in abundance. The purpose of this study is to unravel the mechanisms whereby the variability in climate and oceanic conditions is linked to the population dynamics of Pacific saury. Sea surface temperature (SST) in 1° grid over the northwestern Pacific and Southern Oscillation Index (SOI) were used as climate-ocean indices to investigate their impacts on Pacific saury.

Saury abundance exhibits decadal-scale variation pattern. Abrupt changes occurred around in 1953/54, 1966/77, 1976/77,1987/88 and 1997/98 for large size saury, suggesting strong effect of decadal-scale change or regime shift in oceanic environment. Over the past 50 years, abundance index of saury significantly correlated with winter SST in Kuroshio region from 130°E to 145 between 30°N to 35°N. This region is corresponding with the spawning area of Pacific saury in winter. Spatial and temporal response of saury abundance to SST demonstrated that SSTs in Kuroshio region have marked impacts on the determination of saury recruitment. Correlations between SOI and SST and between SOI and saury also suggested that variations in the abundance of Pacific saury were affected by the SST fields through large-scale atmosphere-ocean interactions such as El Niño events.

10AM2001 S11-249 poster

CETACEAN DISTRIBUTIONS AND OCEANOGRAPHIC FEATURES OF THE NORTHERN CALIFORNIA CURRENT: GLOBEC NORTHEAST PACIFIC PROCESS STUDIES DURING 2000

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The associations between cetacean distributions, climatic forcing, and oceanographic features were examined during two GLOBEC Northeast Pacific process cruises during 2000. Line-transect surveys of cetaceans were conducted across the continental shelf and slope of Oregon (41.9°N – 44.7°N) from May 28 – June 13 and from July 27 – August 12, 2000 in conjunction with three-ship multidisciplinary GLOBEC process studies of the Northern California Current. Densities and distributions of cetacean and pinniped species were analyzed with a suite of oceanographic variables (e.g. SST, surface salinity, depth and strength of the thermocline, mixed layer depth, value and depth of chlorophyll maximum) and circulation patterns (e.g, mesoscale eddies, coastal upwelling fronts, bank circulation) obtained from the SeaSoar instruments and satellite imagery. The abundance and behavior of the dominant cetacean species shifted between the two months. For example, Pacific white-sided

dolphins *Lagenorhynchus obliquidens* were abundant in offshore waters (depth > 500 m) during June, but were rarely seen during August. Humpback whales *Megaptera novaeangliae* appeared to congregate in lenses of warm water during early June, but foraged in the vicinity of coastal upwelling fronts on Heceta Bank in August. Changes in the community structure and density of cetaceans can reflect seasonal alteration in the availability of their prey and in the physical forcing that enhances trophic transfer from mid-trophic levels to top predators.

10AM2001 S11-261 poster

TIME SCALES OF TOP-DOWN AND BOTTOM-UP PROCESSES IN A COASTAL UPWELLING SYSTEM

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There is presently some debate as to whether food limitation or predation limits the populations of marine fishes. As part of the U.S. GLOBEC Northeast Pacific Program, we have begun to address this issue, particularly in relation to survival and production of juvenile salmon in the California Current System (CCS).

I have approached the problem through a simple lower and middle trophic model, similar in structure to the PICES NEMURO model. The model is a multi-component food web model for a single upper pelagic box in the CCS, with compartments ranging from dissolved nitrogen through piscivorous fish. The model is driven by seasonal upwelling and other water-column properties to predict primary, secondary, and tertiary production, expressed as nitrogen content of biomass. The model has been parameterized to represent a section of the CCS near Newport, Oregon, USA, allowing comparison of model output with several years of biweekly observations of water properties and zooplankton abundance. Two sets of runs have been completed: a "steady-state" run with average seasonal physical properties as inputs, and a more realistic run using observed physical properties.

Model predictions for nutrients, phytoplankton, and zooplankton have patterns similar to those observed. In the model, interannual patterns in species abundance are largely determined by top-down processes and depend more on past middle-trophic patterns than on present physical patterns. However, Bottom-up (physical) processes are apparent in short-term (daily-weekly) patterns in lower trophic levels. These short-term fluctuations are filtered out of the dynamics of middle and upper trophic organisms. Thus, it appears that both types of processes are important, but their apparent prevalence may depend on the trophic level of interest and the time-scale of observations.

10AM2001 S11-329 poster

INTER-ANNUAL VARIATION OF NUTRIENTS AND CARBON IN SUBARCTIC NE PACIFIC: INFLUENCE OF WIND-INDUCED UPWELLING AND ENSO EVENTS

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Using decadal oceanographic data at Station P (50°N, 145°W) and Line P and COADS wind stress data, we deduced the long-term trends of upwelling and chemical parameters of nutrients and carbon. Oceanographic and chemical parameters (temperature, salinity, oxygen, phosphate, silicate, nitrate, dissolved inorganic carbon and total alkalinity) and calculated thermocline depth and upwelling were used. Composite and cross-correlation analysis were used to study the long-term changes. Upwelling affects the oceanic regime (near Station P) and the coastal waters (east of 135°W) in opposite way. During El Ninõs, wind-induced upwelling produced positive anomalies and negative changes (except positive values for sea surface temperature and AOU) occurred in oceanic regime. These changes may be caused by different source in sub-surface waters and horizontal advection during ENSO years. Cross-correlation analysis showed a possible time-lag between chemical variability and change in upwelling events.

10AM2001 S11-212 poster

CHANGES IN WATER MASS, NUTRIENT, CHLOROPHYLL, AND ZOOPLANKTON DISTRIBUTIONS ACROSS JUVENILE SALMON HABITAT ON THE CONTINENTAL SHELF DURING THE 1998/1999 SHIFT FROM WARM-OCEAN TO COOL-OCEAN CONDITIONS

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The abrupt change from a warm-ocean condition during the 1998 El Niño to a cool-ocean condition during the 1999 La Niña gave us an opportunity to examine changes in coastal ocean conditions thought to afect biological productivity. Data were collected during a series of cruises from the southern shelf of British Columbia to southeastAlaska. We present comparisons of the physical properties, surface nutrients, chlorophyll*a*, and zooplankton between years with different salmon growth patterns. At the end of the 1998 growing season, juvenile salmon captured on the southern British Columbia (BC) shelf were both significantly smaller and had lower lipid content than fish captured on the northern BC shelf. At the end of the 1999 growing season, fish from both southern and northern regions were of similar size and condition. Regional and yearly variation in mixed-layer properties, nutrients, the timing and location of phytoplankton blooms, and the composition of the zooplankton community will be discussed in relation to salmon distribution and growth.

10AM2001 S11-376 poster

BIOLOGICAL AND AGE-SPECIFIC CHANGES OF THE MATURE PART OF THE KAMCHATKA RIVER CHUM SALMON - *Oncorhynchus keta* (WALBAUM)

Lidiya O. **Zavarina**

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In former times chum was the most abundant of the Far Eastern salmon in Kamchatka, after pink salmon.At present it shifted to the third position by catch after pink salmon and sockeye. The latter's catches exceed that of chum more than 1,5 times. The Kamchatka River basin chum stocks peculiarity is a high level of changeability The maximum and minimum number differs 15.8 times for the last 10 years of the 20th century. At the previous period – only 3.7 times. The changes touched also the main biological features (length, weight, absolute fertility). If the average length of chum slightly decreased for the last 10 years (from 66.2 to 65.9 cm), its average weight dropped 200 g (from 3.53 kg to 3.35 kg), and the average absolute fertility lessened from 2732 to 2314 eggs. In the mature part of the chum spawning stock of the Kamchatka River a portion of elder age groups 4+ and 5+ rose. A latter's relative number increased 3.8 times, so the average maturation age rose accordingly, in our opinion that indicates a bad state of the stock. Alike changes of the biological features and the age structure were noted with NorthAmerica chum stocks (Helle, Hoffman, 1998), Japan (Ishida et al., 1993), and also Russia (Gritsenko and others, 2000). The decrease of biological features and increase of the elder age groups part of the Kamchatka chum salmon, in our opinion, is connected with a high number of the Japanese origin chum (from the Hokkaido and Honshu Islands), which fattens together with the Russian stocks and is the main consumer of the food resources in the North-West Pacific Ocean.

10AM2001 S11-042 poster

THE CLIMATIC JUMP OF THE WESTERN PACIFIC WARM POOL AND ITS CLIMATIC EFFECTS

Yongping **Zhao**, Aiming Wu and Dunxin Hu

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The climatic jump of the Western Pacific Warm Pool and its climatic effects were analyzed using the SST (COADS, NCEP) data sets, the relationship between the decadal variability and the ENSO events was discussed. The results show that, there are very obvious decadal variability with four obvious climatic jumps of theWestern Pacific Warm Pool occurred during over one hundred years, which happened in 1910s, 1970s, 1940s and 1950s. There are obvious climatic effects of the Warm pool jump: after the SST increases about 0.5°C in Central and Eastern Tropical Pacific, the Pacific Subtropical High at 500 HPA strengthen and southwestward the precipitation belt tends to be in south China.

The results also show that, the stronger and persistent ENSO events can induce the jump ofWestern Pacific Warm Pool: El Niño events will be happened more than La Niña events during theWarm pool abnormally development, and La Niña events will be happened more than El Niña events during theWarm Pool abnormally decline.

10AM2001 S11-377 poster

ON THE INFLUENCE OF SOME ENVIRONMENTAL PARAMETERS ON THE KAMCHATKA SILVER COHO SALMON PRODUCTIVITY

Janne **Zorbidi**

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The condition of the Asian Silver (coho) salmon is defined mainly by the number of stocks that spawn in Kamchatka rivers. Silver salmon enters into the majority of them in industrial quantities, though its stocks are on a low level everywhere.

It is proposed that an observed considerable reduction of survival of silver salmon generations in Kamchatka area is caused by the sun-conditioned climatic global parameters reinforced due to the catch intensity growth and producers' number reduction at spawning grounds. The most significant factors are the level and thermal conditions of spawning reservoirs and the sea coastal zone. The Eastern Kamchatka silver salmon generations'survival reveals a direct relationship with rivers water content in March in a year of the smolt migration ($r = 0.495$), its meaning grows in the maximum and minimum Sun activity years ($r = 0{,}672$); it reveals also a feedback with the number of precipitations quantity in the Spring at the time of transition of juveniles that left their nests to active feeding ($r = -0.631$).

The Western Kamchatka populations' formation is influenced by the precipitation quantity and the water level in rivers, 7-9 years periodicity between the maximum features as well as periodicity in catches. Their influence is ambiguous during the early ontogenesis and at juveniles' fattening in reservoirs. Precipitation and the river flow level in the Spring and Summer lead to worsening of the food base of fry and 0+, slowing down of the growth rate and, as an consequence, to increase of the death rate in the river after the migration to sea. The same conditions are favorable for older juveniles of Silver salmon. There's rather high dependence between precipitation quantity during juvenile transition to exogenous feeding and generations' return: $r = -0.631$. In its turn, the number of generations that return for spawning is closely connected with the growth rate at the first year of life ($r = 0.81$).At the decrease of 0+ growth and yearlings there happens lessening of the potential fertility, that, as a result, leads to the drop of reproductive ability of the stock.

S12 TCODE E-poster Session
Regional and national data centres

Convenors: Thomas C. Royer (U.S.A.), Igor I. Shevchenko (Russia) and Toru Suzuki (Japan)
Wednesday, October 10, 2001 17:30-20:30

Computer-based demonstrations of data management activities in the PICES area, focusing on the holdings and capabilities of the various National and Regional Data Centres, but also including other project-based data management initiatives. The goal of this poster session is to improve awareness of data resources available in the PICES region. We will use high speed Internet capability to provide interactive access to the web sites.

10AM2001 S12-392 E-poster

PFEL DATA HOLDINGS AND DATA PRODUCTS

Lynn **deWitt** and Roy Mendelssohn

Presenters at Meeting: George Boehlert, Frank Schwing and Steve Bograd

NMFS, Southwest Fisheries Science Center, Pacific Fisheries Environmental Laboratory, 1352 Lighthouse Avenue, Pacific Grove, CA 93950-2097, U.S.A.

PFEL's data holdings and related data products provide a suite of fisheries and marine mammal relevant data that cover the entire spectrum of the ocean environment - from surface or near-surface wind and pressure data that can affect the ocean, to surface and subsurface measurements of important oceanographic parameters that are updated near real-time. These include a variety of FNMOC fields, gridded fields calculated from GTS and GTSPP observations, and database systems that provide rapid access to the raw COADS and WOD98 datasets.

We will be demonstrating PFEL's implementation of the Live Access Server developed at PMEL, which provides the ability to subset, visualize, and download over the internet most of our gridded datasets. We will also be demonstrating our CD-ROM implementation of the COADS dataset as well as the CODE software for performing extraction and summarization from a desktop computer for both the COADS Release 1 (1854-1990) as well as for Release 1a,b (1950-1997).

10AM2001 S12-396 E-poster

THE BERING SEA AND NORTH PACIFIC OCEAN THEME PAGE: A WEB-BASED OCEAN INFORMATION SYSTEM

Sonia **Hamilton**

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Theme pages bring together data and information associated with a broad, thematic concept, allowing the viewer to do some initial investigation by reading about the broad topic, and ultimately directing the viewer toward a specific information item or data set. A theme page presents a complete, layered approach to understanding the subject area and typically includes several of the following:

- Topic identification
- Data displays, forecasts, photos
- Background information for students and the general public
- In-depth information and analyses for researchers
- Access to analysis software
- Access to on-line data
- Perspectives, publications
- Live gateways to services and directories

In 1995 NOAA's Pacific Marine Environmental Laboratory (PMEL) established a theme page (http://www.pmel.noaa.gov/bering/) devoted to the Bering Sea and North Pacific Ocean. The site is a clearinghouse for information pertaining to these regions and a resource base for the scientific investigation of the biology, oceanography, meteorology and ecology of the area. The theme page also provides a forum for presenting and discussing new ideas, plans and research results. Elements of the theme page include geography and history of the Bering Sea and North Pacific Ocean, data listings, physical and biological sciences, education, news, a chat room and news subscription service, guidelines for using the resource, and a site search engine.

10AM2001 S12-416 E-poster

OCEANOGRPHIC OBSERVATION AND DATA MANAGEMENT ACTIVITIES IN KOREA

Hee Dong Jeong, Bok Kee Kim, Kyu Kui Jung and Seung Heo

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There are three major institutes for the oceanographic observation and research in Korea. The three institutes are the National Fisheries Research and Development Institute (NFRDI), the National Oceanographic Research Institute (NORI), and the Korea Ocean Research and Development Institute (KORDI).

NFRDI has collected several kinds of oceanographic and environmental data by means of periodic oceanographic cruises and remote sensing (NOAA, GMS, SeaWiFs, MODIS). All of these data have been compiled and put into databases in a timely manner according to the standard operating procedures. Those data are opened and distributed to the end users through the internet server and publications. The end users can easily access to the data and download the data file. NORI mainly carries out navigation passage surveys for navigation charts. KORDI also conducts oceanographic observations and research through small to large-scale research programs.

The National Real Time Data Base (NRTDB) and the National Delayed Mode Data Base (NDMDB) have been established at the KORDI and the Korea Oceanographic Data Center (KODC) operated by NFRDI, respectively. The database will lead to forecast an oceanographic condition including long-term oceanographic prediction and develop the fisheries industry. In this presentation, we provide available information on the various oceanographic data resources in Korea for the user communities in the PICES area.

10AM2001 S12-409 E-poster

DEVELOPMENT OF REAL-TIME DATA SERVICE SYSTEM FOR THE KOREAN COASTAL WATERS

Sung-Dae Kim[1], Kwang-Soon Park[1], Sok-Kuh Kang[1], Soo-Young Park[1] and Jong-Kook Lee[2]

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Two realtime data service systems based on newly developed communication and information technologies were set up partially and data service is started, which provide several oceanographic data through WWW as graphic images and digital values simultaneously with automatic observation. Oceanographic data observed by several sensors of several stations around Korean peninsula is transferred to computer system of KORDI through PCS wireless network and internet TCP/IP protocol. The collected data is transformed automatically and provided to internet users through WWW service in realtime base. The transformed data is archived at separate storages by the reserved schedule to prevent sudden data loss.

In 2001, data of about 13 stations around Korean peninsula will be available through internet. The number of observation stations will be continuously increased due to activities of the research projects sponsored by Ministry of Maritime Affairs and Fisheries of Korea. But the systems now can provide data of physical oceanography like temperature, salinity, sea level, wave height, air temperature, etc., it is possible to apply this techniques to other data items like chlorophyll, nutrients etc. if automatic observation instrumentations are developed.

Because these systems can contribute the exchange of data observed automatically and observation technique is rapidly improved, realtime data exchange will be a important method of the data exchange for the North Pacific area.

10AM2001 S12-349 E-poster

JAPAN ARGO DELAYED-MODE DATA BASE IN JAMSTEC

Taiyo Kobayashi[1], Yasushi Takatsuki[2], Yasuko Ichikawa[1], Toshio Suga[1], Keisuke Mizuno[2], Nobuyuki Shikama[1] and Kensuke Takeuchi[1]

[1] *Frontier Observational Research System for Global Change (FORSGC)*

[2] *Japan Marine Science and Technology Center (JAMSTEC), 2-15 Natsushima-cho, Yokosuka, 237-0061, Japan e-mail: taiyok@jamstec.go.jp*
http://www.jamstec.go.jp/ARGO/J_ARGOe.html

Argo is an international project that aims to build a real-time, high resolution monitoring system of temperature and salinity structure from surface to mid-depth of the global ocean. Approximately 3,000 Argo profiling floats will be deployed in the world ocean with a spacing of about 300km. The monitoring system will greatly contribute to the study of interannual, decadal and interdecadal variations of the climate system, and it will substantially improve the performance of long-term weather forecast.

In Japan ARGO project, the Japan Meteorological Agency is responsible for distributing real time float data through GTS (Global Telecommunication System) within 24 hours after receiving them from satellites. JAMSTEC/FORSGC carry out scientific quality control for the ARGO float data: statistical checks using historical data in the vicinity of float location, and corrections for drift of salinity sensor when necessary and possible. Checked data are provided for Japan ARGO Delayed-mode Data Base in JAMSTEC, and then they are freely available to everyone via the Internet within 3 months of observations. Newly-developed methods for this quality control process are presented along with related research activities of JAMSTEC/FORSGC ARGO team. Japan ARGO Delayed-mode Data Base http://www.jamstec.go.jp/ARGO/J_ARGOe.html

10AM2001 S12-084 E-poster

ELECTRONIC TOUR THROUGH THE CARBON DIOXIDE INFORMATION ANALYSIS CENTER'S OCEAN WEB PAGE

Alexander Kozyr

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The Carbon Dioxide Information Analysis Center (CDIAC) at Oak Ridge National Laboratory (ORNL) provides data management support for the Joint Global Ocean Flux Studies (JGOFS) carbon dioxide (CO_2) measurements taken aboard research vessels during World Ocean Circulation Experiment (WOCE) Hydrographic Program cruises. The U.S. DOE sponsored CO_2 measurement operations and continues to sponsor CDIAC's data support activities, which include data archival, data checking and evaluation, preparation of data documentation, and data dissemination. All CO_2-related data are checked before documentation and distribution. As of today, DOE GCRP-supported investigators had collected CO_2 measurements on 42 WOCE cruises. CDIAC has received data from all of these cruises, all data sets have undergone quality assurance checks with 19 of them being fully documented as numeric data packages (NDPs). All data for the WOCE and other cruises and programs can be found on the CDIAC ocean web page as an electronic data files. These files easy to copy straight from the CDIAC FTP web site.

One of the noteworthy developments is the willingness of scientists from around the World to archive their CO_2-related data at CDIAC for comparison, documentation and distribution purposes.

As new measurements are made and submitted to CDIAC, it will be possible to compare measurements obtained at identical locations during different expeditions to assess their agreement. This is particularly important for measurements made in deep and abyssal waters. These checks will assess the geographical consistency of the CO_2-related parameters (TCO_2, pCO_2, alkalinity, and pH), salinity, and the concentrations of dissolved oxygen and macro-nutrients along constant seawater density surfaces.

10AM2001 S12-394 E-poster

DATA MANAGEMENT IN DFO

Savithri (Savi) Narayanan and J. Robert Keeley

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Department of Fisheries and Oceans is in the process of establishing a distributed data management system consisting of a network of databases and expertise, and supported by a Policy for the Management of Scientific Data in the department. This presentation will cover a few of the key elements of the data management in DFO.

10AM2001 S12-167 E-poster

ACTIVITIES OF MARINE INFORMATION RESEARCH CENTER. II: A CONTRIBUTION TO THE CONSTRUCTION OF INVENTORY OF CO_2 RELATED DATA

Sachiko Oguma and Toru Suzuki

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In January 22-24, 2001, PICES CO_2 data integration test workshop was held by members of PICES WG13/TCODE and colleague scientists, to discuss about status of national and international data inventories and technical aspects of development of common database. At that meeting, it was recommended that PICES WG13 and TCODE work together with the data centers (JODC, NODC, CDIAC, MEDS, etc.) to compile an international North Pacific data inventory for CO_2 and CO_2-related data. According to this recommendation, a web site of data inventory of PICES Carbon Dioxide Data in North Pacific (PICNIC) has been prepared at MIRC. For the first step, cruise list of Inventory for Japanese Chemicaloceanographic Data (IJCD), which is managed at MIRC, and cruise list of CDIAC have been compiled into one data inventory. The data inventory mainly includes cruise lists of North Pacific open-ocean data. The cruise lists are under construction, but are going to be available for all scientists who will want to search CO_2 and CO_2 -related data obtained in the North Pacific.

In the PICES/TCODE e-poster session, we will show web sites of data inventories of PICNIC and IJCD, then we would like to discuss about technical issue of data integration with participants as data users or data originators to construct more useful data inventory.

10AM2001 S12-106 E-poster

INTEGRATED BASE OF INFORMATION RESOURCES ON THE N.W. PACIFIC OCEANOGRAPHY AND MARINE ENVIRONMENT: NEW VERSOON OF POI WEB-SITE

Igor Rostov, M.V. Zhayvoronok and V.I. Rostov

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This POI specialized web site in the FEB RAS Network is an independent regional segment for the National Unified System of Information on the World Ocean State "ESIMO" (http://www.meteo.ru/nodc/Project_e/progr.html). Information about the data bases maintained in POI, in the region and over the world as well as about other resources accessible in the on/off-line mode and also information products on various aspects of oceanography, hydrometeorology and ecology will be available soon on the site: http://www.pacific.marine.su.

