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abstracts

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2AM1993-MEQ03 POSTER

ECOLOGIC ASPECTS OF THE BIOCHEMICAL STUDIES IN THE BERING AND OKHOTSK SEAS

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In June-July of 1992 during the 22nd cruise of the R/S "Academic A. Nesmeyanov" studies of horizontal and vertical distribution of the dissolved and particulate organic carbon (C_{org}) as well as of its main biochemical components (protein, nucleic acids, carbohydrates and lipids) were undertaken.

Concentrations of the dissolved C_{org} in the Bering and the Okhotsk Seas ranged from 1.5 to 6 mg l^{-1}, and from 2 to 8 mg l^{-1}, respectively. Spatial distribution of C_{org} both horizontally and vertically was rather heterogeneous and depended on biological factors. Concentrations of the particulate C_{org} ranged from 0.3 to 2.1 mg l^{-1}. The dissolved C_{org} made 3-70% of the particulate one.

For the dissolved organic matter the main biochemical component was carbohydrates, while for the particulate one it was protein. Both horizontal and vertical changes in biochemical components distribution depended on biological factors.

The activity of the electron transfer system (ETS) enzymes and alkaline phosphotase were estimated to determine rates of the OM transformation and regeneration of nutrients.

In the boundary waters of the Bering Sea and the Pacific characterized by the maximal vertical gradient of oxygen an increase of the ETS enzymes total activity was observed.

Areas of the intensive primary production were characterized by high rates of phosphorolise and negative correlation of the latter with concentrations of the inorganic phosphorus.

By the estimation of the phosphorolise rates and the organic phosphorus concentrations a mean time of the complete regeneration of the phosphates in the euphotic layer was determined to be approximately 24 hrs. It was shown that at low concentrations of the inorganic phosphorus up to 80% of the primary production could be promoted by the phosphate recycling.

2AM1993-SB04

LASER MONITORING FOR CHLOROPHYLL-A IN THE NORTH PACIFIC

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The investigations of the World Ocean bioproductivity ask the development of the new methods for the measurements of the primary production. These methods should give the large scale measurements in express-style. The ordinary methods of the chlorophyll-A concentration determination have the high accuracy of the measurements but ask the sampling and long time for its working. Moreover of those many stations and vessel stops are needs for the detail picture of the distribution of the biomass productivity concentration on the large aqua square. The laser methods of the measurements of the fluorescence spectra for the chlorophyll-A developed during last time give the express-method for the determination of the chlorophyll-A concentration. This method is the automated one completely and you can do measurements without vessel stop.

We have developing the laser fluorometer used the second harmonic of the Nd:YAG laser radiation with the wavelength 532 nm of the emission. This equipment can produce the continuous measurements of the chlorophyll-A concentration into the concentration range from 0.1 μg/1 up to 10 μg/1 with the relative error of measurements not more than 5%. The sea water sampling is produced by the special pumping system from the 5 m depth during the vessel speed continuously. The water samples are pumped into the optical dish in which the excitation of the chlorophyll-A fluorescence spectrum by the laser radiation is produced. The photomultipliers detect the chlorophyll-A fluorescence line with the wavelength 680 nm and the Ruman scattering of water into the wavelength range 645-660 nm. The last one is used for the normalization of the chlorophyll-A fluorescence intensity. The system management is produced by the IBM PC/AT. The three-fold

picture of the distribution of the chlorophyll-A concentrations (the first axis is the longitude, the second axis is the latitude and the third axis is the concentration in the R/V place) is demonstrated on the monitor screen in the real time manner.