10AM2001 S12-388 E-poster

REGIONAL OCEANOGRAPHIC DATA CENTER

Nikolay A. Rykov, I.E. Kochergin, A.N. Man'ko, S.I. Rybalko, E.P. Uraevsky and Yu.N. Volkov

Far Eastern Regional Hydrometeorological Research Institute (FERHRI), 24 Fontannaya Street, Vladivostok, Russia. 690600 e-mail: rodc@online.ru

The Regional Oceanographic Data Center (RODC) was established at the late of 1994 in order to increase the efficiency of collection, storage, processing and distribution data for the North Pacific Ocean and Adjacent Seas. The main problems of RODC coincide with the problems being solved by other Data Centers, and it includes the follow functions:

- Collection, accumulation, account, classification and use of the oceanographic data as well as supply the State Hydrometeorological Data Band with information obtained over the World Ocean;
- Data digitizing and data quality control;
- The oceanographic data exchange between the Institutes and Data Centers;
- Providing to concerned organizations and any private persons with oceanographic information and the results of its processing;
- Development of software and technological services to collect, process and data propagate;
- Providing to users of the oceanographic information with a methodical help, particular, to assimilate these data.

The main data sets are the following:

- CTD-data;
- Hydrology and hydrochemistry (temperature, salinity, oxygen, pH, alkalinity, nutrients);
- Current observations (moorings, drifters);
- Marine meteorology;
- Coastal observations;
- Ice conditions;
- Pollutants (trace metals, phenols, chlorinated pesticides, detergents, etc.)

These data sets are collected both from domestic and foreign accessible sources, and RODC keeps also a number of inventories of these observations. The databases are used in investigations on domestic research projects as well as on international cooperative study.

The memberships of RODC participate both in international organizations (PICES, UNEP/NOWPAP, WESTPAC) and international projects (NEAR-GOOS, CREAMS, ARGO, GODAR, etc).

10AM2001 S12-168 E-poster

ACTIVITIES OF MARINE INFORMATION RESEARCH CENTER. I: THREE-DIMENSIONAL PANORAMIC ANIMATIONS FOR BOTTOM TOPOGRAPHY NEAR JAPAN

Toru Suzuki[1], Akira Asada[2], Sachiko Oguma[1] and Yutaka Nagata[1]

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[2] *Institute of Industrial Science, University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo, 153-8505, Japan*

We developed 46 animations of 3D panoramic view for bottom topography near Japan. The animations are made by a high performance visualization tools with new technology for 3D surface modeling, rich lighting and realistic rendering, using mainly J-EGG500 (JODC Expert Grid data for Geography at 500m intervals) and higher resolution data based on high special and quality echo sounding in several coastal region. One of the most features of the animation is that a user can control direction of viewpoint spherically. Also 16 walkthrough movies that camera move along fixed paths are developed. The user can playback and feel like viewing from an airplane or submarine. The animations and movies are distributed by CD-ROM with several detailed descriptions by HTML, and can be displayed using Web browser installed browser plug-in.

10AM2001 S12-166 E-poster

ACCESS TO THE PACIFIC REGION HARMFUL ALGAL BLOOM (PACHAB) DATA THROUGH THE NATIONAL HARMFUL ALGAL BLOOM DATA MANAGEMENT SYSTEM

Michelle C. **Tomlinson**[1] and Vera L. Trainer[2]

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[2] *National Marine Fisheries Service, Northwest Fisheries Science Center, NWFC/2, 2725 Montlake Boulevard E., Seattle, WA 98112, U.S.A.*

The U.S. National Oceanographic Data Center is developing a system to synthesize data from monitoring and research programs in order to assist in Harmful Algal Bloom (HAB) management and research. Data sets suitable for understanding HABs must include information on biological, chemical, and physical components of the ecosystem which contribute to the temporal and spatial distribution of these events. The HAB-Data Management System (HAB-DMS) will provide access to physical, chemical, and biological data acquired from many disparate sources. A prototype has been developed in coordination with the Ecology and Oceanography of Harmful Algal Bloom (ECOHAB) Program and NOAA=s Monitoring and Event Response of Harmful Algal Blooms (MERHAB) Program.

Suitable data for understanding HABs are frequently dispersed among state and academic laboratories, and are generally inaccessible or difficult to interpret. Data are often stored in various formats, with inadequate documentation. Many historical data sets are also unavailable in a digital form. Therefore, the NODC is collaborating with scientists in Pacific Rim countries that experience HABs (PACHAB) to provide a system that facilitates the flow of data into the HAB-DMS by providing tools for managing data locally. The HAB-DMS will initially include biological, chemical and physical oceanographic parameters from *in situ* and laboratory derived measurements. In addition, reports of regional HAB events will be provided in conjunction with oceanographic data, to allow for the integration of information regarding the nature of individual HAB events in the PACHAB region and to better understand the initiation, transport and demise of HABs in the region.

10AM2001 S12-350 E-poster

RECENT ACTIVITIES OF THE JAPAN OCEANOGRAPHIC DATA CENTER (JODC)

Satoshi Sato, Shigeru **Toyoshima**, Norio Baba

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JODC has been fulfilling the role of the synthetic marine data bank of Japan in collecting important and useful data obtained by various marine research institutes and organizations concerned in Japan and providing users with these data. In addition to the above role, JODC is acting as a representative of four Responsible National Oceanographic Data Centers (RNODCs), and also the Director of JODC is paying efforts for the IODE Regional Coordinator for WESTPAC since its assumption in 1997.

Recent activities of JODC are shown as following,

1) Development and operation of the JODC-Data Online Service System (J-DOSS).
2) Management and operation of the NEAR-GOOS RDMDB.
3) Publication of Data-Set such as Ocean Current Data-set, Northwest Pacific Carbon Cycle Study Project (NOPACCS) Data-Set and Zooplankton Biomass in the North Western Pacific Data-Set.
4) Strengthening of activity on IODE Regional Coordinator for WESTPAC
   - The International Conference on the International Oceanographic Data and Information Exchange in the Western Pacific (ICIWP'99).
   - Establishment of Web-Site on the activity on IODE Regional Coordinator for WESTPAC and the E-Mailing List System for the WESTPAC discussion group on the data management.
5) Promoting of the GODAR Type Project in the WESTPAC Region.

W1 REX Workshop
Temporal variations in size-at-age for fish species in coastal areas around the Pacific Rim

Convenors: William T. Peterson (U.S.A.) and Douglas E. Hay (Canada)
Friday, October 5, 2001 08:30-17:30

This workshop will focus on changes in size-at-age for fish species in the North Pacific. We anticipate presentations and discussion of data from a number of different fish species within the PICES study region. Examples of fish species that we want to include are salmonids, clupeids (sardines, anchovy and herring), gadoids (hake and pollock), halibut, etc. Temporal and spatial changes in pattern in size-at-age among species will be examined relative to climate variability and climate change.

10AM2001 W1-225 poster

LONG-TERM CHANGES IN SIZE-AT-AGE OF WALLEYE POLLOCK IN THE WESTERN BERING SEA AND PACIFIC WATERS OFF KAMCHATKA PENINSULA

P.A. Balykin and A.V. Buslov

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The long-term changes in size-at-age of walleye pollock in the age of 0+ and 2-6 years during the 1970-1990s were investigated. Age of 58 thousand fishes defined on scales and otoliths. The length of young-of-year of western Bering Sea walleye pollock by an inversive relation were linked with the ice cover of Bering Sea (r = -0.599). The interannual changes in size-at-age of western Bering Sea walleye pollock were linked to a biomass of a stock and ice cover of Bering Sea. The interannual changes in size-at-age of walleye pollock of Pacific waters Kamchatka peninsula were connected with a biomass of a stock and number of generations.

10AM2001 W1-217 oral

HISTORICAL TRENDS IN SABLEFISH (*Anoplopoma fimbria*) SIZE AT AGE ONE FROM TWO STOCKS: THE GULF OF ALASKA AND THE U.S. WEST COAST

Steven A. Berkeley and William D. Pinnix

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Extensive collections of previously aged sablefish otoliths were catalogued and assigned to a year class based on otolith age and date of collection. Sufficient samples were available to extend the time series for both Gulf of Alaska and West Coast sablefish stocks back to 1950. Because of the rapid growth in their first year, when sablefish are pelagic, the first year's otolith growth mark is usually very distinctive. We found that otolith area at this first mark was proportional to length and used this relationship to estimate mean size at age 1 for each year class from 1950-1994. A significant decreasing trend in size at age 1 was evident over the time series in both stocks. Using stepwise multiple regression on standardized growth anomalies, we found that size at age 1 for the West Coast stock was negatively related to year class index (YCI), PDO, and NOI (lag 1). The negative relationship with YCI suggests that food may be limiting for West Coast sablefish during summer, even in years when feeding conditions (in spring) favor larval survival. For the Alaska stock, size at age 1 was positively related to the PDO and NOI, suggesting that the growth response is out of phase between the two regions, much as we see for salmon production. The apparent density dependent relationship for the West Coast stock was not seen in the Alaska stock, suggesting food is not limiting for YOY sablefish in this region.

10AM2001 W1-227 poster

HERRING DISTRIBUTION IN THE WESTERN BERING SEA IN THE CONDITIONS OF THE NUMBER RAISING

A.A. Bonk

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In the 1990s of the 20th century against a background of reconstructing climate-oceanological processes in the North Pacific Ocean, which caused changes in the Far Eastern seas ecosystems, intensive development of the West Bering Sea herring population is noticed. If in the beginning of the 1990s the number of the commercial part of the stock was about 0.4 billion fishes, with 1993 fruitful generation's introducing into catches this value reached a record for the last for decades – more than 3.7 billion individuals. Extension and duration of fattening migrations of the mature West Bering Sea herring depends on a stock number. Wintering areas are defined by thermal conditions of water and catch activity. In the last years of the 20th century herring fattening happened not only at the Koryakskoye plateau shelf but also in bathypelagic area of the West Bering Sea. Herring return to the wintering areas continued from September to the beginning of December. Wintering gatherings were formed depending on a year's hydrological conditions in the western part of the Olyutorsky Bay or at the northeastern coast of the Karaginsky Island.

10AM2001 W1-087 oral

EFFECTS OF CLIMATE AND ZOOPLANKTON PRODUCTION TRENDS ON PACIFIC HERRING, *Clupea pallasi*, POPULATION SIZE AND LIFE HISTORY PARAMETERS IN THE GULF OF ALASKA

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Factors affecting long-term trends in Pacific herring (*Clupea pallasi*) population size, adult size-at-age, and spawn timing were examined. An index of Gulf of Alaska (GOA) herring abundance was developed by combining historic fishery catches with recent biomass estimates. This index was significantly cross-correlated with three commonly used climate indices with high population levels during the positive phases. The positive phase generally corresponds to intensification of the Aleutian Low, higher SST, and increased storms and wind stress in the GOA. A strong Aleutian Low causes above-average water column stability in the subarctic creating conditions that optimize primary and secondary production and thus may be the mechanism involved in the positive response of zooplankton and Pacific herring as previously hypothesized for salmon. Trends in size-at-age, from 1973 to the present, tend to support this idea. Size-at-age was found to be cyclic, rather than density-dependent, tracking with both climate indices and an index of zooplankton production in Prince William Sound (PWS). The mean date of spawning in PWS was variable but has shown a slight trend toward earlier spawning in the last two decades. The same downward trend was observed in fall surface salinity. Spawn timing is affected by maturity rate that is directly affected by ocean conditions, especially 6-9 mos prior to spawning. Spawning areas have also shifted over the same time period accompanied by a trend in reduced recruit per spawner rates. The implications of these observations will be discussed in terms of expectations for recovery of the severely depressed PWS herring population.

10AM2001 W1-328 oral

THE CHARACTERISTIC OF GROWTH RATE OF HERRING IN PETER THE GREAT BAY (JAPAN SEA)

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Pacific herring (*Clupea pallasi*) is a low boreal species, which forms several local populations within its extensive natural habitat. The populations of herring are known in Japan Sea: Sakhalin-Hokkaido, Peter the Great Bay, Korean - marine form; Plastun-Nelminskaya and Dekastrinskaya - inshore form. The hierarchic status of these groups is not clarified till now. In opinion of some authors it is separate populations or stocks, others consider these groups as subpopulations. From all populations of Japan Sea the herring of Peter the Great Bay is characterized by the highest rate of growth. The most rapid growth of the herring occurs during the first and the second years of life. The first year old individuals (0+) of herring in Peter the Great Bay reach 110 mm of length and 9.9 g weigh to the end of October, after one year these fish have average length 220 mm and weight 100,1 g. The growth increase of the herring rapidly reduce with age and, from 6 year averages less than 10% from one of the first year. It is known that infraspecific groups of Pacific herring have considerable heterogeneity of biological features including growth rate and age of maturity. It has been appeared at comparison of generation's growth of herring of Peter the Great Bay of 1971-1997 births that individuals of 1-3 years old have greatest variability of growth rate. At 5-year-old fish this variability is considerably reduced. During first three years of the herring life there is considerable direct dependence of the subsequent growth from previous. During the last decade slowly growing individuals have been prevailing in spawning part of herring population of Peter the Great, and only at southwestern coast of the Bay rapid growing fishes is observed. The accumulation of small size and early individuals in this herring population probably directs on recovery processes.

10AM2001 W1-147 oral

SIZE-AT-AGE OF NORTH AMERICAN CHUM SALMON BEFORE AND AFTER THE 1976-77 OCEAN REGIME CHANGE

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Some chum salmon stocks in Alaska and Washington have been monitored for age and size at maturity by the author since the early 1970s. Four-year-old chum salmon in the early 1990s declined in size by 46% when compared to 4-year-old chum in the early 1970s. In the mid-1990s size-at-age started to increase. Environmental and density dependent causes for changes in size-at-age are discussed.

10AM2001 W1-145 poster

INFLUENCE OF SOME FACTORS ON THE GROWTH OF SAKHALIN-HOKKAIDO HERRING (SEA OF JAPAN)

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The growth of the Sakhalin-Hokkaido herring during a deep long-term depression is not connected with the state of population only. During the last decade a low growth rate of Sakhalin-Hokkaido herring is noted when there are in the collapse. The same growth rate is typical both for strong ant and poor year-classes. The mean length-at-age fluctuations for Sakhalin-Hokkaido herring appeared to correspond to fluctuations of total zooplankton biomass in the area of feeding along southwestern Sakhalin coast. The herring length-at-age is changed not so much corresponding to the year-class strength, as parallel with fluctuations of the total zooplankton biomass in 1955-1998.

An opposite dependence was observed between the water temperature of 0-50 and 50-100 m layers and length-at-age 4-7 feeding herring in 1969-1992 on feeding ground. Certain connection is not found between water temperature and length (SL) of herring at age 3. A weak negative relation was discovered between the length for ages 5-7 adult herring and water temperature (coefficients of correlation are - 0.45, -0.58, -0.53 for 0-50 layer and - 0.44. -0.57. -0.57 for 50-100 m layer, respectively). Length-at-age 3 herring for strong year-classes (1965, 1973, 1983, 1988) is close to the average long-term year length, as a whole. Any definite regularity is not observed in growth rate for the same year-classes at age 4-7.

10AM2001 W1-220 oral

INFLUENCES OF THE 1997-1999 EL NIÑO-LA NIÑA ON JUVENILE CHINOOK SALMON OFF CENTRAL CALIFORNIA

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The 1997-1998 El Niño and ensuing 1999 La Niña was one of the largest amplitude ENSO cycles in history. Such large-scale climatological events have been shown to cause profound changes to oceanic ecosystems. Altered temperature structure and circulation patterns can produce changes in lower trophic-level biological productivity and amplified consequences to metabolic processes and growth in fishes. Many stocks of Pacific salmon from the continental United States have been depleted for several decades; the impact of a large El Niño - La Niña could be particularly detrimental to year-classes produced during the event. We describe size-at-age and growth rates of juvenile chinook salmon (*Oncorhynchus tshawytscha*) in the coastal waters of central California during the 1997-1998 El Niño and the 1999 La Niña and their relationships to lipid metabolism, prey abundance, feeding, and physical oceanographic factors.

10AM2001 W1-223 oral

TEMPORAL VARIATIONS IN SIZE-AT-AGE OF THE WESTERN BERING SEA HERRING

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Considerable interannual variability in length and weight at age is the most remarkable feature of the Western Bering Sea herring. Difference in mean fish (fork) length reaches 4 cm (24.5-28.5 cm) for age 4; 5.1 cm (30.4-35.5 cm) for age 10; 5.9 cm (31.6-37.5 cm) for age 13. Difference in mean body weight varied between 102 g for age 4 and 227-255 g for ages 8-13. Changeability of herring size-at-age has a 22-years cyclic recurrence. The 30s-40s fish generations' growth was rapid, the 50s-60s ones'- slowed; the 70s-80s ones' - rapid again. During the last 5 years (1996–2000) there happens a gradual decrease of the mean fish size in all the age cohorts. The herring growth rate is defined by two main factors: total fish biomass and food abundance. At the second half of the 50s, i.e. at the peak of the population number, the fish length and weight at age was minimum though relatively high biomass of the feeding organisms was at their foraging areas. For all the rest periods length of annual growth has close linear relationship with zooplankton biomass.

10AM2001 W1-144 oral

SPATIAL PATTERNS OF COVARIATION IN SIZE-AT-AGE OF BRITISH COLUMBIA AND ALASKA SOCKEYE SALMON STOCKS AND EFFECTS OF ABUNDANCE AND OCEAN TEMPERATURE

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We examined patterns of covariation in age-specific adult body length among 31 sockeye salmon (*Oncorhynchus nerka*) stocks from Alaska and British Columbia. Based on 72 time series of size at various ages, positive covariation in length was prevalent across stocks of all regions (e.g., correlations from r = 0.2 to 0.6), indicating that broad-scale processes affect body size. In addition, there was stronger covariation among body length for stocks within regions (r from 0.4 to 0.7), suggesting that unique regional-scale processes were also important. We then tested hypotheses about the effects of oceanographic conditions and competition on sockeye growth rate. Using Principal Components Analysis, we derived a single time series (PC1) that represented the dominant pattern of variability in length at age that was shared among these stocks. Even after taking into account time trends and autocorrelation in residuals, we found that increases in total Gulf of Alaska sockeye abundance and increases in sea-surface temperature (SST) across the Gulf of Alaska where these stocks overlap were significantly associated with reduced adult body length ($p << 0.001$). Abundance and SST together accounted for 71% of the variability in PC1, but the effect of abundance dominated. Although researchers have documented increases in both abundance of sockeye salmon and their food in the Northeastern Pacific Ocean over the last few decades, the increased food supply may have been more than offset by increased sockeye abundance, leading to greater competition and reduced adult body size.

10AM2001 W1-402 oral

PACIFIC HERRING SIZE AT AGE VARIATION IN THE NORTH PACIFIC

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Pacific herring abundance in British Columbia has fluctuated markedly over the past several decades and there are indications of long term trends in size at age which may be linked to trends in population production and climatic effects as presented at the last PICES session. In this study, I examine the links of herring size at age with the available data on zooplankton production and various environmental indices which may influence herring productivity and growth. Synchrony of British Columbia herring size at age with data from Alaska and

California are presented to compare productivity in the various ecosystems. Available plankton time series are also examined to infer whether plankton production or other environmental factors are the primary determinants of size at age variation in Pacific herring.

10AM2001 W1-112 poster

MICROSTRUCTURE OF OTOLITHS AND FEATURE OF GROWTH OF THE PACIFIC SAURY IN THE NORTHWEST PACIFIC OCEAN AND JAPAN SEA

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Saccular otoliths (sagitta) of Pacific saury which was caught in summer - autumn 1995 and 1998 in area off Kuril Islands and in summer 1999 in the Japanese Sea were used for investigation of microstructure of otoliths, age determination and features of body growth.

Average width of daily increments in the central part of otolith, appropriate to the juvenal period of saury growth, in samples from Pacific Ocean was 2.2-2.92 microns. Average width of daily increments for the first 90 days of life was about 2.3 microns at individuals of autumn-winter spawning, 2.8 microns at individuals hatched in winter-spring period and 2.3 microns at individuals hatched in spring-summer period. The average rates of growth for saury of these stocks were 0.86, 1.14 and 0.71 mm per day accordingly.

Average width of daily increments for the first 90 days of life at juveniles hatched in spring in the Japanese sea was about 2.2 microns, in summer – 2.6 microns, in autumn - about 2.9 microns and in winter – 2.6 microns. The growth rates of individuals of different seasonal groups slightly differed: the greatest growth rate was characteristic for individuals hatched in summer-autumn period – 0.82 and 1.02 mm per day (on the average 0.92). The average growth rate of saury hatched in winter was 0.79 mm per day and for saury hatched in spring – 0.71 mm per day.

For the first half-year of life the growth rate of saury in the Japanese Sea, by the generalized curve of growth for all seasonal groups is slightly lower, than at saury from western Pacific (Watanabe et al., 1988), however in further its growth is slowed down not so quickly. Individuals from the Japanese Sea in the age of 1 year can be 2-3 cm larger than individuals from Northwest Pacific.

We made conclusion, based on the received equations of growth and data of length-frequency distribution of saury, that if in the Northwest Pacific the basis of catches consist of individuals hatched in the winter-spring period, in the Japanese Sea, on the contrary – individuals hatched in summer-autumn period. The basic spawning grounds of saury in the Pacific Ocean in winter - spring period are in the south part of area, in subtropical waters, and the main spawning grounds in the Japanese Sea in the end of summer - beginning of autumn are in the central and northern parts of the sea, in interfrontal waters and waters of subtropical structure.

10AM2001 W1-069 oral

IMPLICATIONS OF VARIATION IN EUPHAUSIID PRODUCTIVITY ON THE GROWTH, PRODUCTION AND RESILIENCE OF PACIFIC HERRING (*Clupea pallasi*) FROM THE SOUTHWEST COAST OF VANCOUVER ISLAND

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I have been monitoring the growth of Pacific herring (*Clupea pallasi*) from the southwest coast of Vancouver Island since 1980, and the population biology and productivity of their prey (euphausiids) since 1991. Results suggest that the decline in prey biomass, which began in 1993, disrupted compensatory, density-dependent growth of pre-recruit fish, resulting in recruit fish being "inappropriately" small in the context of stock biomass. This caused a subsequent decline in adult size-at-age for the year-classes affected because adult herring growth rates are determined mainly by size at the beginning of the annual growth period. The depression of growth has resulted in a 20% decline in egg production which would affect the population's resilience. This variability in productivity has potential implications for the precautionary approach. I also present size-at-age time series for the other four major British Columbian stocks for 1980-2001.

10AM2001 W1-150 poster

YELLOW-FIN FLOUNDER (*Limanda Aspera*, Pallas) GENERATIONS SURVIVE DYNAMICS IN THE TARTAR STRAIT, NORTHERN PART OF THE SEA OF JAPAN, IN THE SECOND HALF OF THE 20-TH CENTURY

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Continuous monitoring of catches and biological indexes of yellow-fin flounder population in the Tartar Strait northern part (Sea of Japan) has been conducted from 1955. Data analysis was made by virtual populations methodology with appropriate tuning.

Variation amplitude range of yellow-fin total stock is had approximately 5 times during 1955-2000. Surviving of different age groups from 0 (total amount of releasing eggs) to 4 years (first appearance in the catches) is fixed as 1 fish from 300.000 released eggs. That parameter was varied in wide range with 7.5 multiplying.

66.2% surviving dispersion was explained by density factor, moreover, link between surviving and initial quantity is approximated by e-function with negative step parameter. According this approximation surviving was minimal with bigger initial quantity and vice versa. This is evidence of limitation density impact on the population quantity.

Regression remains are standardized by density factors can to evidence about climatic impact to the surviving. Surviving maximum is registered at first half of the 1970s, minimum at decade period from the 1950s till the 1960s. The 1980s and the 1990s beginning are characterized as close to normal, meanwhile from 1994 increasing in surviving was obtained. Peak of SST warming was observed at northern part Sea of Japan in the early 1970s. The 1950s period was registered atmospheric activity which is noted by maximum in quantity of tropical typhoons, meanwhile during the 1970s tropical storms quantity was low.

10AM2001 W1-152 oral

VARIABILITY OF THE PINK SALMON SIZES IN CONNECTION WITH ABUNDANCE OF OKHOTSK SEA STOCKS

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Pink salmon stocks abundance in Okhotsk Sea is high during the last decade. Total pink salmon catches reached 176,000 t in 1998. Since 1994 pink salmon stock spawning in the western Kamchatka rivers is the most abundant among other stocks originating in the even years (46-60% of total abundance in the Sea of Okhotsk). Eastern Sakhalin pink salmon stock predominates numerously among all stocks in odd years (65-70% of total abundance).

Some peculiarities of size variability of pink were marked for major stocks. On the whole average fish weight for all pink salmon stocks (excepting western Kamchatka stock) is lower in even year comparing to ones in odd. However the average weight of the eastern Sakhalin pink salmon is lower at low abundance of stock in even years comparing to fish size observed in odd years when Sakhalin population number was twice higher.

It was concluded that the pink salmon sizes depend rather on total pink salmon abundance in Okhotsk Sea but not abundance of each stock. Since dependences of the pink juveniles' sizes on their number in the Sea of Okhotsk is not marked in high sea in autumn, we assume that density depended factor effects on the pink sizes in pacific waters during winter-spring period.

10AM2001 W1-224 poster

THE PECULIARITIES OF THE LINEAR GROWTH IN THE PACIFIC HERRING FROM THE NORTHEAST PART OF THE SEA OF OKHOTSK

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The dynamics of the body length variability in Gijigina-Kamchatka herring is analyzed for the period 1950s-1990s. The population is characterized by high level of the year-to-year body length variability in age groups. In the 16 year-old individuals the difference can reach up to 5.7 cm. Length is most variable in the fish from young (3-5 year-old) or old (12-16 year-old) age groups.

Year-to-year variability of body length relates to the biomass of the reproductive stock and to the ice condition in the Sea of Okhotsk. Minimum growth rates are observed in 1950s-1960s, when the biomass of the reproductive stock has been maximum, and in the 1970s, the period characterized by minimum reproductive stock biomass and hard ice condition. Maximum growth rate has been observed in the 1980s when the reproductive stock biomass has been growing and the ice condition has been less hard. Maximum average length is observed in 1988; during next decade the value has been decreasing gradually.

10AM2001 W1-148 oral

CHANGE IN LENGTH-AT-AGE WITH STOCK FLUCTUATION OF CHUB MACKEREL IN THE PACIFIC WATERS OFF CENTRAL JAPAN SINCE 1970 TO 1997

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Mean lengths at ages of chub mackerel *Scomber japonicus* increased from 1970s to 1990s with the decline of the total biomass and year-class strength. A significant negative correlation was found between the total biomass and the mean lengths at ages (0-5 years old). In year-classes, mean lengths at ages were negatively correlated with the number of age 0 recruits to fishing stock. The coefficients of determination between the length at age and year-class strength were higher than between the length-at-age and the total biomass of a year. Growth increments in length from age 0 (6 months old) to age 1 (18 months old) and from age 1 to age 2 did not correlate with the total biomass or year-class strength, indicating that the trend in length was determined during the first summer of life and maintained throughout the life span of each year-class.

10AM2001 W1-149 oral

INTER-DECADAL FLUCTUATIONS IN LENGTH-AT-AGE OF HOKKAIDO-SAKHALIN HERRING AND JAPANESE SARDINE IN THE SEA OF JAPAN

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Length-at-age of Hokkaido-Sakhalin herring *Clupea pallasi* was smaller at 3 years and older ages in the years 1917-1929 and 1934-1939, during which estimated total number of spawning adults ranged from 0.74-19.62 billion. Dominant year-classes exceeding 3.0 billions in cumulative catch in number were established in 1909, 1911, 1915, 1921, 1926, 1939. Length-at-ages in these 6 years were not necessarily small in spite of large recruitment. Long-term trends in length-at-age of the herring could not be explained by the fluctuations in biomass or year-class strengths. They could have been a reflection of ecosystem changes in the subarctic waters in the Sea of Japan. In contrast to the herring, length-at-age of the Japanese sardine *Sardinops melanostictus*

negatively correlated with the total biomass and year-class strength in the years from 1978-1993 when the biomass increased, peaked, and declined. Similar trends were reported during the population peak in the 1930s and 1940s. Responses in length-at-age to the biomass fluctuation and probable ecosystem variability seem to have been different between these two clupeid fishes from subarctic and temperate waters.

BIO Committee posters

Posters on subjects of interest to the Biological Oceanographic Committee will be on display from October 9 - 11 (noon). There will be a 'wine & cheese poster session' (evening of October 10, Wednesday) when poster presenters are expected to be available to answer questions.

10AM2001 GP-089 BIO poster

INFLUENCE OF WATER EXCHANGING THROUGH THE LA PEROUSE (SOYA) STRAIT ON THE INTRUSION OF OKHOTSK SEA ZOOPLANKTON ENDEMICS IN THE SEA OF JAPAN

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Sakhalin Institute of Fisheries and Oceanography carried out several experiments in the area of La Perouse (Soya) Strait in 1996-2000. These experiments included measurements of water's physical parameters using autonomous stations, collection of oceanographic and hydrobiological data on the standard sections.

One of the most interesting results of these investigations was discovery of some species of zooplankton (*Metridia ochotensis*, that usually live in the subarctic waters of Okhotsk Sea) in the subtropical waters of southern part of the Tartar Strait. The share of this species in total biomass increased last several years.

The best conditions for intrusion of these endemics in the Sea of Japan take place in the January-March, when Soya Warm Current is slowed. The effect of 'return' of the current is occurring in a case of relatively strong easterly winds that can be induced by traveling cyclones.

Another cause of intrusion is tidal currents. Tidal currents in the La Perouse Strait are very strong, their maximal velocity is about 5 knots, and about 1 knot near Moneron Island. These strong currents are a cause of intensive tidal mixing in the areas adjusted to the strait. Observed tidal changes of water temperature and salinity (amplitudes about 1°C and 0.25‰) in the Soya Strait and near Moneron Island below thermocline speak well of this opinion. The intrusion of subarctic species in the southern part of Tartar Strait by tides is existed in different seasons.

Probably, tidal mixing is a cause of high biological productivity of areas adjusted to La Perouse Strait.

10AM2001 GP-191 BIO poster

COPEPODS STRUCTURE REPLY ON THE SEA OF OKHOTSK ADVECTION IN THE SEA OF JAPAN

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La Perouse (Soya) Strait and vicinity is region of water exchange between Sea of Okhotsk and Sea of Japan and according dominance species structure parameters is divided at two subregions. Eastern (Sea of Okhotsk side) subregion is characterized by prevailing in biomass cold water species - 59%, such as *Pseudocalanus minutus*, *Acartia longiremis*, *Metridia okhotensis*, *Calanus glacialis* which are increased in the fall-winter season up to 94%. Here, zooplankton biomass depends on upwelling activity in summer season and two-fold high comparing

with western subregion (Sea of Japan side) zooplankton biomass. In winter, western and eastern subregion biomasses are close each other at 89-96 mg/m^3 level. High-density zooplankton biomass sites are coincided with upwelling edges at south-eastern Kril'on peninsula. For western subregion biomass predominance of moderate cold water copepods is existed up to 78%, mainly by *Neocalanus plumchrus*, which are forming high density clusters (up to 2200 mg/m^3) linked with Tsushima and West-Sakhalin currents convergence. Meanwhile, in western subregion high share of warm water species is increased to the winter (29% of total zooplankton biomass) and depended from Tsushima Warm Current. According 1995-1997 and 1999 investigations results, species structures were relatively stable including seasonal variations. In the same time, 1998 is characterized by radical change in the dominance species structures by biomass in the both subregions. For example, in the western subregion in summer sharp increasing was noted for the Sea of Okhotsk endemic *Metridia okhotensis* (up to 37% total subregion biomass). As noted, what during 1986-1992 previous investigations period share of *M. okhotensis* does not exceeded 2% in total subregion zooplankton biomass. From other side, *N. plumchrus* had 67% in total eastern subregion biomass, concentrated near upwelling and southern edge of Aniva bay in 1998. Thus, allow to presume, what due unusually strong advection of Okhotsk waters in spring 1998 were obtained:

1) Destabilization of *N. plumchrus* concentrations and his re-distribution concentrations by West Sakhalin current to the La Perouse (Soya) Strait
2) Total zooplankton biomass decreasing in the western subregion non-compensating by *M.okhotensis* copepods expansion from Sea of Okhotsk

POSTERS

10AM2001 GP-122 BIO poster

BIOLOGICAL EVIDENCE ON INTRODUCTION OF THE KUROSHIO TO THE YELLOW SEA

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To identify introduction of the Kuroshio to the Yellow Sea using zooplankton assemblages, zooplankton sample was collected from April 1997 to February 1999 bimonthly at 34 stations of the Yellow Sea. The spatio-temporal distribution patterns of about 50 copepod species, 3 chaetognaths and one euphausiid contained indicator species of Kuroshio were similar. Occurrence of these species was restricted from August to December. In terms of the spatio-temporal distribution patterns of these species, we verified patterns in introduction of the Kuroshio to the Yellow Sea.

10AM2001 GP-044 BIO poster

CHARACTERISTICS OF ZOOPLANKTON DISTRIBUTION IN THE NORTHERN EAST CHINA SEA

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As a part of the multidisciplinary oceanographic survey of the Northern East China Sea, characteristics of zooplankton distribution such as coupling with water masses, seasonality, and vertical distribution were studied. During the three years from the summer of 1997, one-month cruises were made six times that covered two summer and winter seasons and one spring and fall season.

A 1 m^2 MOCNESS was used for vertically stratified sampling of zooplankton from surface to near bottom. Each stratum covered 20m thickness of water column. First, we compared the vertical distribution patterns for day and night samples collected at the same or nearby sites. Since diel vertical migration appeared to be meaningful, we used only day samples in the following analyses.

Coupling with the distribution of water masses was relatively well noticed in summer but less in winter. The study area can be subdivided into two regions, the Region of Kuroshio influence with high temperatures and salinities (>16°C, >34 psu) and the region of the Yellow Sea and/or Yanzee River influences with low temperatures and salinities (<16°C, <34 psu). The regions of more diverse appearance of zooplankton and of high abundances varied with season. Dominant taxa and other characteristics of the zooplankton assemblages with relation to the subdivided areas and seasons were discussed. Vertical distribution patterns also showed

seasonal differences. In spring and summer subsurface maxima were noticeable, but in fall vertical stratification was not clearly identified. In winter the abundances increased with depths.

10AM2001 GP-373 BIO poster

VERTICAL DISTRIBUTION OF COPEPODS: *Neocalanus cristatus*, *Neocalanus plumchrus/flemingeri* AND *Eucalanus bungii* IN THE SOUTH PART OF THE OKHOTSK SEA, IN SUMMER 1989, 1994

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Changes in fine-scale vertical distribution of 4 calanoid copepods in the south part of the Okhotsk Sea were examined. Plankton sampling were carried out in July and August 1989, 1994. Samples were collected by vertical hauls from 1000 m to surface with plankton net (49 cm diameter, 0.33 mm mesh openings) at 15 stations.

Neocalanus cristatus. Younger stages were distributed in the total catches throughout the 1000 m water column during night. Although most CV were concentrated in mesopelagic layers 100-2000, 200-500 m throughout the day. Significant number of CV stages did not demonstrate diel vertical migration.

Neocalanus plumchrus/flemingeri. Younger stages demonstrated bimodal vertical distribution (particularly C IV-V, at 0-200 m and 500-1000 m throughout the day, and 0-50m, 100-200 m at night). Most CII-IV stages inhabited in the 0-200 m layer throughout the day and night.

Eucalanus bungii. Younger *Eucalanus bungii* (CIII-VI) were concentrated in two strata, surface (10-20 m) and bathypelagic (500-1000 m) layers, throughout the day and night. Most CII-VI stages were seldom found near the surface in the upper 10m during either day or night. CV-VI were concentrated in 200-500m layer throughout night. Although most part of CV-VI migrate downward in 500-1000 m layer during the daytime.

10AM2001 GP-335 BIO poster

STUDY OF ECOLOGICAL CHARACTERISTICS OF COPEPODS IN THE EAST CHINA SEA

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This paper deals with ecological characteristics of copepods based on seasonal data (four curies) during 1997,10th ~2000,3nd in the East China Sea (23°30~33°N 118°30~128°E). It shows that its species composition of copepods is complex in the East China Sea. 226 species of copepods were identified. Among them, 78 species were found in whole year (32.7%); key species are obvious. Seasonal variation of species is obvious. All species could be divided four eco-types. Abundance average value is 24.46ind/m^3. Seasonal variation trend: Autumn (561.6 ind/m^3) > Summer (211.31 ind/m^3) > Winter (11.07 ind/m^3) > Spring (7.07 ind/m^3). Abundance seasonal distribution changes obviously. In summer its high concentration occurred coastal water and off sea of north part of East China Sea. It could be food for fishes. Key species of copepods are *Calanus sinicus, Undinula valgaris, Euchaeta concinna, E. plana and Eucalanus subcrassus* etc.

CCCC Program posters

Posters on subjects of interest to the PICES-GLOBEC Implementation Panel on Climate Change and Carrying Capacity Program will be on display from October 9 – 11 (noon). There will be a 'wine & cheese poster session' (evening of October 10, Wednesday) when poster presenters are expected to be available to answer questions.

10AM2001 GP-143 CCCC poster

PELAGIC OCEAN HABITATS IN THE BERING SEA

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There is a growing need in the oceanographic community for comprehensive spatial coverage of water column properties. This necessitates the development of analytical tools to extract water column properties from large data sets. We develop analytical methods to measure water column properties and evaluate the potential errors associated with them. We use these methods to analyze water column data in the Bering Sea and map the distribution of water masses that share similar mixed layer characteristics. These characteristics define Pelagic Ocean Habitats (POH) based on volumes of water of common habitat characteristics. Temperature profiles from two transects in the Bering Sea are chosen as a test case. Data from 1998, 1999 and 2000 are analyzed to represent different general conditions (warm, cold and average years respectively). Spatial and temporal patterns in water column characteristics are found. Implications for the study of the distributions of biological resources in the region are discussed.

10AM2001 GP-355 CCCC poster

PHYSICAL FACTORS DEFINING CLIMATE AND OCEAN ECOSYSTEM VARIATIONS

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Many observations of considerable change in populations and ecosystems have shown that they can practically coincide in time with climate change, lag behind them up to several years, and foreshadow them. To explain these facts and create the base for modeling interactions between climate and living matter we should take into account first of all the heat content anomalies which can origin locally or propagate with ocean currents, having solar radiation fluctuations as the main external factor. But analyzing fluctuations of electromagnetic and magnetic fields of external (mainly solar) and internal (inside and around the Earth) origin, we see that they can influence distribution of effective radiation and climate variations over the Globe in many ways. A comparative analysis of cyclic recurrences in external, internal, climate and ecosystem disturbances is made and theoretical considerations are used to show that 1) Electromagnetic and magnetic fields have different effects on different populations inside the ecosystem with possibility of changes going up and down the food chains. As a consequence, our conclusions about interrelations between climate and ecosystem changes depend on the kind of parameters, used to characterize the ecosystem state. 2) There are key regions and key periods of time, when and where sensitivity to external forcing is maximum and from where disturbances expand to larger space and time

scales. 3) Fluctuations of electromagnetic and magnetic fields can have direct effects on individual organisms (from the cell metabolism till the brain and behavior reactions) and indirect effects through the generation of secondary electric currents and magnetic fields in the moving ocean water.

10AM2001 GP-104 CCCC poster

INSHORE AND OFFSHORE FLUCTUATION OF THE KUROSHIO PATH MAY AFFECT THE ENVIRONMENT AND ZOOPLANKTON IN KII CHANNEL, A SHELF WATER ON THE PACIFIC SIDE OF SOUTHWESTERN JAPAN

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Twelve year (from 1987 to 1999), monthly investigations were made to measure the environmental conditions and occurrence of the major mesozooplankton taxa at 13-21 stations in Kii Channel, a productive coastal fishery ground on the Pacific side of southwestern Japan. In the begining period, viz. in 1987, 1988 and 1990, the Kuroshio flowed farther offshore from Kii Channel than the latter period. Water column average temperature was nearly stable during the period with small cyclic fluctuations. Water transparency, a negative indicator of phytoplankton biomass, was low (mean: 8.3 m) in the former period from 1987 to 1991, and increased thereafter (mean: 11.1 m for 1998 and 1999). Although DIN concentration was stable during the period, the relative importance of NH_4-N increased in recent years. In accordance to these environmental changes, one of the most significant changes in the zooplankton was a numerical decline of suspension-feeding (or mainly herbivorous) calanoid copepods, e.g. *Calanus sinicus*, *Paracalanus parvus* (s.l.), *Clausocalanus* spp. and *Acartia omorii*. However, raptorial-feeding (or mainly carnivorous) cyclopoid and poecilostomatoid copepods, *Oithona* spp., *Corycaeus* spp. and *Oncaea* spp. were relatively stable in abundance, but showed short-term irregular fluctuations.

We speculate that these changes of environmental condition and zooplankton community structure in Kii Channel are associated with the location of the Kuroshio path. When it is far from Kii Channel, like in the former period, the bottom intrusion of cold, nutrient-rich water into the Channel is enhanced. Due to strong tidal mixing in a narrow Tomogashima Strait, this bottom water nourishes Kii Channel to stimulate the new production. On the other hand, when the Kuroshio path is close to Kii Channel, like in the later period, the area is largely occupied with warm oligotrophic oceanic water, in which regenerated production prevails. Above ecosystem shift, observed in our study period, may coincide with the decrease in phytoplankton primary production, that further results into the decline of hervivorous mesozooplankton and planktivorous fish production.

10AM2001 GP-334 CCCC poster

SPECIES COMPOSITION AND DISTRIBUTION CHARACTERISTICS OF KEY SPECIES OF CHAETOGNATHS IN THE EAST CHINA SEA

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Based on survey results during 1997-2000 years in the East China Sea (North latitude 26°-35°, west of East longitude 127°30') 300 samples were collected by vertical trawl of plankton net. It describes that species composition and distribution of key species of chaetognaths, and analyses its distribution characteristics combining physical oceanography data of large ocean scale and discus key species role in marine ecosystem. It offers science data for studying dynamic of ecosystem of the East China Sea.

FIS Committee posters

Posters on subjects of interest to the Fishery Science Committee will be on display from October 9 - 11 (noon). There will be a 'wine & cheese poster session' (evening of October 10, Wednesday) when poster presenters are expected to be available to answer questions.

10AM2001 GP-314 FIS poster

FECUNDITY OF FEMALES *Todarodes pacificus* (OMMASTREPHIDAE, CEPHALOPODA) IN THE JAPAN SEA

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The Japanese common squid, *Todarodes pacificus* belongs to monocyclic species with short life span. Large-scale fluctuations of abundance in different years are characteristic of such species. Stock assessment and an abundance forecast of these species are very important for fecundity estimation at individual and population levels. Estimation of individual absolute fecundity (IAF) is complicated because of the pronounced asynchronous type of oogenesis, i.e. development and maturing of oocytes of females *Todarodes pacificus*. A fundamental question is at what stage of reproductive system development the fecundity potential is completely formed. As our histological research has shown, oogoniums, producing oocytes, transport into the ovary through hemolymphatic vessels. It continues up to an appearance of ovulated eggs in oviducts. After that, coming of oogoniums in the ovary stops. The localization zones of germinal epithelium has exhausted and disappeared. This fact confirms reproductive monocyclic type of this squid. It shows that IAF of females can be correctly estimated when oogoniums stop coming in ovaries. IAF was calculated as the total sum of oocytes in the gonads and in the oviducts of 30 mature females with dorsal mantle length (DML) 179-285 mm. The samples were collected on the migration patterns of this species in the Japan Sea. IAF ranged from 116,000 to 1,058,000 oocytes with the mean value of 506±37 thousand. IFA increases with DML. The oocyte diameters from the oviducts ranged from 0.69-0.9 mm with the mean value of 0.82 ± 0.01 mm. Significant correlation between DML and oocyte diameter from oviducts was observed.

10AM2001 GP-088 FIS poster

PILOT STUDY OF NEW NEAR-FIELD REMOTE SENSING METHODS FOR ASSESSING FISH: LIGHT DETECTING AND RANGING (LIDAR) USING LASERS AND IMAGERS

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Aerial surveys used for fishery and wildlife census have typically been limited to sensing aggregations or individuals at or very near the surface. Lidar (light detecting and ranging) using lasers can penetrate the ocean beyond the visible range and map subsurface biological features. In a recent pilot study, we demonstrated the potential of a combined laser/imager instrument package, mounted in an aircraft, for studies on marine ecology. The lidar produces short pulses of green laser light which reflect off fish and particles in the water and return to a

telescope receiver. The strength of the returning pulse separates fish targets from small particles and the elapsed time indicates the range or depth of the object. At 305 m in altitude, the lidar swath was 5 m during the day and 7 m at night. Synoptic images were captured with a high-resolution video camera equipped with a tunable spectral filter capable of capturing 10 different bandwidths;focal length and frame-capture rate were adjustable. The image swath ranged from 150-200 m. Data was binned and processed with custom software. We were able to survey 222 km per hour at 120 knots. Capelin schools were observed day and night along with associated plankton layers, predators, and ocean structure. Spatial autocorrelation in abundance estimation was not a problem due to the speed of data collection. The penetration depth was 15-30 m in inside waters (non-silty) and up to 50 m in outside waters over the continental shelf. Spatial statistics were used to describe distributions. The data collection capabilities of airborne remote sensing can be expanded to measurements of salinity, SST, and ocean color with addition of three instruments. Nighttime distributions of sea birds and marine mammals can be captured with and IR digital camera.

10AM2001 GP-090 FIS poster

FEEDING OF THE SQUID, *Berryteuthis magister*, IN THE AREA OF KURIL ISLANDS

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Diurnal change of food composition and intensity of feeding of the squid *Berryteuthis magister* was investigated on the data of 24-hours trawl station carried out at Simushir Island (Kuril Islands) in October 2000. Food spectrum of the squid included 10 plankton species and 2 nekton species. Plankton crustaceans as Euphausiids (44%), Hyperiids (20%), and Decapods (20%) were the basis of the food, the share of nekton (young squids and Myctophidae fish) was about 14% in average. Daily diet of the squid females was 5.9% of their mass per day, males - 6.8% of their mass per day. The station was executed in the period of irregular semidiurnal tide (with two times of high water and two times of low water per day). As usual, squids' concentrations are not dense in the area of investigation (isobaths 200-500 m) in these environments. Squids' stomachs fullness was maximal twice per day: at 12-13 (second flood time) and 18-19 (second ebb time) o'clock.