We fulfilled the continuous measurements of the chlorophyll-A concentrations in the research cruise of the "Akademik Alexander Vinogradov" R/V by means of this equipment. The measurements were fulfilled in the two regions of the North Pacific: in latitude (26°-43°) north, Long (122°-138°) E and in latitude (46°-56°) north, Long (140°-177°) E. The data received by the laser fluorometer were calibrated with the ordinary methods of the measurements on the beginning of the expedition. In the next the comparisons between the ordinary methods and the laser measurements were also fulfilled on the stations. We had the coincidence of the results into the 10% limits when the changebility of phytoplankton species composition was not observed (the first region). In the second region, in which the R/V crossed some seas, the additional calibration species composition. The calibration gave the insignificant difference for the Okhotsk and Japan seas. The calibration was changed in two times in the Bering sea. The correlation between the intensity of the fluorescence line and the sea water temperature was observed when the R/V crossed frontal zones. The cool water upwelling determines the increasing of the chlorophyll-A concentration. We found the ramification of the chlorophyll-A concentrations into the interfrontal opportunity to do the distribution mapping of the chlorophyll-A concentration on the large aqua squares in the North Pacific.

2AM1993-FIS04 POSTER

DISTRIBUTION AND ABUNDANCE OF THE SPAWNING JAPANESE SARDINE *SARDINOPS MELANOSTICTUS* OFF SOUTHERN KYUSHU, SOUTHWESTERN JAPAN

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Distribution patterns of the spawning population of Japanese sardine *Sardinops melanostictus* off southern Kyushu were investigated in relation to water temperature and the Kuroshio current in three successive winters from 1990 to 1992. Data were obtained from hydroacoustic surveys, measurement of gonads and histological examination of oocyte maturity stage. Sardine distribution varied during January - March as time advanced. It was closely associated with both water temperature and spawning activity. The fish abundance in the area of sardine concentration decreased markedly in the 3 years. Sardine shoals were aggregated in the lower temperature inshore side of the Kuroshio front at the beginning and end of the spawning season and that the majority of spawning sardine occurred in the Kuroshio region where temperature >20°C in the peak spawning period. Physiology of spawning seems change a preference for temperature. Spawning sardine crossed the Kuroshio front that appeared to have acted as a barrier to distribution till then. Spawning was concentrated within a short period of about 10 days in early March, though detectable in February and March. Around 1950 when stock levels were low, Japanese sardine spawned inshore on the continental shelf. Japanese sardine change their spawning behavior probably in response to increased population size, which is a significant feature found only in the period of high abundance.

2AM1993-BIO03 INVITED

INTERDECADAL VARIABILITY OF COASTAL PELAGIC FISH POPULATIONS IN THE CALIFORNIA CURRENT OVER THE PAST TWO MILLENNIA

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The anaerobic, varved sediments of the Santa Barbara Basin, off the California coast contain a well preserved history of deposition of the scales of the northern anchovy and Pacific sardine. The longest record to be reconstructed, so far, extends AD 300 to 1970. This is a time series comprised of 10-year averages of annual scale-deposition-rates (SDRs) which indicate interdecadal fluctuations in the sizes of the fish populations. The sampling frequency allows us to resolve the variability into periods as short as 40 years. The purpose of this presentation is to consider the significance of changes in SDRs over periods of 50 to 100 years through the length of the record.

Comparison of the interdecadal variability in the sardines and anchovies reveals a generally consistent pattern of alternation in the magnitudes of the two species consistent with the idea of a continuing back-and-forth replacement of one species by the other. We do not find a strict inverse relationship, but rather a tendency for one species to maintain numerical dominance over an average of roughly 35 years (complete period equivalent to 70 years). The phase relationship between the two species varies from episodes in which the two series vary perfectly in phase to other periods in which they are completely out of phase. Model simulations of these phenomena suggest that this interdecadal variability in the sardines and anchovies is not the result of direct competition, but is an effect produced by independent response of each species to a changing mix of environmental conditions that generally produce different levels of habitat suitability and carrying capacities for each species.

2AM1993-FIS11
RESPONSE OF PACIFIC SALMON AND HERRING IN THE STRAIT OF GEORGIA
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Young Pacific salmon and herring are abundant in the plume of the Fraser River. Nutrients in the plume are advected from bottom water that enters the Strait from offshore, in response to the less dense surface water that leaves through Johnstone Strait. The productivity of salmon within the plume was more related to the pattern of discharge from the river than to the pattern of winds. The relative abundance of salmon and herring over the short term was closely related to the amount of discharge. Poor years of fish production tended to correspond to periods of high discharge and good years of fish production tended to correspond to periods of reduced discharge. The changes in abundance relative to discharge indicated that the marine environment and not smolt abundance was regulating salmon production at the current levels of chinook and coho production in the Strait of Georgia.