10AM2001 GP-240 FIS poster

BASED ON DIVING SURVEY, STOCK ASSESSMENT AND MANAGEMENT IMPLICATIONS OF PEN SHELL (*Atrina pectinata*) IN THE KOREAN ADJACENT WATERS OF THE YELLOW SEA

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Diving survey for pen shell, *Atrina* (*Servatrina*) *pectinata* (Linnaeus), was conducted at 300 stations in the Korean adjacent waters of the Yellow Sea (36°00'-37°00'N, 125°34'-126°39'E) from April to June, 1999. Based on the survey and monthly population ecological measurements, this study is to estimate population ecological parameters, including growth parameters, survival rate, instantaneous coefficients of natural and fishing mortalities, and spawning season, to conduct stock assessment, and to employ management implications of the Korean pen shell, focusing on estimates of acceptable biological catch (ABC). The von Bertalanffy growth parameters estimated from a non-linear regression were SH_∞=308.6 mm, K=0.33, and t_0=-0.419. Annual survival rate (S) of the Korean pen shell was determined to be 0.497 with lowest sum of squared deviations (SSQ) about the mean rate. The estimated instantaneous coefficient of natural mortality (M) was 0.451/year. From the estimates of S and M, the instantaneous coefficient of fishing mortality (F) was calculated as 0.249/year. Spawning occurred once a year, that is, June-August, mainly July. Yield-per-recruit and spawning biomass-per-recruit were suggested under various harvest strategies based on the biological reference points, such as $F_{0.1}$, $F_{30\%}$, $F_{40\%}$. Considering the economic value of fishing ground, current biomass of the Korean pen shell in the target age classes (ages of 3-5) was 82,641 mt and maximum sustainable yields (MSY) was ranged from 13,945-18,593 mt. An appropriate acceptable biological catch (ABC) of the Korean pen shell was estimated to be 14,771 mt with F_{ABC} of 0.248/year for the total allowable catch (TAC)-based management in Korea.

10AM2001 GP-313 FIS poster

A NEW TRIAL FOR ACOUSTIC ABUNDANCE ESTIMATION OF JAPANESE COMMON SQUID

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Japanese common squid, *Todarodes pacificus*, is the important species for commercial fisheries (jigging, trawls, and purse seiners) in the Pacific coast waters off northern Honshu of Japan. The purpose of this study is to confirm the reliability of acoustic estimation of the abundance of squid. Acoustic estimation of squid abundance has been considered to be difficult because the echo of squid is very low. I determined the normalized target strength (*TScm*) of squid by carefully measuring *TS* of live squid controlled in the body tilt angle. I also discovered the distribution patterns peculiar to the echo of squid. In order to perform a tentative estimation of squid abundance, I designed some parallel line transects for the acoustic survey across the contour lines of this fishing ground. Echo integrator data (38KHz frequency) were collected along these transects in the summers of 1996 to 2000. The echo data of squid schools were selected from all collected data on the basis of the specific distribution patterns. The squid densities were calculated from the selected echo data using squid *TS* that determined from *TScm* and average body sizes. In order to confirm the reliability of acoustic estimation of squid densities, I estimated squid densities using data of CPUE of purse seiners and compared the densities estimated from the CPUE with the densities estimated from the acoustic survey. This comparison showed that both the densities estimated almost corresponded. Annual acoustic estimation (1996-2000) of the squid abundance fluctuated between 13 and 200 thousand tons. Annual fluctuation of this estimation roughly corresponded with annual fluctuation of commercial catch. This correspondence also shows that the acoustic abundance estimation was appropriate. These results confirmed that the acoustic survey for squid could be reliable and practical.

10AM2001 GP-352 FIS poster

TROPHIC RELATIONSHIP OF FISHES IN PELAGIAL IN NORTHERN PART OF THE SEA OF OKHOTSK

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To characterize an intensity of food relationship (strength of competition) we used a technique of quantitative studying of the trophic relations, developed by A.A. Shorygin (1952) for researching on feeding habits of fishes in the Northern Caspian Sea. In autumn 2000 the most tense food relationship have developed in Pritaujsky area, where pollock, herring and capelin had high similarity of food structure (volume of competition) ranged 65-68%, as well as herring and capelin (87%). Also a significant pressure of competition (ratio between required and available food ranged from 609 to 1362) conditioned by the consumption of the preferred food organisms, basically euphausiids *Thysanoessa raschii* has been revealed. Strength competition between pollock and herring, pollock and capelin, and also capelin and herring reached the maximal values - 17911, 9842, 9507 c.a. accordingly. In the waters of the northwestern Kamchatka the essential increase of pressure of competition (4662) between pollock and capelin has resulted to significant decrease of similarity in food structure (35.3%) and as consequence strength of competition between these species has dropped up to 3390 c.a. In the northwestern areas strength of competition was significantly less and amounted 168-1160 between pollock and herring, 267-815 - between pollock and capelin and 63-263 c.a - between capelin and herring. The minimal strength of competition was observed in those areas where high biomass of food organisms especially euphausiids occurred. However, in Sakhalin waters strength of competition between pollock and herring (1160 c.a.) increased due to feeding on hyperiids, which biomass was insignificant in this area and as consequence pressure of a competition was relatively higher there. Over the Kashevarov Bank strength of competition between Pollock and Capelin looked to be increased (815 c.a.) due to high degree of the food similarity (66.3%).

10AM2001 GP-343 FIS poster

ENVIRONMENTAL INFLUENCE IN THE DEFINITION OF THE RECRUITMENT MAGNITUDE OF THE BROWN SHRIMP (*Farfantepenaeus californiensis*) IN THE GULF OF CALIFORNIA, MEXICO

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The shrimp fishery in the Gulf of California is a very valuable fishing resource that contributes foreign currencies and employments for a very important sector of the fishing population from Mexico. At the moment the catch is compound mainly for brown shrimp *Farfantepenaeus californiensis* (70-80% of the total catch) and blue shrimp *Litopenaeus stylirostris* (20% of the catch).

It is recognized that the fisheries based on the penaeid crustaceans have a high interannual variability in the captures, and diverse causes of that variation have been suggested such as fishing effort, effect of some environmental variable and a combination of both sources. In this work, the interannual variability in the recruitment magnitude of the brown shrimp, and its relationship with environmental variables (such as the seawater temperature and mean level of the sea) was explored for the period of 1978 at 1995. The recruitment magnitude was obtained by means of a Sequential Population Analysis, to which is incorporated growth and mortality natural variable among years. The results show that a non linear relationship exists among the accumulated temperature three months previous to the spawn and the accumulated mean level of the sea among the moment of the spawn and the recruitment. We propose a non linear multiplicative model among the parental stock, the mean level of the sea and the seawater temperature with the recruitment.

10AM2001 GP-247 FIS poster

THE DIFFERENCE OF BIOLOGICAL INDICATORS IN CHUM (*Oncorhynchus keta*) FRY OF SOME NATURAL AND FISH-FARM POPULATIONS

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In the report there was chosen and studied a range of biologically important features of chum (*Oncorhynchus keta*) fry in Primorye and Sakhalin Island, namely number of seismosensoric pore channels, number of pectoral fin rays, etc. in order to describe peculiarities of the studied populations. There were determined the most important biological features, magnitude of their variability, rate of heredity and fluctuating asymmetry (FA). The number of ontogenesis disorder events exposed by fluctuating asymmetry was recorded as highest in the chum fry from Sakhalin and Primorye's fish farm populations. Thus, rate of fluctuating asymmetry in fry pectoral fin rays taken from Sokolovsky fish farm in Sakhalin was equal to 62.6%, and from Barabashovsky fish farm in Primorye it was some 68.6%, while fry of wild populations from Melkaya River had the rate of 33.3% and from Tym River only 32.5%. Using method of sperm selection (SS) we achieved decrease (approximately 2 times less) of FA level in the fry from Sokolovsky fish farm. The FA level of seismosensoric pores channels on preoperculum was highest at Barabashovsky fish farm and equalled 36.75%, being significantly lower at Sokolovsky - 19% and in the rivers Melkaya, Belaya, Tym of Sakhalin Island it was 16.3%, 21.3%, 20.1% correspondingly. One of the factors that increases FA level in fry of Barabashovsky fish farm evidently is unfavourable water regimen in this fish farm. Decrease of FA was accompanied by the rise of growth speed, also length, mass of body and number of gill rakers, spots number in sideline increased. It is described variability of features in explored populations. The most representative feature among the others became the number of seismosensoric pores channels. The wild fry from the rivers Melkaya and Tym had 5 pores often, 6 pores were met approximately 2 times more seldom and sometimes there were specimens with 4 pores. At fish farms the fry with 6 pores were met most often, with 5 pores seldom but at Sokolovsky fish farm some specimens with 7 and 8 pores were encountered. The populations were discriminated also according to gill rakers, spots number along the side line and number of pectoral fin rays.

Thus, every population was characterized by its own features and FA of coupled features. The body size of salmon is correlated with the explored fluctuating asymmetry. Decrease of FA was accompanied by the rise of growth speed, also length, mass of body and number of gill rakers, spots number in sideline increased.

10AM2001 GP-371 FIS poster

FEEDING HABITS OF SHORTRAKER *Sebastes borealis* AND ROUGHEYE *S. aleutianus* ROCKFISHES (SCORPAENIDAE) IN THE WESTERN BERING SEA

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Shortraker rockfish *Sebastes borealis* and rougheye rockfish *Sebastes aleutianus* due to their red coloration and delicious meat are very important targets of groundfish fishery in the North Pacific Ocean. Biology of species considered is studying during recent years intensively (McDermott, 1994; Tokranov, Davydov, 1997, 1998; Krieger, Ito, 1998; Tokranov, 1998; Orlov, Abramov, 2001). Feeding habits of these scorpaenids were investigated only in Alaskan waters (Yang, 1993, 1996; Yang, Nelson, 2000). No studies dealing with feeding habits of shortraker and rougheye rockfishes in the western Bering Sea were conducted till present.

Stomach contents of shortraker and rougheye rockfishes brought aboard Japanese trawler Kayo maru No. 28 during summer 1997 were analyzed. The stomach samples were selected without known bias from bottom trawl hauls carried out around the clock in the western Bering Sea between 170° E and 178° W. Stomachs examined and those with food were as follows: 301/107 shortraker rockfish and 58/12 rougheye rockfish.

The diet of shortraker rockfish consisted of variety of marine organisms from small crustaceans to fishes. The most important dietary components were red squid *Berryteuthis magister* and various fishes represented by Pacific herring *Clupea pallasi*, mesopelagic myctophids and bathylagids, and unidentified species. The diet of rougheye rockfish consisted of lesser number of prey categories and included mysids, amphipods, pandalid shrimps, Tanner crabs, mesopelagic myctophids and bathylagids, and fishery discards. Diet composition of species considered caught in the western Bering Sea is compared with that from the Alaskan waters. Changes of diet of shortraker and rougheye rockfishes with fish size increasing are analyzed.

10AM2001 GP-386 FIS poster

FACTORS INFLUENCING STOCK INCREASE OF THE GREY SEA URCHIN (*Strongylocentrotus intermedius*) IN NORTHWESTERN PART OF THE JAPAN SEA

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In TINRO-Centre the Program on maintaining the supplies of grey sea urchins *Strongylocentrotus intermedius* and active catch in stable condition in the period of their regulation has recently been worked out and successfully carried out. The realization of the program is being carried out by undertaking melioration and aquaculture measure based on all -round knowledge of the sea urchin biology.

First of all the bonitatative estimation of the sea urchin habitat area was made and simultaneously somatic index, index of fullness of digestive tracts and the composition of used food were determined, the correlation between the composition of feeding base and degree of maturity of sexual products were revealed., migration oppotanities and the maturity of sexual products.

A comparative chemical analysis of seaweed Laminaria was made for this purpose (before feeding it and after the usage). It was found out that the mannit content in the Laminaria secreted by sea urchins reduced to 0.13% as compared with 5% in the initial seaweed. The largest quantity of mannit is observed in healthy, strong species of Laminaria growing in the dense accumulations. While analysis such plants it was determined that mannit composition in them is 10-12%. However natural observations showed that sea urchins never penetrate such dense Laminaria kelp in spite of its nutritive attraction. The chemical analysis of the strong plants from this dense kelp demonstrated that they contain inhibitions component of the ferments of digestive tracts of sea urchins

that makes this Laminaria kelp inaccessible for sea urchin nutrition. But the moment the plant is torn off the substratum in the result of the storm, it is most willingly eaten by the sea urchin, since inhibitor of the ferments have albumin nature and act only when the plant is alive (in the living plant). On the basis of the revealed bio-chemical peculiarities of "sea - urchin - Laminaria" relations TINRO-Center began elaborating bio-technologies of feeding sea-urchins with Laminaria containing maximum mannit and minimum of inhibitions components digestive tracts of sea urchins.

10AM2001 GP-376 FIS poster

ON THE POPULATION STRUCTURE AND NUMBER DYNAMICS OF THE BOLSHAYA RIVER *Salvelinus malma*

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The age structure is the most important element of the population structure, that is why its study is one of the main directions in the fish stock dynamics research. Fluctuations of separate generations' number define its changeability. In the catches of the Bolshaya River *Salvelinus malma* they count 7 age categories. Out of them 5 and 6 year-old fishes compose a modal group. The age of replenishment of the industrial part of char population is mainly 5-6 years. Considering the freshwater years the number of the age categories in different years counts from 10 to 15 ones. The majority of char spends 3-4 years in fresh water. The most frequently met age group is 2.4+ (6 years with two outcomes to the sea). The diversification of char roll-down to the sea and a big variety of combinations of freshwater and "sea" years are reflected on the size structure of even-aged groups. This allows char to occupy maximum of ecological recesses both in the river and sea. At the equal general age those char individuals are bigger that spent less years in fresh water (with a bigger number of sea fattenings accordingly). At the equal number of the "sea" years those individuals are bigger that spent more time in fresh water. For the first time char migrates to sea at the size of 9.5 - 22.8 cm. So, the individuals, migrated down at the age of 4 years, usually mature the next year. The individuals, migrated down first at the age of 2 and 3 years, mature after the second and the third outcome to sea. By the age of maturity (5+) their sizes become somewhat even. The fertility range of the Bolshaya River *Salvelinus malma* is wide enough and varies from 1640 to 3740 eggs. The highest is noted at the size of 40-42 cm. The genital structure is characterized by a stable females' predominance. In the dynamics of the industrial catches 30 and 5-6 years' cycle are noted. The latter are connected with the time of the replenishment joining the spawning stock.

10AM2001 GP-289 FIS poster

ARE PACIFIC SALMON STARVING IN THE OCEAN?

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Hatcheries release large numbers of salmon in the North Pacific each year to sustain the high demand of commercial and recreational fisheries, and to replenish endangered stocks. However, this practice has raised several concerns including the potential genetic meltdown of wild stocks and the introduction of disease to wild fish. Hatchery fish may also compete for food with wild fish, and hence, may decrease their ability to achieve large size during their marine residency. Several recent studies have showed that the body size of returning adults generally decreases with salmon abundance, suggesting that they may be competing for food either during their coastal residence or on the high seas (or both), and, as a result of stocking programs, that salmon abundance may be exceeding the carrying capacity of the ocean. In order to determine the carrying capacity, we need to accurately estimate prey supply and predator demand. Here, we present food consumption rates of juvenile coho and chinook salmon off the west coast of British Columbia that were obtained using a chemical tracer approach. Food consumption rates of juvenile salmon averaged 10% $bw \cdot d^{-1}$ during summer and represented 85% of their maximum consumption rates. These values were sufficient to allow juvenile salmon to grow at 2-3% $bw \cdot d^{-1}$. Overwinter feeding rates of these fish averaged 3% $bw \cdot d^{-1}$, and were sufficient to generate positive growth, albeit

at a much lower rate than during the summer. Thus, we found no evidence that salmon are starving in coastal waters.

10AM2001 GP-128 FIS poster

FINAL OOCYTE MATURATION AND OVULATION OF THE JACK MACKEREL, *Trachurus japonicus*, INDUCED BY HCG

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The jack mackerel (*Trachurus japonicus*) is an important resource for the purse-seine fishery. However, little is known about its spawning biology or its final oocyte maturation (FOM), fecundity, or spawning frequency, perhaps because it is difficult to collect females with mature oocytes in natural populations. This study examined FOM and ovulation of *T. japonicus* treated with human chorionic gonadotropin (HCG) in the laboratory. Fish were caught by commercial vessels, kept in a sea pen for several days without food, and transferred to an experimental tank. Female fish with yolk-accumulated oocytes were selected by ovarian biopsy, performed just before the experiment. After a single injection of HCG (500 IU/kg), five to nine fish each were sacrificed at five different times (0, 12, 24, 36, and 48 hours), and their ovaries were dissected and examined histologically. Oocytes at the germinal vesicle migration stage first appeared 24 hours after HCG injection. Germinal vesicle breakdown had already occurred in all fish sampled at 36 hours. At 48 hours, ovulated eggs were observed in five of seven fish. All specimens, however, had vitellogenic oocyte atresia, likely due to handling stress and starvation before the experiment. The results indicate that a single injection of HCG is sufficient to induce oocyte maturation and ovulation in *T. japonicus* with yolk-accumulated oocytes. FOM and ovulation occurred within 36 hours and at around 48 hours after HCG treatment, respectively. These findings provide fundamental information for estimating the spawning biology of natural populations.

10AM2001 GP-348 FIS poster

SALMON ESCAPEMENT FORECASTS USING ARTIFICIAL NEURAL NETWORKS

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Forecasts of Pacific salmon escapement are essential for fishery management. Based on data availability and quality, several forecast methods have been used for different stocks. Data limitation has been a key impediment for the use of formal statistical forecast methods for many Pacific salmon stocks. To date, the Moving Average (MA) of historical escapement has been the only choice for these data lack stocks. In this paper I investigate the potential application of artificial neural networks (ANN) technique for salmon escapement forecast. ANNs are constructed with three layers (input, hidden, and output) with three neurons in the hidden layer. The historical escapement indices are the only available data and are used as inputs. The output is the predicted escapement index. ANNs are tested for two Oregon coastal fall chinook stocks, the Siletz and Nehalem Rivers, from 1986 to 2000. The outputs are compared with forecasts using the traditional MA methods. The results indicate a promising application of ANN for escapement forecast. For the Siletz River stock, ANN results in a mean absolute percent error (MAPE, error between observed and predicted escapement) of 20.3%, compared to 31.7% from MA method. The correlation coefficient between observed and predicted escapement is 0.593 for ANN and -0.305 for MA. For the Nehalem stock, ANN results in a MAPE of 25.3%, compared to 34.8% for MA method. The correlation coefficient between observed and predicted escapement is 0.649 for ANN and 0.577 for MA. ANN forecasts outperform MA methods for both stocks.

MEQ Committee posters

Posters on subjects of interest to the Marine Environmental Quality Committee will be on display from October 9 - 11 (noon). There will be a 'wine & cheese poster session' (evening of October 10, Wednesday) when poster presenters are expected to be available to answer questions.

10AM2001 GP-372 MEQ poster

PECULIARITY OF BENTHOS ABUNDANCE AND SPECIES COMPOSITION IN CONDITIONS OF POLLUTION (THE SEA OF JAPAN)

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Investigations of benthic assemblages distribution carried out in 1986-1989 and 1992-1997 in the Peter the Great Bay allowed to detect changes in benthos distribution, abundance and species composition along pollution gradient. Benthic communities in the most polluted areas had common properties:

1. Low total biomass (<80 g/m^2) and Shannon-Wiener diversity index (0-1.2), high total density (>5000 ind/m^2), caused from strong agglomeration of small organisms - polychaetes, phoronids and some snails.

2. Density decreasing of pollution-sensitive species: polychaetes *Maldane sarsi*, *Scalibregma inflatum*, *Sigambra bassi*, *Scoloplos armiger*, *Spiophanes bombyx*, *Laonice cirrata*, *Praxillella praetermissa*, bivalves *Axinopsida subquadrata*, *Raeta pulchella*, *Alveinus ojianus*, ophiuroids *Ophiura sarsi*, *O. kinbergi* and *Amphiodia fissa*.

3. Domination of tolerant pollution species: polychaetes *Tharyx pacifica*, *Dipolydora cardalia*, *Capitella capitata*, *Schistomeringos japonica*, *Cirratulus cirratus*, *Chone cincta*, *Chaetozone setosa*, phoronid *Phoronopsis harmeri*, snail *Pusillina (Thapsiella) plicosa*. All of these species successively increased their densities along pollution gradient.

Thus, low benthos biomass and diversity index, elimination of echinoderms, molluscs, crustaceans, and high density of tolerant pollution species can be evidence of adverse effects of pollution. Analysis of these benthic parameters can be useful on marine environmental quality assessment.

10AM2001 GP-051 MEQ poster

LONG-TERM CHANGES IN BOHAI SEA ECOSYSTEM

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Bohai Sea is an inland sea in North China with an area of 77,284 km^2 and average depth of 18 m. Bohai is are an important fishing ground, an abundant oil and gas field, has good transportation and harbors and beautiful tourism spots. It plays the important service function for the economical rings surrounding Bohai Sea. Since 1980s, several comprehensive investigations were carried out to illuminate the ecosystem changes in Bohai Sea. The results showed this ecosystem has changed sharply.

Eutrophication has occurred extensively in Bohai Sea. The important pollutants are heavy metal and nutrient in Liaodong Bay, nutrient in Bohai Bay, nutrient and oil in Laizhou Bay. Times of red tide double compared with 1980s and the area of red tide reached more than 6,000 km^2 in 1998. Moreover the primary productivity of phytoplankton is weakened. The dominant species of plankton communities change and whole ecosystem degrades. The biomass and catch per unit effort of economical fish decreased. These changes may be contributed by the artificial activities (discharge waste, over-dense mariculture, overfish, oil spill etc.) conducted in Bohai Sea. These change in Bohai Sea also affect the fisheries production in Yellow Sea, because Bohai Sea serves as the most important spawning field for many fishes living in Yellow Sea.

10AM2001 GP-366 MEQ poster

COMPARATIVE STUDIES ON THE ANTIOXIDANT ENZYME ACTIVITIES IN COELOMOCTYES OF FAR EASTERN HOLOTHURIANS *A. japonicus* AND *E. fraudatrix*, AND SEA STAR *A. amurensis*

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Little is known about the antioxidant enzyme activity in coelomocytes of the lower invertebrates, which are functionally similar to immunocytes of vertebrates. We investigated the activities of superoxide dismutase (SOD), catalase, and glutathione transferase (GT) of two close species of far eastern holothurians (Holothuroidea) *A. japonicus* and *E. fraudatrix,* and sea star *(Asteroidea) A. amurensis*. The animals were collected in the Peter the Great Bay. The enzyme activities were defined in nuclear-free supernatants by spectrophotometric methods. We have shown that all three enzymes are present in the coelomocytes of all species studied. Their activity values measured at optimal and suboptimal pH and temperature are significantly higher than those in hepatopancreas or digestive glands of mussels and crabs and are comparable with those in phagocytes of mammalians. The activities in two holothurian species are close to each other, and their pH-optimums are equal. However, activities of GT and catalase differ in coelomocytes of holothurians and sea star (catalase activity is 430 ± 96 and 900 ± 85 mkmol/min/ mg protein, and GT activity - 3120 ± 900 and 7945 ± 314 mkmol/min/ mg protein in *E. fraudatrix* and *A. amurensis*, correspondingly). Their pH-optimums also are different. SOD activities of coelomocytes in Holothuroidea and Asteroidea species were more close to each other (471 ± 113 and 435.6 ± 81.5 unit/mg protein in *E. fraudatrix* and *A. amurensis*, correspondingly). The high activity of antioxidant enzymes in coelomocytes of echinoderms suggest their possible use for environmental contamination biomonitoring and the estimation of functional activity of these species immunocytes in model experiments. *The work was financially supported by RFFI Grant (N 00-04-48949).*

10AM2001 GP-063 MEQ poster

RESPONSES OF PHYTOPLANKTON ON PHOSPHATE ENRICHMENT IN MESOCOSM

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The correlation among the excess phosphate and biomass of phytoplankton and species composition were studied by mesocosm experiments in the water off Changjiang River Estuary. After adding the phosphate, the biomass of phytoplankton increased exponentially but the concentration of dissolved inorganic phosphate decreased exponentially until the fifth day. When the density of phytoplankton and the concentration of chlorophyll *a* reached the peak, the species diversity and evenness declined to minimum. The value of these two indexes was 0.008 and 0.003 respectively. The bloom of *Skeletonema costatum* was induced by adding phosphate. The growth rate and uptake rate on phosphate of *Skeletonema costatum* were estimated in the paper.

POC Committee papers & posters

Convenor: Vyacheslav B. Lobanov, POC Chairman (Russia)
Thursday, October 11, 2001 15:25-17:30

Posters on subjects of interest to the Physical Oceanography and Climate Committee will be on display from October 9 - 11 (noon). There will be a 'wine & cheese poster session' (evening of October 10, Wednesday) when poster presenters are expected to be available to answer questions.

10AM2001 POC-367 oral
DECADAL VARIABILITY OF THE NORTH PACIFIC POLAR FRONT
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The North Pacific Polar Front (PF) is the southern boundary of the Subarctic Zone that features a well-defined subsurface Tmin underlain by a Tmax, associated respectively with the dicothermal and mesothermal waters. The Tmin and Tmax are typically collocated with, respectively, the upper and lower boundaries of the subsurface halocline and oxycline, especially in the Western Subarctic Gyre. We have used all available hydrographic data to trace the PF across the ocean and to study its decadal variability. The highly regular repeat sections of the Hokkaido University along 155°E, 170°E, 175.5°E and 180°E form the backbone of our dataset since these are the only cross-PF datasets that cover two decades, the 1980s and 1990s. We found that PF is a major temperature, salinity, oxygen, and nutrients front, the northernmost of the major climatic (large-scale, quasi-stationary) trans-oceanic fronts of the North Pacific. It is largely a subsurface, deep (>2 km) front, associated with strong geostrophic currents (East Kamchatka, Kuril, Oyashio, and Subarctic Currents, and Alaskan Stream); its surface manifestations are weak or absent or shifted relative to the main (subsurface) front. The PF extends non-zonally across the North Pacific from 42-43°N off Japan to 52-55°N in the Gulf of Alaska where the front surrounds the Alaskan Gyre proper. The most significant changes of frontal characteristics occurred in the 1990s. In the long term, from early 1950s-late 1990s, the Alaskan Gyre Retroflection of the PF has significantly shifted to the west.

10AM2001 GP-058 POC poster
COASTAL TIDAL FRONTS IN THE OKHOTSK SEA
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Analysis and generalization of oceanographic, aircraft and satellite data in visible, IR and radar ranges testify to presence of expressed frontal zones along the shelf border in some places of Okhotsk Sea (Kamchatka's shore). To similar thermal fronts it is possible to attribute also frontal zones originating on peripheries of areas of local tidal mixing in Kuril straits (straits of Ekaterina and Friza). As a rule, the high biological and fishery

productivity is characteristic for such zones. For explanation of their origin the hypothesis is put forward that tidal phenomena can play significant role in formation of coastal frontal zones.

Theoretical estimations based on using Simpson-Hunter criteria showed that coastal tidal front separating mixed coastal waters from stratified waters of open sea, should be above depths of 50-160 m, that is confirmed with measurements *in situ*. Alongside with thermodynamic shelf front, a pure dynamic one originates manifesting in spasmodic changes of tidal current characteristics caused by morphological features.

Tidal currents spread mainly along isobaths having reverse sign tendency of propagation at shelf edge. Tidal current velocities decrease nearby the shore due to bottom and lateral friction but then increase reaching maximum at 100-200 m depth. Baroclinic mode conditioned by internal tidal waves, renders input in tidal flow spreading.

Transversal standing wave arising at excitation of entrapped shelf waves, promotes formation on shelf border of a dynamic tidal frontal zone separating opposite directed tidal flows. Intensive tidal stirring is attached to boundaries of demarcation of tidal currents or to boundary of invasion of strong tidal flow onto a water area of straits. Last are usually well seen through lop lines.

10AM2001 GP-291 POC poster

PARTICULATE ORGANIC CARBON VARIABILITY IN THE SUBARCTIC PACIFIC BASED ON TRANSMISSIOMETER DATA

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The marine biogeochemical cycle is reflected in the spatial and temporal variability of particulate organic carbon (POC). Because POC is related to biological processes (e.g. photosynthesis, grazing) quantification of its distribution may indicate how the marine biogeochemical cycle responds to changes in physical environment. Past efforts to quantify POC by bottle sampling or *in situ* filtration, however, have been hampered by difficulties in obtaining representative samples (bias and sparseness). The use of transmissometer data (beam attenuation coefficient) as a proxy for POC addresses this problem.

In this paper, beam attenuation coefficient data from the subarctic Pacific were used to identify processes that control the POC distribution in this high nutrients low chlorophyll (HNLC) region. The combined influence of several factors including mixed layer depth (including mixing history), availability of light for marine photosynthetic organisms and grazing on POC distributions was examined.

Values of POC were calculated from the beam attenuation coefficient data obtained from two surveys in the subarctic Pacific: the 1995 Highseas survey (53 stations, March-April) and the 1993 INPOC survey (69 stations, April-May). The vertical distribution of POC in the upper layers of the eastern section of the Eastern Subarctic gyre was governed by wind mixing and its effect on the light availability for photosynthetic organisms. Within the upper mixed layer wind stirring makes light uniformly available for phytoplankton which, in turn, leads to high and quasi-uniform POC values. Below the base of the mixed layer zooplankton grazing on sinking particles likely becomes the major factor governing a sharp decrease of POC. The vertical POC distribution in the western section of the Eastern Subarctic gyre and in the entire Western Subarctic gyre was significantly different: most of the stations showed subsurface POC maxima slightly above the base of the mixed layer. This suggests that factors other than mixing/availability of light may shape the POC vertical profile; these include a possible non - homogeneous distribution of both phytoplankton and its grazers in the upper layer above the pycnocline related to nutrient/micronutrient influx from below the euphotic zone.

Horizontal and vertical variability of POC in the upper 300 m was investigated. A strong vertical POC gradient existed everywhere at about 100 m coinciding with the halocline. Horizontal variability of POC in the upper layer was mainly due to biological processes; areas with elevated biological activity, such as the East Kamchatka Current and oceanic frontal zones, showed a significant increase in POC.

10AM2001 GP-397 poster

THERMAL FRONTS AND LARGE-SCALE GYRE IN THE JAPAN SEA ON PALACE FLOATS DATA

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Analysis of two-years observations by PALACE in the Japan Sea revealed two thermal fronts (Subarctic and North-western), large-scale gyre (in Japan Basin) and belt of salt water (between 41N and 43N). Importance of salt-water transport (inside the belt) for deep water formation was investigated on data of extremely cold winter of 2001.

10AM2001 POC-165 oral

THE HEAT FLUX ACROSS LINE-P IN 1996-1999

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Routine monitoring of ocean conditions along Line-P has been continuing for almost 50 years. During the 1997-98 El Niño episode sufficient warning was available that a special El Niño Watch Program was initiated to monitor the passage of the oceanic anomalies past the coast of British Columbia, and that program included an intensification of sampling along Line-P. Comparison of the sampling along Line-P during this period allows comparison with the long-term mean states and so allows a description of the anomalies associated with the El Niño and the subsequent La Niña event. The availability of detailed offshore sea-level observations from the Topex-Poseidon satellite allows estimation of velocity anomalies which, together with estimates of the temperature anomalies allows calculations of the heat fluxes across Line-P before the El Niño began, during the development and mature phases of the El Niño and the subsequent La Niña phase. We also have about 12 years of data available from a network of offshore weather buoys, this allows estimates of the Ekman heat flux. The anomalous heat fluxes computed are very large. The paper will discuss the implications of this for the climatic state of the Gulf of Alaska.

10AM2001 POC-161 oral

SIMULATION OF NPIW CIRCULATION BY HIGH-RESOLUTION NORTH PACIFIC OCEAN MODEL

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Long-term integration of a high-resolution North Pacific Ocean model were conducted to clarify the formation and spreading of the intermediate low salinity water and to simulate the circulation of the North Pacific Intermediate Water (NPIW) with a salinity-minimum layer. The model domain is 100E-75W and 15S-65N with 1/4 deg (EW) x 1/6 deg (NS) horizontal resolution and 44 vertical levels. Restoring fluxes of heat and salinity are specified at the surface, below 2000m, and in the Okhotsk and Bering seas.

Results of the control run with Hellerman-Rosenstein's monthly-mean climatological wind stress data show the simulated Oyashio front to stay to the north of its observed latitude by several degrees, leading to insufficient mixing of the Oyashio and Kuroshio waters and, in turn, insufficient formation of the low salinity NPIW with a weak salinity minimum in the meridional salinity section.

Usage of the NCEP reanalyzed wind stress data instead of Hellerman and Rosenstein's data fairly improves the simulated Oyashio front location with occasional southward intrusions of the Oyashio along the east coast of Japan. The simulated salinity minimum layer is smoother than that in the control run. Better result based on the monthly-mean time-series of wind stress data than that with the monthly-mean climatology suggests that short-term variabilities in the wind field may be important to the mixing of the Oyashio and Kuroshio waters.

10AM2001 GP-268 POC poster

THE ANALYSIS OF THE SEASONAL VARIABILITY OF UPPER MIXED LAYER DEPTH OF THE JAPAN SEA AND OKHOTSK SEA

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The mixed layer depth and its variability is the great importance for the understanding and interpretation of thermal and velocity fields of the upper sea, for parameterizing mixed layer processes. On the basis of integrated data bases of Japan and Okhotsk Seas upper mixed layer depth have been calculated at 25′ squares for each 12 months. Oceanographic data used for it were obtained the following sources: the POI oceanographic data; CD-ROM of US NOAA/NODC : "NODC-01-03", WOD'98"; CD-ROM of JODC (Japan) "Temperature Profile Data Set" (1940-1993, Western Pacific); CD-ROM of JODC (Japan) "Temperature and Salinity Profile SD and CTD Data Set (Japan Sea)"; CD-ROM of JMA (Japan) "Data Report of Oceanographic Observations" (No. 87, 88, 89).

10AM2001 GP-162 POC poster

HORIZONTAL STRUCTURE OF SEA SURFACE HEIGHT ANOMALY ESTIMATED FROM TOPEX/POSEIDON IN THE EAST (JAPAN) SEA

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The East Sea (ES) draws particular attentions from international scientific community. This study utilizes the dataset of Topex/Poseidon (TP) altimeter to understand the general circulation pattern in ES. The dataset is analyzed to show the general circulation pattern as well as eddy fields in terms of mean and anomaly sea surface height. TP dataset covers the period of 8 years from 1992 to 2000 with 10 day ERM. For spatio-temporal structure, optimal interpolation (OI) technique was first applied to the pre-processed TP dataset to produce sea surface height (SSH) and sea surface height anomaly (SSA) map on the regular grids. To determine the spatial structures and temporal variability, empirical orthogonal function (EOF) analysis was carried out to yield three dominant eigen modes. Results of EOF analyses draw following significant points:

1) For spatial structure, 1st mode explains the entire ES field while 2nd and 3rd modes are associated with north-south (across polar front) and west-east variability respectively.

2) The spectral analysis of the time coefficient of eofs shows that 1st mode reflect the seasonal variation, while 2nd and 3rd modes are associated with inter-annual variability of major current system such as Tsushima Warm Current, East Korea Warm Current, North Korea Cold Current, Liman/Primoriye Current and polar frontal jet.

POC PAPER

10AM2001 GP-345 POC poster

LINEAR STABILITY PROBLEM FOR A SYSTEM WITH THERMOHALINE CONVECTION IN A LIMIT OF HIGH HOPF FREQUENCY

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Heat-mass transfer in the ocean is an important effect of thermohaline convection. To evaluate a growth rate of unstable convective mode for various heat-salt boundary conditions in a limit of high Hopf frequency multiscale decomposition technique is used. As a small parameter a square root of an inverse salt Rayleigh number is introduced. Perturbations of eigen functions and growth rate parameter caused by different types of the boundary conditions are obtained. It appeared, that in main order of value growth rate is not dependent from type of boundary conditions and is proportional to inverse salt Rayleigh number.

10AM2001 GP-047 POC poster

MOORING OBSERVATION OF OYASHIO CURRENT SOUTHEAST OF HOKKAIDO, JAPAN

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We carried out mooring observation at Stn. AK2 (at a depth of 1160m) in inshore waters and Stn. AK5 (at depths of 250m, 1260m and 3240m) in offshore waters, in the vicinity of the main path of the Oyashio off southeast of Hokkaido in Japan from May 1991 to May 2000. Stable southwest directional current, nearly coincident with the direction of the Oyashio path, was observed at Stn. AK2 throughout the year and its direction was almost parallel to the local isobath around there. At Stn. AK5, the observed current flowed southwestward until autumn 1997 at all three depths, especially the southwest component intensified remarkably during 1994-1996. However, after autumn 1997, the southwest current at Stn. AK5 drastically changed to northeast at depths of 250m and 1260m and to northwest at a depth of 3240m, respectively. The reason for this change may be due to the effect of revolutional motion of warm-core ring, which situated near the mooring station about that time. Some warm-core rings often appeared and stayed around there since then. We could observe the maximum velocities in southwest component during winter and spring seasons before the autumn of 1997, but the seasonality became not clear after that time. We will further discuss the annual and seasonal variation of the Oyashio using hydrographical data in addition to the mooring data.

10AM2001 GP-398 POC poster

VARIABILITY OF THE NORTH PACIFIC CIRCULATION MODEL UNDER THE SURFACE FORCING FROM RE-ANALYSIS DATA

Victor I. **Kuzin** and Valery M. Moiseev

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The 3-D finite element North Pacific Circulation Model developed in the Novosibirsk Institute of Computational Mathematics and Mathematical Geophysics (ICMMG) is used to study the variability of the North Pacific circulation to the time-varying boundary conditions at the surface. The numerical simulation was concerned with the prognostic experiments to study the response of the North Pacific hydro-physical characteristics to real forcing. The integration period was selected as period of the El Niño and La Niña events. For this purpose the ten-days mean distribution of the surface forcing was adopted from the European Center Medium-Range Forecast (ECMWF) Seasonal Ensemble Simulation, 1987 as well as from the ECMWF Re-Analysis Sample Data 1979-1993. The initial conditions were taken from the results of diagnostic numerical experiments of climatic circulation which were carried out on the basis of climatic temperature and salinity data and wind-stress. The results show the development of the main temperature anomalies in the eastern part of the tropical Pacific. However, ocean variability concerns not only the tropical Pacific, but also sub-polar region where significant anomalies also arise during this period. The analysis of these processes and the comparison with the climatic state are done in the paper.

10AM2001 GP-399 POC poster

DIAGNOSIS OF KUROSHIO STATES

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The observational data were obtained in 40 oceanographic cruises made by the FERHRI vessels during the period 1980-1990. The data measurements were interpolated to the regular 1/3 deg. grid and reaching the depth of 1500m. The main goal of analysis is to continue study the difference of the hydrological fields for two states of the Kuroshio Current. These characteristics are as follows: temperature distribution for different zones, potential vorticity distribution, principal component for the T&S fields etc. Additionally, the pressure tendency and

vertical velocity equations were analysed on the basis of the geostrophic velocities. Some of the periods were characterised by the on-shore, non-large meander state, whereas during other periods the typical offshore, large-meander path was observed. The P-vector estimate of the 3-D velocities was made for all of these data. These velocity fields were compared with the traditional dynamic method results. Complete diagnostic calculations of 3-D velocity fields on the basis of the Novosibirsk Computing Center Ocean Circulation Model (NCCOCM) were carried out for some selected data.

10AM2001 GP-316 POC poster

THE MUSSEL, *Mytilus californianus*, AS INDICATOR OF Cd IN UPWELLING REGIMES

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The oceanic distribution of dissolved Cd is highly correlated with that of nutrients. Thus, nutrient-rich upwelled waters are also Cd rich. On the Pacific coast of North America upwelling occurs during spring and summer. Mussels can reflect these Cd inputs by increasing their soft tissue concentrations. This study presents results on the Cd variability in the mussel *Mytilus californianus* at two different upwelling regimes: 1) At Baja California where seasonal (monthly) and short-term (days) variability was measured, and 2) At Vancouver Island where only short-term variability was measured. Baja California mussels reached up to 17 μg Cd g^{-1} (dry wt) in June. A Principal Component Analysis (PCA) for the monthly study showed a strong relation of mussel Cd concentrations to those in seaweed and to upwelling indicators (temperature, phosphate, upwelling index). The short-term variability study during upwelling, showed that this species (contrary to other species) is able to decrease its soft tissue Cd concentrations very rapidly. At Vancouver Island, mussel samples, together with upwelling indicators (temperature, salinity, phosphate, dissolved Cd) were taken during 4 weeks during summer. The mussels increased their soft tissue Cd levels due to upwelling (up to 9.5 μg g^{-1}) and to mixing, but they decreased shortly afterwards. A PCA on these data showed a relationship of mussel Cd soft tissue concentrations to their condition index. However, after accounting for the variability due to this index, a relation with dissolved Cd emerged. The shells did not exhibit the high variability of Cd presented by mussels' soft tissue, in the short-term studies, where only one sample was significantly different. This difference was related to mussel age.

10AM2001 GP-337 POC poster

DYNAMIC CHARACTERIZATION OF THE NORTHEAST PACIFIC TRANSITION ZONE

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The transitional area is of great importance because it has influence of the decadal (PDO) and interannual (ENSO) variability. Some of the most important fisheries resources like sardines, anchovies, abalone, and macroalgae among others, are located in this zone; resources that have been subjected to an important fishing pressure and the variations up mentioned. The present work analyzed the seasonal variability for the western coast of the North Pacific using sea surface temperature of boxes of 2°x2° from Reynolds. For every year and box was obtained the monthly average of temperature and to the maximum value it was subtracted the minimum to obtain a series of width, which was standardized later on. With these results it is observed that there is an important area that does not have a continuous structure due to the solar influence in the different latitudes and it is appreciated that the boxes 15-21 (Mexican Pacific) have a superior width to the 5° and 6°C. When the width along the time is showed it is perceived that the limit marked by the 15°N and smaller, it does not have superior variations to the 6°C during the whole period, setting this latitude as an important barrier. For higher latitudes it is observed that an important variability exists, which was analyzed by means of the series of the Pacific Decadal Oscillation (PDO) and the Multivariate ENSO Index (MEI), which represent respectively the decadal and interannual variability.

POC PAPER

10AM2001 GP-357 POC poster

TYPIFICATION OF THERMAL STRUCTURES IN THE JAPAN SEA BASED ON SATELLITE INFORMATION

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The hydrological seasons in the Japan Sea were adopted on a classification (Yurasov, 1977) taking into account annual changes of vertical thermal structure of waters. The months, belonging to a hydrological season, were arranged as follows: winter (January - March), spring (April - June), summer (July - September), autumn (October - December). For allocation of a typification of the main patterns (fronts, eddies, meanders, warm and cold advections) in the Japan Sea more than 1100 cards position of fronts and eddies were examined. In the Japan Sea the large diversity of thermal structure is marked. That is why their typification was done. 104 seasonal composite cards from 1977 to 2001 were compounded. The main totals of the typification of thermal patterns (fronts, eddies and meanders) are submitted in the Table, giving below.

Typification of thermal patterns (fronts, eddies and meanders)
in the Japan Sea by the satellite information

N	Seasons	Type of year	Year
1	Winter	Cold	1981, 1982, 1983, 1984, 1986, 1987, 1988, 2000, 2001;
		Warm	1979, 1980, 1989, 1990, 1992, 1995, 1996, 1997, 1998, 1999;
		Intermediate	1985,1991, 1993, 1994;
2	Spring	Cold	1977, 1981?, 1982, 1983, 1986, 1987, 1988, 2000;
		Warm	1979,1980, 1984, 1989, 1990, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999;
		Intermediate	1978, 1985, 1986, 1991;
3	Summer	Cold	1982, 1983, 1986, 1987;
		Warm	1980, 1981, 1984, 1985, 1988, 1989, 1990, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000;
		Intermediate	1991;
4	Autumn	Cold	1980, 1985, 2000;
		Warm	1979, 1986, 1988, 1989, 1990, 1991, 1993, 1994, 1995, 1996, 1997, 1998, 1999;
		Intermediate	1981, 1982, 1983, 1984, 1987, 1992;

10AM2001 GP-368 POC poster

SHALLOW WATER METHANE ANOMALY IN THE WESTERN PART OF THE OKHOTSK SEA

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Detailed methane investigations were carried out in different seasons in western part of the Okhotsk Sea on the Russian-German project KOMEX and KOMEX subprogram «Methane Monitoring»: *Lavrentyev* 28 (Summer, 1998), *Gagarinsky* 25 (Autumn, 1998), Ice-expedition 99 (March, 1999), *Utyos* 99 (Spring, 1999), *Gelovany* 99 (Autumn, 1999), *Gagarinsky* 28 (Spring, 2000). They showed high methane anomalies in water column in the shallow area and background methane distribution in deeper part of the Okhotsk Sea with sharp change between. Methane concentration changes in water column (especially surface water) in the different seasons.

Aniva Bay. Methane concentration increases from background value 53-56 nl/l in surface water to 150-180 nl/l in bottom water for shallow depth less than 100 m.

Kuril Basin. Waters of stations deeper than 1000 m have very low methane concentration 5-20 nl/l from seafloor to depth about 1000 m. Such low methane concentration usually contain deep water of Pacific Ocean, coming to Kuril Basin from Kuril's Straits. It means that methane doesn't come to water from sediments in Kuril Basin.