2AM1993-POC34 POSTER
THE NOAA-PMEL REPEAT HYDROGRAPHY PROGRAM IN THE PACIFIC
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Researchers at NOAA's Pacific Marine Environmental Laboratory have undertaken a long-term program to monitor the invasion of CFCs, carbon dioxide and other tracers into the thermocline waters of the Pacific Ocean, by means of repeat hydrographic sections taken at intervals of 5-10 years. Central goals of the CFC program are to document the transient invasion of the CFC tracers and to interpret these changing distributions in terms of coupled ocean-atmosphere models. Studies of the entry of CFCs (and other tracers) into the ocean provides a unique description of the time-integrated circulation of the ocean on decadal time scales.

Early sections occupied as part of this program consisted of relatively coarsely spaced CTD stations, and included discrete measurements of dissolved CFCs, total carbon dioxide, alkalinity and oxygen. More recent sections have consisted of more closely spaced CTD stations, and included high precision nutrient measurements, additional carbon-system components and sampling for other transient tracers. Five year changes in dissolved CFC distributions along these sections will be discussed, along with current activites and future plans for this program in the Pacific Ocean.

2AM1993-POC33 POSTER
VARIABILITY OF INTERMEDIATE WATER OVER THE JUAN DE FUCA RIDGE
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The Juan de Fuca Ridge in the northeast Pacific Ocean is at the southeast edge of the subarctic gyre and is a region of extensive hydrothermal activity. Although plumes emanating from the ridge occur in the deeper ocean, the effect of the ridge on the circulation extends well into the upper layer including the intermediate water. This paper describes time series measurements of

currents and repeated CTD observations over several years near 45°N, 130°W. The upper ocean is in the West Wind Drift near its divergence at the North America coast. However, current measurements in the intermediate water rarely are eastward. The flow appears to be a series of eddies over, or moving along, the ridge. CTD observations from several years show complex eddy patterns along the ridge from 45°N to 48°N, while farther west the property distributions are relatively smooth. Also, the temperature and salinity over the ridge are higher than in the water to the west suggesting that there may be another source of water, possibly from the south along the coast. The ridge apparently causes complex eddy patterns which may be important in modifying water properties in this part of the subarctic gyre.

2AM1993-MEQ14 INVITED

TRANSOCEANIC TRANSPORT OF BIOLOGICAL CONTAMINANTS: BALLAST WATER, EXOTIC SPECIES AND THE ROLE OF ICES

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Ballast water and sediments in ocean-going cargo vessels serve in the 1990s as one of the major mediators for the transoceanic and interoceanic introduction of nonindigenous (exotic, introduced) species. Recent studies in Canada, Australia and the United States have demonstrated the presence of hundreds of species of marine animals, plants and protists surviving in post-voyage ballast. In turn, numerous invasions linked to ballast release have been recorded world-wide, notably increasing (for reasons that remain unclear) beginning in the early 1980s. Of further concern is the potential for ballast to transport and inoculate viruses and bacteria of importance to human health. The invasion of Tasmania and southwestern Australia by Japanese red tide-causing dinoflagellates and the invasion of the Laurentian Great Lakes (Canada and the USA) by the Eurasian zebra mussel *Dreissena polymorpha* have prompted international interest in ballast water by the International Maritime Organization (IMO) of the United Nations. ICES considered the problem of ballast water in 1988 at a meeting of its Working Group on Introductions and Transfers of Marine Organisms, and convened a special Study Group on Ballast Water in 1991. ICES urged its member States to critically examine the role of ballast in releasing exotic species in their countries and encouraged the formulation of ballast water management programs that would reduce the probabilities of exotic species transport. "Ballast water exchange" (the open ocean discharge and subsequent uptake of water on the high seas) is the most commonly suggested strategy to reduce the transoceanic transport of coastal (neritic) species. However, numerous problems in the ability to conduct complete exchanges by present-day ships indicate the need for direct removal of, or lethal measures to reduce the presence of, living organisms in ballast water. As this will be a process extending over many more years, future spectacular invasions by exotic species through ballast water release may be expected.