The total regularity of methane distribution in water column in this area is presence of high methane concentration (150-250 nl/l) in depth 50-150 m and usual concentrations (50-70 nl/l) in surface water.

Terpenia Bay. Methane distribution in the water column of all seasons is stable: average 600 nl/l on bottom (depth 70-80 m) and methane concentration decreases to surface: 85-90 nl/l in summer, 119-140 in spring and autumn.

East Sakhalin Shelf. High methane anomaly 2200-2900 nl/l on shallow part of shelf in water column is in spring and autumn. On the surface methane concentration is 761 nl/l and 122 nl/l accordingly. Methane concentration in the last autumn changes in water column unusually - lesser on bottom water (243 nl/l) and bigger on surface (651 nl/l). It means that in cold season in shallow area warmer bottom water with methane anomaly is going up to surface and cold water from surface without methane is going down to bottom. In spring and autumn in shallow area surface water is over saturated by methane and CH4 will emanate to atmosphere.

Methane monitoring showed that the surface water on shallow areas has anomaly over methane saturation in autumn and spring seasons. In summer upper part of surface water (20-30 m) has background methane concentrations. Methane concentration is low in deep water and has no seasonal change. Between shallow and deep areas we observe intermediate waters with methane anomaly. In expeditions 1999-2000 we found a good correlation between methane concentration and phytoplankton distribution. It is in agreement that primary production in shallow area is increased in spring and autumn from surface to bottom and in summer it will be essential below 20-30 m from surface.

10AM2001 POC-213 oral

LINEAR DECREASE OF NUTRIENT CONSUMPTION IN THE SPRING OYASHIO MIXED LAYER FROM 1968 TO 1998

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We have analyzed 30-years time series of phosphate concentration observed in the Oyashio mixed layer in February, April, May, July, and August, respectively. Most of the data were originally collected by Hakodate Marine Observatory and also by JODC. From 1968 to 1991, phosphate concentration of Oyashio mixed layer in February was found to have decreased linearly at the rate of 0.01 μmol/l/y. However, May phosphate time series shows higher variability with no decreasing trend. The average concentration of May time series was 0.86±0.18 μmol/l throughout the duration. The mixed layer phosphate consumption from February to May, or net community production in terms of phosphorous in the spring Oyashio mixed layer, thus had been decreased linearly at the rate of 0.48 mmolP/m^2/y. Our finding suggests that the extent of spring bloom in the Oyashio area may have been decreased in the recent years. The mixed layer phosphate consumption from May to August, on the other hand, was found to show slight linear increase in the same period. The rate of increasing trend in May-August phosphate consumption, however, was far smaller than that of decreasing trend in Feb.-May phosphate consumption.

10AM2001 GP-381 POC poster

SURFACE PHENOMENA OF FRONTAL CHARACTER IN THE NORTH PACIFIC

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In the article the frontal zones (FZ) and frontal sections (FS) in a north part of Pacific Ocean are studied. Initial data - continuous observations on temperature (T) and salinity (S) by a system «SEIL» on three sections with expansion 1745, 2689, 2688 km (April - June, 1992). The purpose of research - to reveal character a frontogenesis and to define by profiles of hydrological units physical reasons of frontogenesis. As a result of the multivariable analysis is allocated 61 FZ on (T) and 66 zones on (S). It is supposed, that: 1) There is a relation between exterior of profiles of spatial variability of temperature and salinity with the characteristics of water; 2)

The coefficients of correlation between temperature, salinity and density characterize reasons frontalgenesis: thermosalinity processes or occurrence of vertical motions stipulated by operation of an external driving force such as interleaved vortexes.

Conclusions:

1. The region of research represents a dense system of frontal zones and frontal sections distinguishing on an expansion, a kind and amplitudes of gradients of hydrological units. The spatial scales of frontal zones make 50-200 km. Width of frontal sections makes 1-1.5 km on the average;
2. There is a certain spatial scale, characteristic for all units, it is equal 50-80 km;
3. The main reasons frontogenesis:
   - contact of water with the different characteristics (thus the profiles of units have a stairstepping);
   - vertical motions in vortical frames (kind of profiles have a interleaved or inclined);
4. The concurrence isolated on exterior of main frontal sections with boundaries of water and fronts obtained on the data of the analysis of deep water hydrological observations is marked too.

10AM2001 POC-215 oral

LONG PERIOD SIGNALS IN THE ALASKAN SALMON CATCH, NORTHEAST PACIFIC COASTAL FRESHWATER DISCHARGE, SALINITY, TEMPERATURE, NORTHERN OSCILLATION INDEX (NOIX) AND PACIFIC DECADAL OSCILLATION (PDO)

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The time series of the Alaskan salmon catch, Northeast Pacific coastal freshwater discharge, salinity, temperature, NOIx and the PDO reveal significant low frequency signals with periods ranging from 15 to about 50 years. Wavelet analysis has been used in conjunction with Fourier spectral and cross-spectral analysis and maximum entropy spectral analysis to analyze these data. These methods allow investigation of 1) regime shifts, 2) sensitivity of the techniques to the length of the records, 3) assumption of a stationary time series and 4) the coherency and phase of these time series. The largest variance for the PDO is associated with a signal of 52.5 years while Alaska salmon catch has maximum variance at a period of 47.1 years. The coastal runoff has large variances at periods of 41.6 and 15.4 years. The long period signals in the Winter PDO and coastal freshwater discharge are coherent. The coastal freshwater discharge and salmon are also coherent at low frequencies (about 40 years) with freshwater leading the salmon production by about one-year, reflecting the difference between year entering the ocean and year of catch. These signals might be linked by decadal changes in the upper layer stratification that control the air-sea heat and salt exchanges and the horizontal advection. This also provides a possible mechanism linking the PDO with coastal freshwater discharge. This consequently links coastal freshwater discharge to salmon production in Alaska. Interdecadal glacial ablation along this coast enhances the coastal freshwater discharge and could increase salmon production on decadal time scales.

10AM2001 GP-108 POC poster

WATER DYNAMICS IN THE SAKHALIN-KURIL REGION

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The oceanographic data (about 84 th. stations) for the period 1960-1998 in the Sakhalin-Kuril region (40-56N, 143-160E) were averaged in 1-degree squares. Seasonal climatic schemas of the main geostrophic streams were constructed and the velocities and volume transports of the main geostrophic streams in the layer of 0-500 m were calculated for certain sections.

The following constituents of water dynamics of Sakhalin-Kuril region were accepted: Kuril Current, eastern branch of Kuril Current, Oyashio Current with its branches, Subarctic Current, northeastern branch of Kuroshio, West-Kamchatka Current, East-Sakhalin Current, Northeastern Current, Soya Current and different eddy formations were marked everywhere in the considered water area.

From winter to summer the Oyashio Current is formed by Kuril Current water and water from the Okhotsk Sea penetrated in the area through Bussol and Friz Straits. In autumn Oyashio Current is completely formed by outflow from the Okhotsk Sea through the Friz and Bussol Straits.

Two types of the circulation were distinguished in the Okhotsk Sea part of the area: the circulation of the warm period of year (spring and summer) and the circulation of the cold period (autumn and winter).

In the warm period the East-Sakhalin Current extends southward to 47N only. In the cold period this current extends farther (to 45N). Northern position of the East-Sakhalin Current in spring and summer is explained by magnification of intensity of Soya Current in this period.

Since winter till summer the West-Kamchatka Current is shaped by inflows of Pacific waters through Chetvertiy Kuril Strait and northern straits; in autumn practically all flows penetrate in the Okhotsk Sea through Chetvertiy Kuril Strait.

Seasonal variability of characteristics of the main geostrophic streams of the region was estimated.

10AM2001 GP-365 POC poster

CARBONATE CHEMISTRY DYNAMICS IN THE BERING STRAIT AND CHUKCHI SEA

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The subpolar and polar seas where oceanic deep and halocline waters form are potentially an important sink for atmospheric carbon (Chen et al., 1990; Broecker and Peng, 1992; Anderson et al., 1998; Anderson et al., in press; Miller et al., 1999). In this paper we examine CO_2 carrying capacities in the Bering Strait-Chukchi Sea using the data obtained in 1996 (RV ALPHA HELIX). Mesoscale temporal and spatial variability of carbonate system dynamics is analyzed with a special eye for the Atlantic Layer which was observed in the Barrow Canyon. Relationship between AOU and fCO_2 in the surface and bottom waters demonstrates low correlation at the top layer (probably due to different rates of air-sea exchange for oxygen and carbon dioxide (Wanninkhov, 1992)). Short-term absorption of atmospheric carbon is evaluated. Inorganic carbon pumping from the surface layer down to the bottom water (observed from the Bering Strait towards the ice-edge) is examined. Selected AOU and fCO_2 data obtained in the POI Trans-Arctic Expedition-2000 are presented also in discussion.

POC PAPER

10AM2001 GP-114 POC poster

RELATION OF A DIURNAL VARIATION AND AVERAGE OF OCEANOGRAPHIC PARAMETERS IN AMURSKIY BAY (SEA OF JAPAN)

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The diurnal variability of oceanographic parameters is investigated. A density of water *in situ* p_t, salinity, major dissolved constituents, the CO_2 system components and their ratios to chlorinity, pH, nutrients, common organic carbon C_{org}, dissolved oxygen, particulate matter concentration C_p are considered. The data were obtained in summer of several years during the complete tidal cycle on 19 horizons of 6 daily stations from a mouth of river Razdolnaya up to the south part of Amurskiy Bay with the average daily salinity in a range 22.6–33.0‰.

On magnitude and significance level of coefficients of correlation (r and p) between diurnal average P and standard deviation s all parameters can be divided into three groups: 1) $r < 0$, $p < 0.02$; 2) $r > 0$, $p < 0.02$ and 3) $p > 0.02$. The linear dependence $s = b + aP$ at $a < 0$ is typical for Na^+, SO_4^{2-}, A_{tot}, S, Cl^-, K^+, Mg^{2+}, p_t, Ca^{2+}, ΣCO_2, O_2. The same linear dependence at $a > 0$ is typical for C_p, NH_4, C_{org}, PO_4, SiO_3, $\Sigma CO_2/Cl$, CO_2, A_{tot}/Cl, NO_2, NO_3. On a large-scale of diurnal average concentrations ($6.7 \cdot 10^{-5}$ – $3.3 \cdot 10^4$ mg/kg) of the parameters for all horizons, the approximate linear reliance between $lg\ s$ and $lg\ P$ ($r = 0.972$, $n = 237$) was observed.

10AM2001 POC-068 oral

RENEWAL OF OKHOTSK SEA WATERS AT INTERMEDIATE DEPTHS NEAR THE SAKHALIN CONTINENTAL SLOPE

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The results of five cruises to the North-East Sakhalin coast implemented by POI in collaboration with GEOMAR during the period 1998-2000 are discussed. CTD and methane observations on shelf and slope regions were performed for just the same sections for different seasons even in winter time. The maximum density of shelf waters near the northern Sakhalin coast not more than 26.84 σ_θ was found on shallow shelf from drifting ice in March 1999 and 26.80 σ_θ in May 1999 among ice field. Hydrographic sections across the continental slope demonstrate that renewal of waters on intermediate depths in the Sea of Okhotsk occurs in following manner:

1. Formation of relatively dense shelf waters (up to 26.84 σ_θ) due to winter brine rejection.

2. During late winter and spring seasons waters from shallow shelfs diapicnally penetrate along continental slope into the sea interior up to 600 m in the form of cold and fresh intrusions. Reverse tidal currents play an important role in this process.

3. The cold intrusions are transported southward along continental slope by East Sakhalin current. They dissipate due to cabelling convection and tidal mixing. Nevertheless remnants of these intrusions were found in the south part of Kuril Basin on the depths 500-600 meters.

Possible energy sources for diapicnal penetration of shelf waters to intermediate depths are discussed.

10AM2001 GP-136 POC poster

TEMPORAL VARIABILITY OF HYDROCHEMICAL PROPERTIES IN THE JAPAN SEA

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Data discussed in this paper were collected during cruises in the Japan Sea aboard the R/V *Akademik Vinogradov* in 1992, and aboard the R/V *Roger Revelle* and the R/V *Professor Khromov* in 1999. Our analysis has revealed essential differences in dissolved oxygen, nutrients, normalized total alkalinity and normalized dissolved inorganic carbon between the Japan Sea and adjacent basins (the Okhotsk Sea, the East-China Sea and the Northwest Pacific), and has indicated the temporal variability of hydrochemical properties in intermediate and deep water of the Japan Sea. Total inorganic phosphate, total inorganic nitrate and normalized dissolved inorganic carbon increase, and dissolved oxygen and normalized alkalinity decrease in time.

A proposed open-basin model for the Japan Sea suggests that the major reason of the temporal variability of hydrochemical properties is water exchange between the Japan Sea and adjacent basins. The assumption was made, that water exchange depends strongly on variability in intensity and direction of the main currents in the Northwest Pacific, especially Kuroshio.

10AM2001 GP-280 POC poster

CLIMATIC CHARACTERISTIC OF CURRENTS IN THE JAPAN (EAST) SEA

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All available data (1925-1997) were used to calculate climatic temperature and salinity values in 1 degree squares. Preliminary these data were examined on 2 sigma limits on each standard depth. Thus about 4 percent of data were removed. In result 7358, 13590, 14085 and 7874 stations were used for February, May, August and November relatively. Besides the temporal trend in temperature and salinity distribution for May and November was removed and all data were fitted to middle of month. This procedure was useful for upper 50 m layer. After that mean data obtained in 1 degree squares were gridded using Kriging procedure with 0.5 degree step. To calculate geostrophic currents a 1000 db surface and bottom relief obtained from ETOPO5 archive with 1/12 degree resolution were used.

Schemes of circulation distinctly show well known currents of the warm part of the sea: the Tsushima Current, the East-Korea Current and the spread cyclonic circulation over the Japan Basin, ceasing from February to November. In the Tatar Strait bounds during transitional seasons the currents of southward directions are developed. Along the western coast the currents are markedly ceased and though their prevailing direction is southwestward, coastal streams (Limanskoye and Primorskoye) are not distinctly expressed possibly because of poor grid resolution. The North Korea Current is traced only in summer (August) scheme. Being different in details the general features of geostrophic circulation of the Japan (East) Sea are kept throughout the year.

10AM2001 GP-038 POC poster

AN ENERGY-ACTIVE ZONE IN THE OCEAN AND ATMOSPHERE OF THE NORTHWESTERN PACIFIC

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POC PAPER

Close interaction of the ocean and atmosphere is commonly known and it does not raise any doubts. In this tandem some authors give the priority to the ocean, the other ones - to the atmosphere. Evidently, both processes occur, but the extent of their influence depends on some concrete conditions in the given situation. Really, short-term variability of hydrological elements, especially on the ocean surface is often almost fully predetermined by meteorological factors. For instance, the wind wave fields are generated by the field of the wind which is observed directly in the near-water layer. Wind- and wave-induced surge, especially near the shore induces not only the level increase, but as well the water temperature changes. Significant influence on the sea heat balance is imposed by such meteorological factors as the air temperature, cloudiness, wind, etc. Processes of the fall ice formation and spring ice destruction when the water temperature is constant, especially in the shallow water areas, are conditioned mainly by the air temperature, wind velocity and direction. Long period vibrations of the sea level are also often conditioned by the atmosphere pressure vibrations.

Special interest of researchers is paid to the energy-active zones of the ocean (EAZO), probably, due to the fact that here the intensive processes take place both on the surface and in its depth. We should suggest that the atmosphere and ocean interaction in these areas is also more intensive. Hence, we can suggest that the atmosphere processes in these areas should be more intensive as well. Let's consider this problem on the example of the EAZO in the North-Western Pacific.

The North-Western Pacific is the area of the major routes of cyclones, which are moving by different trajectories generally from the west to the east as a result of the west-eastern transference. With this, never matter what the trajectories are, in the majority of cases it is observed the trajectories convergence in the NW Pacific to the east of Japan. To prove this fact, at the POI FEB RAS it has been performed the type design of the atmosphere circulation with consideration of cyclones and anti-cyclones movement over the NW Pacific. Matching of trajectories of all obtained types of atmospheric circulation with consideration to non-stationary has given the opportunity to ascertain that the main number of cyclones passes over the NW Pacific, that is over the EAZO. Consequently, here it is concentrated the energy of cyclones of all six types of synoptic processes. The same can

be said about the energy of tropical cyclones, after the turning point their considerable part moves as well to the EAZO zone. According to G.M. Tarasova, the main paths of the typhoons displacement, excluding those ones coming to the territory of Philippine and China, this or that way are confined to the energy-active zone in the NW Pacific. Thus, we may conclude that to the EAZO in the ocean it corresponds an energy-active zone in the atmosphere and visa versa, and they are closely interacting. One of the examples to confirm this interaction is an intensive wave zone with the maximal frequency of large waves occurring in the EAZO area of the NW Pacific.

Hence, we may put forward a suggestion about the existence of the ocean-atmosphere energy-active zone in the NW Pacific (EAZOA).

10AM2001 GP-126 POC poster

MERIDIONAL TRANSPORT OF THE NORTH PACIFIC INTERMEDIATE WATER ACROSS 37°N LINE BASED ON THE OBJECTIVE ANALYSIS OF LOWERED ACOUSTIC DOPPLER CURRENT PROFILER DATA

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Meridional transport and origin of the North Pacific Intermediate Water (NPIW) in the Kuroshio-Oyashio interfrontal zone (K/O zone) were examined using hydrographic and directly-measured velocity data with LADCP (Lowered Acoustic Doppler Current Profiler) along 37N line in the northwestern Pacific performed in July 1998. Furthermore, the optimal interpolation method was applied to all the parameters which were needed to calculate the transports horizontally in each isopycnal surface, to derive the more objective transports and its spatial-interpolation errors. Dominant and statistically significant northward transports were observed west of the Shatsky Rise (coast--157E) in both the upper NPIW (26.6--27.0 Sigma-theta; 4.1Sv <error 1.2Sv> (Kuroshio: 3.0Sv <error 0.7Sv>, Oyashio: 1.1Sv <error 0.5Sv>) and the lower NPIW (27.0--27.5Sigma-theta); 7.9Sv <error 3.4Sv> (Kuroshio: 4.7Sv <error 1.9Sv>, Oyashio: 3.2Sv <error 1.5Sv>), and less significant southward transport were observed east of it (157--179.5E) in 26.6--27.5Sigma-theta; 4.4Sv <error 3.6Sv>. In the west of the Shatsky Rise, the Oyashio mixing ratio derived from the transports was 0.27 (1.1/4.1), and the ratio derived from potential temperature and salinity was 0.4 in the upper NPIW, suggesting that the upper NPIW in the K/O zone was formed by the mixing between the southward Oyashio water across the Oyashio (Subarctic) Front and the Kuroshio water bifurcated from the Kuroshio Extension. On the other hand, both of the ratios derived from the transports and from T-S were almost same; 0.4 in the lower NPIW, suggesting that the lower NPIW in the K/O zone was maintained by the northward transport of the NPIW formed near the Kuroshio Extension.

Index of Authors

Author Name:	Paper #:	Page #:
(bold numbers indicate main and/or presenting author)		
A		
Adare, Kathie	S6-072	p.81
Addison, Richard F.	**S1-403**	p.3
	S1-020	p.7
	S8-016	p.101
Agostini, Vera	**GP-143**	p.177
Ainley, David G.	S11-249	p.154
	S4-370	p.48
Akamine, Taturo	S11-078	p.154
Aké-Castillo, José A.	S2-320	p.16
Aleksanin, A.I.	S4-238	p.54
Alekseev, A.V.	S4-332	p.60
Alheit, J.	S1-219	p.7
Allen, Susan E.	S3-083	p.26
	S4-237	p.48
	S2-290	p.12
Alonso, R.	S9-308	p.110
Amador Buenrostro, A.	S3-338	p.38
Anderson, David J.	S3-118	p.30
Andreev, Andrey	**S5-001**	p.63
Andreeva, Valentina V.	**S2-319**	p.12
	S6-254	p.82
Anikiev, Vladimir V.	**S4-369**	p.48
Antonenko, D.V.	W1-328	p.167
Armstrong, David	S7-182	p.94
	S7-183	p.95
	S7-185	p.88
	S7-270	p.95
	S7-272	p.90
Arredondo-Vega, B.O.	S9-308	p.110
Arreguín-Sánchez, F.	GP-343	p.182
Asada, Akira	S12-168	p.163
Auer, Carol	**S9-420**	p.107
Augerot, Xanthippe	S1-312	p.3
Aydin, Kerim Y.	**S10-211**	p.114
Azumaya, Tomonori	S10-209	p.119
	S3-137	p.26
B		
Baba, Norio	S12-350	p.164
Baduini, Cheryl L.	S10-117	p.118
	S10-210	p.120
Baier, Christine T.	S10-140	p.125
Baitaluk, Aleksei A.	W1-112	p.170
Bakun, Andrew	S1-219	p.7
Balazs, George	S3-025	p.39
Balykin, P.A.	S10-226	p.125
	W1-225	p.166
Ban, Syuhei	S2-195	p.18
Banas, Neil	S7-179	p.89
Barth, Jack A.	**S5-138**	p.63
	S11-249	p.154
	S4-370	p.48
Basyuk, Eugeny O.	S10-353	p.128
Batchelder, Harold P.	**S4-229**	p.49
Beamish, Richard J.	S1-344	p.5
Beauchamp, David	S7-272	p.90
Belan, Tatyana A.	**GP-372**	p.186
Belkin, Igor M.	**POC-367**	p.188
Bell, Kathleen	S7-023	p.93
	S7-186	p.90
	S7-187	p.91
	S7-273	p.91
	S7-277	p.91
Benitez-Nelson, Claudia	S5-002	p.64
Bennett, Andy	S7-187	p.91
Benson, Ashleen J.	**S3-083**	p.26
Bentley, Paul	S11-146	p.141
Berkeley, Steven A.	**W1-217**	p.166
Bertold, Stan	**S8-292**	p.103
Bertram, Douglas F.	**S11-395**	p.138
Bessmertnaya, Natalya	**GP-314**	p.179
Bidigare, Robert R.	**S5-002**	p.64
	S5-109	p.77
Biebow, N.	GP-368	p.194
	POC-068	p.198
Blamey, Georgina A.	**S2-315**	p.13
	S4-267	p.51
Blinov, U.G.	S6-256	p.84
	S6-257	p.85
Block, Barbara	S3-142	p.28
Bobkov, Andrew	**GP-058**	p.188
Boehlert, George W.	S1-344	p.5
	S3-046	p.26
	S3-052	p.44
	S3-142	p.28
Bogdanov, M.	S11-134	p.144
	S11-279	p.144
Bogdanovsky, Alexander A.	S8-135	p.101
	S8-129	p.99
Bograd, Steven J.	**S4-296**	p.49
	S5-065	p.75
Bokhan, Larisa N.	**S11-374**	p.138
Bond, N.A.	S10-375	p.131
Bonk, A.A.	**W1-227**	p.166
Borde, Amy B.	S7-184	p.96
	S7-410	p.88
Boretz, L.A.	S3-360	p.35
Borisenko, G.S.	S6-255	p.84
Borisovets, Eugene E.	S10-085	p.124
Bornhold, Elizabeth A.	S2-244	p.20
	S5-243	p.74
Bos, J.	S4-239	p.57
Bottom, Daniel L.	**S1-312**	p.3
Boubnov, Pavel V.	**GP-291**	p.189

Bower, J.R. S3-175 p.32
Bragina, Irina **GP-089** p.174
GP-191 p.174
Bravo-Sierra, Ernesto S2-320 p.16
Brodeur, Richard D. **S11-139** p.139
S4-269 p.58
S10-169 p.114
Brown, Eric S10-293 p.115
Brown, Evelyn D. **GP-088** p.179
S4-086 p.50
W1-087 p.167
Brown, J. S4-013 p.51
Buckley, Troy W. **S3-214** p.27
Budaeva, Valentina D. S8-129 p.99
Bueler, Edward S2-315 p.13
Bugayev, Victor F. **S11-228** p.139
Burkill, Peter **S2-003** p.13
Buslov, A.V. W1-225 p.166

C

Campbell, Robert W. **S3-071** p.27
Capone, Douglas G. **S2-004** p.13
Carillo, L. S4-013 p.51
Carmack, Eddy C. S5-028 p.76
Casillas, E. S11-139 p.139
Cervantes-Duarte, R. S4-317 p.60
Chang, Man S2-075 p.21
Chapman, Peter M. **S6-049** p.81
Chavez, F.P. S1-219 p.7
Checkley, Jr., David S4-094 p.52
S2-081 p.14
S2-082 p.14
Chen, Chen-Tung Arthur **S4-005** p.50
Chen, Jay-Chung S8-125 p.104
Chen, Shang GP-063 p.187
S9-064 p.112
GP-051 p.186
Chen, Yaqu GP-335 p.176
S11-333 p.140
Cherniawsky, Josef Y. S5-190 p.65
S5-009 p.68
Chernoivanova, Ludmila A. **W1-328** p.167
Chiba, Sanae **S2-115** p.15
Chierici, Melissa **S5-120** p.64
S5-155 p.78
Cho, Eun Seob S9-218 p.109
Cho, Kyu-Dae S9-015 p.108
Christensen, J.P. GP-365 p.197
Churnside, James H. GP-088 p.179
Ciannelli, Lorenzo **S10-169** p.114
S10-405 p.132
Cisneros Mata, Miguel A. S11-347 p.150
Coil, John S6-254 p.82
Colin, C. S1-219 p.7
Collins, Richard L. GP-088 p.179
Conners, M. Elizabeth **S10-293** p.115
Coombs, Steve H. **S11-116** p.140
Cornuelle, Bruce D. S5-157 p.72
Cortés-Altamirano, R. S9-383 p.111
Cortes-Verdin, P. S4-055 p.51
Costa, Daniel P. **S3-142** p.28
Cowles, T.J. S5-138 p.63
Coyle, Kenneth O. S10-210 p.120
S4-086 p.50
S10-323 p.115
S10-405 p.132
Crawford, William R. S4-124 p.55
S5-009 p.68
S5-073 p.78
S5-131 p.68
S5-190 p.65
Cummins, Patrick **S11-006** p.140

D

Danchenkov, Mikhail A. **GP-397** p.190
Danielson, Seth S4-307 p.56
Darnitsky, Vladimir B. **S5-281** p.66
S5-282 p.67
S5-361 p.65
Davidova, Svetlana V. **S1-419** p.4
Davis, Nancy D. S10-209 p.119
S10-130 p.116
Demenok, O.V. GP-247 p.182
Denman, Kenneth L. **S2-401** p.15
deWitt, Lynn **S12-392** p.159
Di Lorenzo, Emanuele **S5-156** p.67
S5-157 p.72
Dmitrieva, E.V. GP-268 p.191
POC-068 p.198
Dobbins, E.L. S4-267 p.51
Dolganova, Natalia T. **GP-090** p.180
S11-351 p.141
Dolmatova, L.S. **GP-366** p.187
Dotson, Ronald C. S3-119 p.31
Dower, John F. S3-071 p.27
S3-083 p.26
S5-131 p.68
Dudarev, O.V. S4-369 p.48
S10-265 p.116
Dumbauld, Brett S7-183 p.95

E

Edwards, Christopher A. S4-229 p.49
Ehinger, W. S4-239 p.57
Elliott, John E. **S8-406** p.99
Emmett, Robert L. **S11-146** p.141
S11-139 p.139
Ermolenko, S.S. GP-280 p.199
Evdoshenko, M.A. S4-238 p.54

F

Falkowski, Paul G. **S2-007** p.16
Färber-Lorda, Jaime **S4-055** p.51
Farley, Christopher **S7-276** p.89

Fauchot, Juliette	**S9-411**	p.107
Fedorets, Yury A.	GP-090	p.180
Feinberg, Leah R.	**S11-153**	p.141
Fernand, L.	S4-013	p.51
Ferriss, Bridget	S7-187	p.91
	S7-274	p.89
Figurkin, Alexander L.	**S3-132**	p.28
Finney, Bruce P.	S10-170	p.117
Firing, Eric	GP-126	p.200
Fisher, J.P.	S11-139	p.139
Flament, Pierre	S5-109	p.77
Fleischbein, Jane	S11-393	p.153
Foreman, Michael G.	**S5-009**	p.68
Foux, Victor R.	GP-058	p.188
Fowler, Charles W.	**S1-310**	p.4
Foy, Robert	S4-086	p.50
Francis, Robert C.	S10-169	p.114
	GP-143	p.177
	S7-181	p.92
Freeland, Howard J.	**POC-165**	p.190
Friday, Nancy	S10-311	p.123
Fujino, Tadanori	**S3-173**	p.29
Fujiwara, Tateki	S4-098	p.53
Fukushima, Hajime	S10-283	p.118
Fukuwaka, Masa-aki	S10-130	p.116
	S10-209	p.119
	S3-137	p.26

G

Galbraith, Moira D.	S5-158	p.69
García-Juárez, Alma R.	GP-343	p.182
Gasanova, G.R.	GP-247	p.182
Gaudet, Connie	**S6-072**	p.81
Gavrilova, Tatyana A.	S8-135	p.101
Glebov, Igor I.	S10-353	p.128
Goering, John J.	S10-208	p.126
Goes, Joaquim I.	S11-204	p.146
Gómez-Gutiérrez, Jaime	**S11-306**	p.142
Gonzalez-Armas, S.	S3-338	p.38
Greig, Angie	S3-214	p.27
Grevatt, Peter C.	**S6-010**	p.82
Gritsenko, O.	S11-279	p.144
Grosch, Chester E.	POC-215	p.196
Gunderson, Donald R.	S7-271	p.95
	S7-185	p.88

H

Hagino, Tetsuo	GP-104	p.178
Haidvogel, Dale	S4-229	p.49
Haldorson, Lew	S4-086	p.50
Hamatsu, Tomonori	**S11-079**	p.142
Hamilton, Sonia	**S12-396**	p.158
Hare, Steven R.	S11-201	p.147
Harfenist, A.	S11-395	p.138
Harris, S.	S4-237	p.48
Harrison, D.E.	**S1-032**	p.5
Harrison, Paul J.	S2-194	p.18
	S2-244	p.20
	S2-295	p.19
	S5-243	p.74
	S9-221	p.110
Hashimoto, Jun	S2-123	p.22
Hay, Douglas E.	**S1-344**	p.5
	S3-407	p.29
Healey, Michael C.	**S3-011**	p.30
Hedd, A.	S11-395	p.138
Helle, John H. (Jack)	**W1-147**	p.168
Henrichs, Susan	S10-216	p.131
Heo, Seung	S12-416	p.160
Heredia-Tapia, A.	S9-308	p.110
Hermann, Albert J.	S4-267	p.51
	S10-095	p.120
	S5-154	p.69
Hernández, E.	S6-080	p.86
Hernández-Becerril, David U.	**S2-320**	p.16
Hernández-Vázquez, Sergio	GP-343	p.182
Hickey, Barbara M.	S4-239	p.57
	S7-271	p.95
	S7-179	p.89
	S7-180	p.96
	S7-182	p.94
	S9-012	p.108
Hill, A. Edward	**S4-013**	p.51
Hinckley, Sarah	**S4-267**	p.51
Hiroe, Yutaka	S5-099	p.76
Hirons, Amy C.	**S10-170**	p.117
Hiyama, Yoshiaki	W1-149	p.172
Hobbs, Roderick C.	S10-311	p.123
Hollowed, Anne B.	GP-143	p.177
	S10-259	p.135
	S10-293	p.115
	S1-301	p.108
Holsman, Kirstin K.	**S7-272**	p.90
Hong, Gi-Hoon	S8-417	p.104
Hong, Sung Hyun	GP-240	p.180
	S11-241	p.146
Honjo, Susumi	POC-367	p.188
Horikawa, H.	S3-059	p.46
Horsburgh, K.J.	S4-013	p.51
Howell, Evan	S3-025	p.39
Hu, Dunxin	S11-042	p.156
Hulbert, Lee	S4-086	p.50
Hunt Jr., George L.	S4-094	p.52
	S10-014	p.117
	S10-117	p.118
	S10-133	p.134
	S10-210	p.120
Huppert, Daniel	S7-187	p.91
	S7-275	p.92
	S7-277	p.91
	S7-186	p.90
	S7-273	p.91
Huyer, Adriana	S11-393	p.153
Hwang, Hak Jin	GP-240	p.180
	S11-241	p.146
Hwang, Jae-Dong	S9-015	p.108

Hwang, Sun Do S3-178 p.37
Hyrenbach, David **S10-117** p.118
S10-210 p.120
S3-118 p.30
S3-119 p.31
S7-390 p.94

I

Ianelli, James S3-214 p.27
Ianson, Debby S4-237 p.48
Ichikawa, Yasuko S12-349 p.161
Iguchi, Naoki **S2-192** p.17
Iida, K. S3-173 p.29
Iida, Takahiro S10-236 p.127
S10-283 p.118
Ikeda, Motoyoshi GP-126 p.200
Ikeda, Tsutomu **S1-263** p.5
S2-096 p.17
S2-327 p.23
Ikonomou, Michael G. **S8-404** p.100
Im, Yang Jae S11-241 p.146
GP-240 p.180
Imai, Keiri S10-031 p.130
S10-284 p.123
S10-321 p.119
Inoue, Takashi S3-121 p.34
Ishida, I. S11-322 p.143
Ishida, Yukimasa S10-130 p.116
S10-031 p.130
S10-209 p.119
S3-137 p.26
Ishikawa, Ichiro POC-161 p.190
Ishizaki, Hiroshi **POC-161** p.190
Isoda, Yutaka S2-195 p.18
S3-093 p.31
Ito, Shin-ichi GP-126 p.202
S3-093 p.31
Itoh, Sachihiko S5-159 p.77
S5-092 p.69
Ivshina, Elsa R. **W1-145** p.168
Iwahashi, Masayuki **S3-093** p.31
Izergin, Vladimir L. S4-354 p.57

J

Jaffe, Dan **S8-189** p.100
Jahncke, Jaime S10-117 p.118
S10-210 p.120
S4-094 p.52
Jang, Min Chul S2-075 p.21
Jang, Pung Kuk S2-075 p.21
Jeffrey, N. S2-290 p.12
Jeong, Hee-Dong **S12-416** p.160
S9-015 p.108
Jiang, Mei GP-335 p.176
S11-333 p.140
Jin, Yong Hyun S8-417 p.104
Johnson, Rebecca S7-186 p.90
S7-276 p.89
S7-277 p.91
Johnson, W. Keith S5-120 p.64
S5-155 p.78
Jorgensen, R. S3-338 p.38
Jung, Kyu Kui S12-416 p.160

K

Kachel, Nancy **S10-095** p.120
Kaeriyama, Hideki **S2-096** p.17
Kaeriyama, Masahide S10-130 p.116
S11-322 p.143
S3-175 p.32
Kaev, Alexander M. **S3-057** p.32
Kajiwara, Yoshiyuki S10-284 p.123
Kalinin, V.V. GP-247 p.182
Kang, Sok-Kuh S12-409 p.160
Kang, Sukyung **S3-060** p.33
Kang, Young Shil **S10-297** p.120
S10-298 p.121
S11-299 p.143
S3-252 p.33
Kantakov, Gennady A. **S4-077** p.52
S4-113 p.59
Kasai, Akihide S5-053 p.72
S4-098 p.53
Katoh, Osamu GP-126 p.200
Kavun, V.Ya. S6-054 p.85
Kawabata, Atsushi **GP-313** p.181
Kawasaki, Yasuhiro GP-047 p.192
Keeley, J. Robert S12-394 p.162
Keister, Julie E. S11-200 p.151
Khen, Gennady V. S11-134 p.144
Khrapchenkov, Fedor F. **GP-268** p.191
Kikuchi, Tomohiko S2-123 p.22
Kim, Bok Kee S12-416 p.159
S9-015 p.108
Kim, Eung S5-048 p.75
GP-162 p.191
Kim, Hak Gyoon S11-299 p.143
S9-218 p.109
S9-015 p.108
Kim, Jin Yeong **S3-252** p.33
S3-253 p.34
Kim, Kyung Tae S8-417 p.104
Kim, Suam S10-297 p.120
S10-298 p.121
S3-060 p.33
Kim, Suk Hyun S8-417 p.104
Kim, Sun Song S3-253 p.34
Kim, Sung-Dae **S12-409** p.160
Kim, Wan Soo S3-178 p.37
Kim, Won-Rok GP-122 p.175
Kimura, Shingo S3-100 p.35
S5-053 p.72
S3-121 p.34
Kimura, Takuma S4-098 p.53

King, Jackie R.	**S3-172**	p.34
Kishi, Michio	**S2-231**	p.18
Kitagawa, Takashi	**S3-100**	p.35
Klimbley, P.	S3-338	p.38
Klitin, Andrew K.	S4-077	p.52
Klovatch, Natalia	S11-134	p.144
	S11-279	p.144
Ko, Tae Seung	GP-240	p.180
Kobari, Toru	S2-193	p.23
Kobayashi, Taiyo	**S12-349**	p.166
Kochergin, Igor E.	S12-388	p.163
	S8-129	p.99
	S8-135	p.101
Kochevar, Randy	S3-142	p.28
Konovalova, Tatiana	**S6-254**	p.82
Kopelevich, O.V.	S4-238	p.54
Kovaleva, A.L.	GP-366	p.187
Kozitskiy, Sergey B.	**GP-345**	p.191
Kozyr, Alexander	**S12-084**	p.161
Krishfield, Richard	POC-367	p.188
Krovnin, Andrei	**S11-134**	p.144
Krupnova, Tatiana N.	GP-386	p.183
	S9-385	p.109
	S9-387	p.109
Kruse, Gordon H.	**S10-389**	p.121
	S10-414	p.133
Krutzikowski, Gregory	S11-146	p.141
Kudo, Isao	**S2-195**	p.18
Kumamoto, Y.	S5-001	p.63
Kurita, Yutaka	S3-233	p.42
Kusaka, Akira	**GP-047**	p.192
Kusakabe, M.	S5-001	p.63
Kusumoto, Teruichi	GP-104	p.178
Kuzin, Victor I.	**GP-398**	p.192
	GP-399	p.192
Kuznetsov, Mikhael Y.	**S3-360**	p.35
Kuznetsova, Natalia A.	**GP-352**	p.181

L

Ladah, Lydia B.	**S11-346**	p.145
Ladd, Carol	**S11-074**	p.145
Lagerloef, Gary	S11-006	p.140
Lammers, S.	POC-068	p.198
Lapko, Victor V.	**S3-382**	p.36
Lapointe, Michael F.	W1-144	p.169
Lares, Maria Lucila	**GP-316**	p.193
Laurs, Michael	S11-286	p.147
Lavaniegos, B.E.	S2-141	p.19
Lawson, Peter	S7-181	p.92
LeBlond, Paul H.	**S1-105**	p.6
Lee, Jong-Kook	S12-409	p.160
Lee, Chang Kyu	S9-218	p.109
Lee, Choon-Weng	S2-195	p.18
Lee, Dong Woo	S3-253	p.34
Lee, Jae Bong	GP-240	p.180
	S11-241	p.146
Lee, Pyung-Gang	GP-044	p.175
Lee, Sam Geun	**S9-218**	p.109
Lee, Tae Kyun	S2-075	p.21
Lee, Tae Won	**S3-178**	p.37
Lee, Yoon	S11-241	p.146
Lee, Young Hwa	S11-299	p.143
Leonard, Carrie L.	S5-002	p.64
Leschine, Thomas	**S7-187**	p.91
	S7-274	p.89
Levasseur, M.	S9-411	p.107
Lewis, Craig V.W.	**S4-326**	p.53
	S4-229	p.49
Li, B.	S4-235	p.58
Li, Baohua	GP-063	p.187
Li, Jiguang	S8-040	p.104
Li, Ruixiang	GP-051	p.186
	S8-336	p.105
	S9-064	p.112
	GP-063	p.187
Lim, Donghyun	S11-241	p.146
	GP-122	p.175
Limsakul, Atsamon	**S11-204**	p.146
Lin, Chuanlan	**S4-358**	p.54
Lipsen, Michael S.	**S2-194**	p.18
Livingston, Patricia	S10-211	p.114
	S3-214	p.27
	S3-303	p.45
Lluch-Belda, Daniel	S11-347	p.150
	S3-174	p.39
	S11-286	p.147
	S1-219	p.7
Lluch-Cota, D.B.	S11-286	p.147
	S1-219	p.7
	S9-383	p.111
Lluch-Cota, Salvador E.	S11-286	p.147
	S9-308	p.110
	S9-383	p.111
	S8-300	p.102
	S1-219	p.7
Lobanov, Vyacheslav B.	**S4-238**	p.54
	S5-001	p.63
Logerwell, Elizabeth	S7-023	p.93
	S7-181	p.92
	S7-390	p.94
Lohan, Maeve	**S2-294**	p.19
López-Martínez, Juana	**GP-343**	p.182
Lounejeva Baturina, E.	S6-080	p.86
Lu, Richard H.J.	S3-060	p.33
Lu, Ruihua	GP-063	p.187
Luchin, V.A.	S10-324	p.128
Lumpkin, Rick	S5-109	p.77
Lynn, Ronald J.	S4-296	p.49

M

MacDonald, Don	S6-285	p.83
Macdonald, Robie W.	**S1-020**	p.7
	S8-016	p.101
MacFarlane, Gordon A. (Sandy)	S3-172-	p.34
MacFarlane, Bruce	**W1-220**	p.168
MacFarlane, Mike	**S6-285**	p.83

Mackas, David L. **S5-158** p.69
MacWilliams, Sarah S7-187 p.91
S7-275 p.92
Magni, Paolo S4-101 p.56
Makarov, Viatcheslav G. **S5-248** p.70
S8-129 p.99
Maldonado, M.T. S9-412 p.111
Man'ko, Alexander N. S12-388 p.163
GP-399 p.192
Mandych, Albert T. S11-134 p.144
S5-164 p.73
Mantua, Nathan S7-181 p.92
S11-201 p.147
Manzo-Monroy, Hector G. **S5-160** p.70
Marchenko, S.L. W1-152 p.171
Marchetti, Adrian **S9-221** p.110
Marinone, Silvio Guido **S4-245** p.55
Masuda, S. S3-173 p.29
Masuda, Shinya S11-287 p.152
Mate, Bruce R. **S3-017** p.37
Matsukawa, Yasuo S11-205 p.149
Matsuo, Yutaka GP-126 p.200
Matsuyama, Michiya S3-059 p.46
GP-128 p.185
Maximenko, Nikolai **S5-222** p.71
McClintick, Anna S8-189 p.100
McCluskey, Shannon M. S1-310 p.4
McFarlane, Gordon A. S3-083 p.26
S3-172 p.34
McGowan, John A. S4-296 p.49
McKendry, Ian S8-189 p.100
McKinnell, Stewart M. (Skip) S3-407 p.29
S4-124 p.55
McRoy, C. Peter **S10-418** p.122
Meador, James **S6-018** p.83
Mendelssohn. Roy S12-392 p.159
Methot, Richard S3-305 p.41
Midorikawa, Takashi POC-213 p.195
S11-204 p.146
Miller, Arthur J. S5-157 p.72
S11-198 p.147
Miller, Jessica A. **S7-278** p.93
Miller, Lisa A. S5-120 p.64
Minobe, Shoshiro **S10-207** p.122
Mishukov, Vasiliy F. S8-061 p.102
S8-062 p.102
S8-129 p.99
Mishura, Pravakar S5-159 p.77
Mitrofanov, Yuri **GP-247** p.182
Mitsudera, Humio **S5-163** p.71
Miyake, Hiroshi S2-123 p.22
Miyamura, Tsuyoshi S10-284 p.123
S10-283 p.118
Miyashita, K. S3-173 p.29
Mizobata, Kohei S10-418 p.122
S10-284 p.123
Mizuno, Keisuke S12-349 p.161
Mizuta, Koji GP-128 p.185
Mochizuki, Mamiko S10-264 p.129
Moisan, John R. S5-157 p.72
Moiseev, Valery M. GP-398 p.192
Moiseychenko, Galina **S6-255** p.84
S6-256 p.84
S6-257 p.85
Montani, Shigeru **S4-101** p.56
Moon, Deok Soo S8-417 p.104
Moon, Hyung Tae S3-178 p.37
Moore III, Berrien **S1-019** p.8
Moore, Sue E. **S10-311** p.123
Morales-Pérez, R. S4-318 p.61
Morales-Zarate, María Verónica **S8-300** p.102
Morgan, C.A. S4-269 p.58
Morimoto, Haruyuki S2-192 p.17
Moroz, Valentina V. **S10-230** p.124
Morris, J.F.T. S11-212 p.156
Morton Bermea, O. S6-080 p.86
Morton, Brian S1-020 p.7
Mosyagina, S.Y. S4-238 p.54
Moury, G. S11-134 p.144
Mueter, Franz J. **S11-203** p.148
Muhlia-Melo, Arturo **S3-338** p.38
Mukai, T. S3-173 p.29
Muktepavel, Larisa S. **S11-356** p.148
Mukuno, Y. S3-059 p.46
Mullin, Michael M. S2-082 p.14
Muñoz Mejía, Ehecatl Manuel **GP-337** p.193
Muratov, Leonid F. **S8-061** p.102
S8-062 p.102
Murawski, Steven A. **S1-021** p.9
Musgrave, David L. S2-315 p.13
S4-307 p.56
Myers, K.W. S3-175 p.32

N

Nadtochy, Victor A. **S10-085** p.124
Nadtochy, Victoria V. **S11-331** p.149
Nagata, Yutaka S12-168 p.163
Nakamura, M. S3-175 p.32
Nakamura, Yoshikazu S3-251 p.39
Nakanishi, Shigeko S10-418 p.122
Nakata, Hideaki S3-100 p.35
S5-053 p.72
S5-022 p.72
Nakata, Kaoru S4-239 p.57
S11-205 p.149
Napazakov, Vladimir V. S10-353 p.128
Napp, Jeffery M. S3-303 p.45
S10-298 p.121
S10-140 p.125
Narayanan, Savithri (Savi) **S12-394** p.162
Naumenko, E.A. S10-226 p.125
Naumenko, Nikolay I. **S10-226** p.125
W1-223 p.169
Navrotsky, Vadim V. **GP-355** p.177
S4-354 p.57
Naydenko, Svetlana V. **S3-102** p.38
Nedashkovsky, A.P. GP-136 p.198
Needoba, Joseph A. **S2-295** p.19

Neilson, Douglas J.	**S5-157**	p.72
Nelezin, A.D.	GP-399	p.192
Nevárez Martínez, Manuel O.	**S11-347**	p.150
Newton, Jan A.	**S4-239**	p.57
	S7-182	p.94
Nigmatulina, L.V.	S6-257	p.85
Nikitin, Alexandr A.	S11-356	p.148
	GP-357	p.194
Nishimura, Akira	S10-391	p.135
Nojiri, Yukihiro	S10-321	p.119
Norton, Elizabeth	W1-220	p.168
Novikov, Yury	GP-108	p.196
	S3-251	p.39
Nuñez-Vázquez, E.	S9-308	p.110

O

Obzhirov, Anatoly	S4-235	p.58
	POC-068	p.198
	GP-368	p.194
Ochoa, Jose Luis	**S9-308**	p.110
Odate, Tsuneo	S10-321	p.119
Oguma, Sachiko	S12-168	p.163
	S12-167	p.162
Oh, Im Sang	S10-262	p.126
	S5-258	p.74
Ohman, Mark	**S2-141**	p.19
Okazaki, Yuji	**S5-053**	p.72
Okunishi, Takeshi	S2-231	p.18
Ono, Tsuneo	**POC-213**	p.195
Oozeki, Yoshioki	S3-093	p.31
Orians, K.	S4-237	p.48
Orlov, Alexei M.	S11-134	p.144
	GP-371	p.183
	S5-164	p.73
Orlova, Tatiana Y.	S4-238	p.54
Ortega-García, S.	S3-174	p.39
Ozaki, Koji	**GP-104**	p.178

P

Park, Cha Soo	S3-252	p.33
	S3-253	p.34
Park, Chul	**GP-044**	p.175
Park, Kwang-Soon	S12-409	p.160
Park, Myoung Sook	**S5-258**	p.74
Park, Soo-Young	S12-409	p.160
Park, Soung Yoon	S11-241	p.146
Park, Soung Yun	GP-240	p.180
Park, Wonsun	**S10-262**	p.126
Park, Yeong Chull	GP-240	p.180
Parker, Denise	S3-025	p.39
Parrish, Julia K.	**S7-023**	p.93
	S7-390	p.94
Parsons, Timothy R.	**S1-024**	p.9
Pavlov, A.S.	S8-061	p.102
Pavlova, Elena P.	S4-354	p.57
Pavlyuchkov, V.A.	**GP-386**	p.183
Peña, M. Angelica	**S2-309**	p.20
Perez-Linarez, J.	S9-308	p.110
Perry, R. Ian	**S1-301**	p.10
	S11-302	p.150
Peterman, Randall M.	S11-203	p.148
	W1-144	p.169
Peterson, Tawnya D.	**S2-244**	p.20
	S5-243	p.74
Peterson, William T.	S11-153	p.141
	S11-200	p.151
	S11-306	p.142
	S4-269	p.58
	S5-138	p.63
Petrov, Alexander G.	**GP-381**	p.195
	S10-380	p.134
Pico, Michelle	S7-187	p.91
Pierce, S.	S5-138	p.63
Pinchuk, Alexei I.	S10-323	p.115
Pinnix, William D.	W1-217	p.166
Pipko, I.I.	GP-365	p.197
Plotnikov, V.V.	S10-364	p.134
Polovina, Jeffrey J.	**S3-025**	p.39
	S5-002	p.64
	S5-109	p.77
Polyakova, A.M.	GP-038	p.199
Popp-Noskov, J.	S11-139	p.139
Potts, C.L.	S4-269	p.58
Powell, Thomas M.	S4-229	p.49
Presley, B.J.	S6-054	p.85
Prestbo, Eric	S8-189	p.100
Price, Heather	S8-189	p.100
Putov, Viktor F.	S8-129	p.99
	S8-135	p.101
Pyper, Brian J.	S11-203	p.148
	W1-144	p.169

Q

Qi, Yuan	GP-334	p.178
	GP-335	p.176
Qian, Peiyuan	S9-056	p.112
Qiao, Fangli	S9-064	p.112

R

Rabinovich, Alexander B.	**S5-065**	p.75
Radchenko, Vladimir I.	**S10-026**	p.126
	S1-344	p.5
Reid, P. Christopher	**S11-027**	p.151
Reznik, Yaroslav	GP-314	p.179
Rho, Tae Keun	**S10-208**	p.126
Riser, S.C.	GP-397	p.190
Ro, Young Jae	GP-162	p.191
	S5-048	p.75
Robert, Marie	S11-212	p.156
	S5-043	p.78
Robinson, James	S6-254	p.82
Robson, B.	S10-169	p.114
Rodgers, Jeffrey D.	S1-312	p.3
Rodríguez-Figueroa, G.	S6-080	p.86

Rodriguez-Romero, J.	S3-338	p.38
Rodríguez-Sánchez, Ruben	**S3-174**	p.39
Roegner, Curtis A.	S7-278	p.93
	S7-023	p.93
	S7-183	p.95
	S7-182	p.94
	S7-270	p.95
Rogachev, Konstantin A.	**S5-028**	p.76
Romashina, V.V.	GP-366	p.187
Romero-Vadillo, E.	S4-318	p.61
Rooper, Chris N.	S7-185	p.88
	S7-271	p.95
Rose, George	**S3-029**	p.40
Rosenkranz, Gregg E.	S10-414	p.133
Ross, Peter S.	**S8-266**	p.103
Rostov, Igor	**S12-106**	p.162
Rostov, V.I.	S12-106	p.162
Roy, S.	S9-411	p.107
Royer, Chantell	W1-220	p.168
Royer, Thomas C.	**POC-215**	p.196
	S4-307	p.56
Rue, E.L.	S9-412	p.111
Ruesink, Jennifer	**S7-183**	p.95
Rumrill, Steven	S7-184	p.96
	S7-410	p.88
Rybalko, Sergey I.	S12-388	p.163
	S8-129	p.99
Rykov, Nikolay A.	**S12-388**	p.163

S

Saadon, N.	S4-005	p.50
Sagaleaev, S.G.	GP-136	p.198
Saino, Toshiro	S11-204	p.146
	S2-115	p.15
	POC-213	p.195
Saito, Hiroaki	**S2-196**	p.20
Saitoh, Sei-ichi	S10-031	p.130
	S10-283	p.118
	S10-284	p.123
	S10-321	p.119
	S10-418	p.122
	S10-236	p.127
Sakagami, Yasuhiro	S2-195	p.18
Sakurai, Yasunori	**S11-287**	p.152
Salinas-González, F.	S4-317	p.60
Salo, Sigrid A.	S10-095	p.120
	S10-107	p.127
Salyuk, Anatoly N.	GP-368	p.194
	POC-068	p.198
	S4-238	p.54
	S4-235	p.58
Samko, Eugene	**GP-108**	p.196
Sapozhnikov, D.Yu	S6-080	p.86
Sasaki, Katsuyuki	**S5-099**	p.76
Sasaoka, Kosei	S10-236	p.127
	S10-284	p.123
Sassa, Chiyuki	S10-264	p.129
Sato, Satoshi	S12-350	p.163
Saucier, F.J.	S9-411	p.107
Savelieva, N.I.	S10-265	p.116
	S10-364	p.134
Savinykh, Vadim F.	**S10-353**	p.128
	S3-234	p.40
Schabetsberger, Robert	**S4-269**	p.58
Schirripa, Michael J.	**S3-305**	p.41
Schneider, Niklas	S11-198	p.147
Schweigert, Jake	**W1-402**	p.169
Schwing, Franklin B.	**S11-030**	p.152
Seki, Michael P.	S5-002	p.64
	S3-110	p.41
	S5-109	p.77
Selivanova, E.N.	S2-318	p.12
Semiletov, Igor P.	S10-265	p.116
	GP-365	p.197
	S10-324	p.128
	S4-325	p.59
Seong, Ki Baek	S3-252	p.33
	S3-253	p.34
Sevostianov, Vladimir	**S10-111**	p.129
Shakirov, R.	POC-068	p.198
Shanks, Alan L.	S7-278	p.93
	S7-182	p.94
	S7-270	p.95
Shatilina, T.A.	S11-356	p.148
Shebanova, Marina	**GP-373**	p.176
Shelekhov, Vladimir A.	S3-234	p.40
	W1-112	p.170
Shevchenko, George V.	GP-089	p.174
	S4-077	p.52
	S4-113	p.59
Shevtsov, V.P.	S4-235	p.58
Shevtsova, Olga	**GP-114**	p.197
Shiga, Naonobu	S10-284	p.123
	S10-264	p.129
Shikama,Nobuyuki	S12-349	p.161
Shimizu, Yugo	GP-126	p.200
Shimura, Takeshi	S11-287	p.152
Shin, Kyoungsoon	**S2-075**	p.21
Shin, Kyung-Hoon	**S10-363**	p.130
Shinada, Akiyoshi	S2-193	p.23
Shiomoto, Akihiro	**S10-031**	p.130
	S10-321	p.119
Shirley, Tom	S4-086	p.50
Shirmankina, Lyudmila S.	S4-077	p.52
Shtraihert, E.A.	S4-332	p.60
Shulkin, Vladimir M.	**S6-054**	p.85
Shumilin, Evgueni N.	S4-369	p.48
	S6-080	p.86
Siegel, E.	S4-239	p.57
Sierra-Beltrán, Arturo P.	**S9-383**	p.111
Slobodskoy, Eugene V.	S3-251	p.39
Smirnoff, Anatoly A.	**S2-197**	p.21
	W1-224	p.172
Smirnova, Elena V.	S2-197	p.21
Smith, Neville	S1-032	p.5
Smith, Robert L.	**S11-393**	p.153
Smith, Stacy	**S10-216**	p.131
Snidvongs, A.	S4-005	p.50

Sosnin, Valery **POC-068** p.198
Southard, John S7-184 p.96
Spear, L.B. S4-370 p.48
Spillane, Michael S5-154 p.69
Spry, Doug S6-072 p.81
Stabeno, Phyllis J. S10-095 p.120
S10-107 p.127
S10-014 p.117
S10-375 p.131
S5-154 p.69
GP-143 p.177
Staritsin, Dmitry K. GP-058 p.188
Statscewich, Hank S4-307 p.56
Stein, John E. S1-403 p.3
Stepanenko, Mikhail A. S5-361 p.65
Stockwell, Dean A. S10-208 p.126
Streihert, E.A. S4-238 p.54
Su, Jilan S4-358 p.54
Suda, Maki S11-078 p.154
Suess, E. GP-368 p.194
Suga, Toshio S12-349 p.161
Sugimoto, Takashige S3-100 p.35
S3-121 p.34
S5-092 p.69
S5-127 p.79
S5-159 p.77
Sullivan, Peggy GP-143 p.177
Sutherland, Nes S5-155 p.78
Suyama, Satoshi **S3-233** p.42
S3-093 p.31
Suzuki, Toru S12-167 p.162
S12-168 p.163
Swartzman, Gordon **S10-405** p.132
S7-180 p.96
Swift, D. GP-397 p.190
Sydeman, William J. S7-390 p.94

T

Tadokoro, Kazuaki S10-130 p.116
POC-213 p.195
Takahashi, Kozo **S10-033** p.132
Takatsuki, Yasushi S12-349 p.161
Takeuchi, Kensuke S12-349 p.161
Talley, Lynne D. GP-136 p.198
Tameishi, Hideo S5-159 p.77
Tanaka, Noriyuki S10-363 p.130
Tanasichuk, Ron W. **W1-069** p.170
Tang, Qi-Sheng S1-344 p.5
Taniguchi, Akira **S2-034** p.22
Tarasyuck, Sergey N. **W1-150** p.171
Teel, David S11-139 p.139
Temnykh, Olga S. **S3-342** p.42
W1-152 p.171
Tengku Rozaina, T.M. S4-005 p.50
Tetsumura, K. S3-173 p.29
Thedinga, John S4-086 p.50
Thiess, M.E. S11-212 p.156
Thimgan, Michael P. S2-082 p.14
Thom, Ronald M. **S7-184** p.96
S7-410 p.8
Thomas, Gary L. S11-066 p.153
S11-067 p.153
Thompson, LuAnne S11-074 p.145
Thomson, Richard E. S5-065 p.75
Thorne, Richard E. **S11-066** p.153
S11-067 p.153
Tian, Yongjun **S11-078** p.154
Tiller, Igor V. **GP-378** p.184
Tishchenko, Pavel Ya. POC-068 p.198
GP-365 p.197
GP-136 p.198
Tkalin, Alexander V. S8-061 p.102
S8-062 p.102
S1-403 p.3
Toda, Tatsuki S2-123 p.22
Tomiyama, Minoru S11-205 p.149
Tomlinson, Michelle C. **S12-166** p.164
Toratani, Mitsuhiro S10-031 p.130
S10-283 p.118
S10-284 p.123
Tourre,Y.M. S1-219 p.7
Toyokawa, Masaya **S2-123** p.22
Toyoshima, Shigeru **S12-350** p.164
Trainer, Vera L. S12-166 p.164
S9-221 p.110
Trasviña, A. S4-055 p.51
Trasviña-Castro, A. S3-338 p.38
Trick, C.G. S9-412 p.111
Trofinov, I.K. **W1-224** p.172
Trudel, Marc **GP-289** p.184
S11-212 p.156
Tsuda, Atsushi S2-327 p.23
S2-193 p.23
S2-196 p.20
Tsukamoto, Katsumi **S3-036** p.43
Tucker, S. GP-289 p.184
Turrent Thompson, C. S4-317 p.60
Tyler, Albert **S10-414** p.133
Tynan, CynthiaT. S4-370 p.48
S10-206 p.133
S11-249 p.154

U

Ueno, Yasuhiro S10-130 p.116
S11-078 p.154
S3-137 p.26
S3-233 p.42
Uji, Ryosuke S3-173 p.29
S11-287 p.152
Uraevsky, Evgeniy P. S12-388 p.163
S8-129 p.99
Urawa, S. S11-322 p.143
Uye, Shin-ichi GP-104 p.178

V

Vaillancourt, Robert D. S5-002 p.64
van Roodselaar, Albert S8-292 p.103
Vanin, Nikolay S. **GP-280** p.199
S4-332 p.60
Varanasi, Usha S1-403 p.3
Varela, D. S4-237 p.48
Vasilenko, Alexander V. **S3-037** p.44
Vasilevskaya, L.N. **S10-364** p.134
Vdovin, A.N. W1-328 p.167
Veenstra, Tim GP-088 p.179
Vereshchagina, O. POC-068 p.198
Vézina, A. S9-411 p.107
Villalobos, H. S3-174 p.39
Vlasova, Galina **GP-038** p.199
Vlietstra, Lucy S. **S10-133** p.134
Volkov, Yu.N. S12-388 p.163
Vologdin, Vladimir N. S5-361 p.65

W

Wada, Tokio S1-344 p.5
Wagey, Tonny S2-295 p.19
Wainwright, Thomas C. **S11-261** p.155
Waite, Janice M. S10-311 p.123
Wakulskay, N.M. **S10-380** p.134
Walker, R.V. S3-175 p.32
Walters, Carl J. W1-144 p.169
Walters, Gary S10-259 p.135
S3-214 p.27
Wang, Yunlong GP-335 p.176
S11-333 p.140
GP-334 p.178
Ware, Daniel M. S1-344 p.5
Waseda, Takuji S5-163 p.71
Watanabe, Chikako **W1-148** p.172
W1-149 p.172
Watanabe, Yoshiro W1-148 p.172
W1-149 p.172
Weingartner, Tom S4-307 p.56
Weiss, Peter S8-189 p.100
Welch, David W. S11-212 p.156
S3-052 p.44
GP-289 p.184
Weller, G.E. S10-324 p.128
Wells, Mark **S9-412** p.111
Wheeler, Patricia A. S1-263 p.6
White, W.B. S1-219 p.7
Whitledge, Terry E. S10-208 p.126
S4-307 p.56
Whitney, Frank A. S11-212 p.156
S2-244 p.20
S5-043 p.78
S5-120 p.64
S5-243 p.74
Wiggert, Jerry S3-060 p.33
Wilderbuer, Thomas K. **S10-259** p.135
Williams, Gregory S7-184 p.96
Wilson, Chris S7-180 p.96
Wilson, James GP-088 p.179
Wilson, Laurie K. S8-406 p.99
Wilzbach, Peggy S3-046 p.26
Winckler, G. POC-068 p.198
Winter, Andreas S10-405 p.132
Wong, C.S. S4-237 p.48
S5-120 p.64
S11-329 p.155
S5-155 p.78
Woodruff, Dana S7-184 p.96
Wooster, Warren S. **KA-039** p.1
Wu, Aiming S11-042 p.156

X

Xie, L. S11-329 p.155
Xu, Zaholi **GP-335** p.176
S11-333 p.140

Y

Yabuki, Keizou S11-079 p.142
Yamada, Hirokatsu S3-100 p.35
S11-205 p.149
S4-098 p.53
Yamada, Yuichiro **S2-327** p.23
Yamaguchi, S. S3-175 p.32
Yamamoto, Jun S3-173 p.29
S11-287 p.152
Yamamoto, K. S3-059 p.46
Yamamura, Orio **S3-303** p.45
Yamasaki, S. S3-059 p.46
Yan, Jihui **S8-040** p.104
Yan, Tian S6-232 p.86
S9-056 p.112
Yanada, Mitsuru S10-033 p.132
Yanagi, Tetsuo **S4-041** p.60
Yanagimoto, Takashi **S10-391** p.135
Yang, Dong-Beom **S8-417** p.104
Yang, Joon-Yong GP-122 p.175
S11-241 p.146
Yasuda, Ichiro GP-126 p.200
Yatsu, Akihiko S3-110 p.41
W1-148 p.172
Yelland, Douglas R. **S5-073** p.78
S5-131 p.68
Yoda, Mari S3-059 p.46
GP-128 p.185
Yoneda, Michio **S3-059** p.46
Yoon, Won D. GP-122 p.175
S11-241 p.146
Yoshida, Takafumi **S5-127** p.79
Yoshimura, Takeshi S2-195 p.18
Yoshinari, Hiroshi **GP-126** p.200
Yu, Jun S8-417 p.104
Yurasov, G.I. GP-280 p.199
S4-332 p.60

Z

Zabin, I.	S5-001	p.63
Zakharkov, S.P.	S4-238	p.54
	S4-332	p.60
Zamon, Jeannette	**S11-212**	p.156
Zavarina, Lidiya O.	**S11-376**	p.156
Zaytsev, Oleg	**S4-317**	p.60
	S4-318	p.61
Zeeman, Stephan	S10-107	p.127
	S10-171	p.136
Zertuche-González, José A.	S11-346	p.145
Zhang, Chang-Ik	S1-344	p.5
Zhao, Yongping	**S11-042**	p.156
Zhayvoronok, M.V.	S12-106	p.161
Zheng, Jie	S10-389	p.121
Zhou, Jia-Yi	S1-403	p.3
Zhou, Mingjiang	S9-056	p.112
	S6-232	p.86
	S8-125	p.104
Zhou, Shijie	**GP-348**	p.185
Zhu, Mingyuan	GP-051	p.186
	GP-063	p.187
	S8-336	p.105
	S9-064	p.112
Zorbidi, Janne	**S11-377**	p.157
Zuenko, Yury I.	S11-331	p.149
	S1-419	p.4
Zuess, E.	S4-235	p.58
Zvalinsky, Vladimir I.	GP-136	p.198
	S2-075	p.24
	S2-246	p.24
	S4-238	p.54

PICES Acronyms

BASS Task Team	Basin Scale Studies Task Team
BIO	Biological Oceanography Committee
CCCC	Climate Change and Carrying Capacity Program
CPR	Advisory Panel on Continuous Plankton Recorder Survey in the North Pacific
EC/IP	Executive Committee / Implementation Panel for CCCC
F & A	Finance and Administration Committee
FIS	Fishery Science Committee
F-R	Fundraising Committee
GC	Governing Council
IFEP	Iron Fertilization Experiment Panel
MBMAP	Advisory Panel on Marine Birds and Mammals
MEQ	Marine Environmental Quality Committee
MODEL	Conceptual / Theoretical and Modeling Studies Task Team
MONITOR	Monitor Task Team
PC	Publication Committee
POC	Physical Oceanography and Climate Committee
REX	Regional Experiments Task Team
S1	Session 1: Science Board Symposium on *Ten years of PICES science: Decadal-scale scientific*
S2	Session 2: BIO Topic Session on *Plankton size classes, functional groups and ecosystem dynamics: Causes and consequences*
S3	Session 3: FIS Topic Session on *Migrations of key ecological species in the North Pacific Ocean*
S4	Session 4: POC Topic Session *on Coastal ocean physical processes responsible for biological productivity and biological resource distribution*
S5	Session 5: Joint POC/BIO/FIS Topic Session on *The physics and biology of eddies, meanders and rings in the PICES region*
S6	Session 6: MEQ Topic Session on *Sediment contamination – the science behind remediation standards*
S7	Session 7: MEQ Topic Session on *Physical oceanography to societal valuation: Assessing the factors affecting coastal environments*
S8	Session 8: MEQ Topic Session on *Emerging issues for MEQ: a 10-year perspective*
S9	Session 9: Joint MEQ/BIO/POC Topic Session on *Physical, chemical and biological interactions during harmful algal blooms*
S10	Session 10: CCCC Topic Session on *A decade of variability in the physical and biological components of the Bering Sea ecosystem: 1991-2001*
S11	Session 11: Joint CCCC/GLOBEC Topic Session on *Results of GLOBEC and GLOBEC-like programs (with emphasis on a possible 1999 regime shift).*
S12	Session 12: TCODE Electronic Poster Session on *Regional and national data centres*
SB	Science Board
SG "ER"/"RAC"	Study Group on Ecosystem Report & Regional Analysis Centre
TCODE	Technical Committee on Data Exchange
W1	Workshop 1: REX Workshop on *Temporal variations in size-at-age for fish species in coastal areas around the Pacific Rim*
W2	Workshop 2: BASS/MODEL Workshop *to review ecosystem models for the subarctic Pacific gyres*
W3	Workshop 3: REX/MODEL Workshop *to include higher trophic levels in the PICES NEMURO Model*
W4	Workshop 4: MONITOR Workshop *to review progress in monitoring the North Pacific*
W7	Workshop 7: Working Group 15 Practical Workshop on *Taxonomy and identification of HAB species*
WG	Working Group