2AM1993-SB16 INVITED

RADAR REMOTE SENSING OF LARGE-SCALE SURFACE CIRCULATION OF THE OCEAN

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Previous studies from CalCOFI historical ship-based observations have demonstrated a close coupling between alongshore transport and zooplankton productivity off the California coast. Sea level measurements from coastal tide gauges provide an index of the current transport farther offshore. It has been speculated that these large-scale changes in the transport of the California Current are related to changes in the bifurcation of the West Wind Drift. This hypothesis cannot be tested from existing hydrographic data because of insufficient coverage on the relevant space and time scales. This information can be obtained from satellite altimeter data such as the TOPEX/Poseidon altimeter launched in August 1992. A brief review of the technical aspects of altimetry will be given, emphasizing the strengths and limitations of the technique. An overview of past investigations of large-scale sea level (and associated geostrophic surface current) variability from the U.S. Navy GEOSAT altimeter will be given. Examples include seasonal variability along the west coast of North America, seasonal variations in the latitude of the Confluence of the Brazil and Malvinas Currents in the South Atlantic, and seasonal variability of the West Wind Drift in the South Pacific.

A natural question that arises from such studies is the cause of the large-scale variations in sea level. The primary forcing mechanism is wind forcing, but accurate, high-resolution wind fields are not presently available over much of the open ocean to investigate the coupling between wind forcing and ocean response. Such information can be obtained from radar scatterometry such as the ERS-1 scatterometer launched in July 1991 by the European Space Agency and the NSCAT scatterometer to be launched in 1996 by NASA. The technique of radar scatterometry will be reviewed and the potential impact of long-term scatterometer data will be demonstrated from results obtained from the limited scatterometer data available to date.

In combination, altimetry and scatterometry promise to significantly improve our present understanding of large-scale wind-forced ocean circulation. As clouds are essentially transparent to microwave radiation, both the altimeter and scatterometer are all-weather instruments. In combination with relevant in situ biological measurements, the information provided by scatterometry and altimetry can be used to investigate the relationship between physical and biological variability in cloud-covered regions such as the North Pacific.

2AM1993-SB07 POSTER

THE PEGGY BERING SEA BUOY - REAL-TIME ATMOSPHERIC AND BIOPHYSICAL OCEANIC MEASUREMENTS IN THE SE BERING SEA BASIN

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Peggy Bering Sea is an oceanographic buoy anchored in 2200 m of water in the southeast Bering Sea basin (54°47'N, 168°32'W), 160 km northwest of Dutch Harbor, Alaska. Its purpose is to make atmospheric and biophysical measurements of the upper ocean to elucidate the effects of the environment on the recruitment success of walleye pollock (*Theragra chalcogramma*), object of the world's largest single-species fishery. This work is part of Bering Sea FOCI (Fisheries Oceanography Coordinated Investigations) under the auspices of NOAA's Coastal Ocean Program.

Beginning in 1992 Peggy has been successfully deployed from April to September of each year measuring solar radiation, winds, humidity, air temperature, water temperature, salinity, ocean currents and acoustic backscatter. This gives a long time series of the local solar and atmospheric forcing and the response of the upper-ocean mixed layer. In 1993 new-technology chlorophyll and spectral absorption meters were added to the mooring to observe the timing, magnitude and duration of the spring bloom. Occasional CTD's and net-hauls from ships nearby allow for calibration and the identification of species associated with the acoustic backscattering signals.

A subset of the data is telemetered to the lab in near real-time via satellite through Service Argos. This has several advantages. Drifters have been deployed in passing eddies. Ocean current accelerations forced by strong storms are seen as they happen. A malfunction has been identified, diagnosed and a repairman dispatched thus rescuing a field-season's data. A response of the diel vertical migration of zooplankton owing to a change in the current direction has been observed in the ADCP acoustic backscatter and currents, and a Japanese research vessel (*Kaiyo Maru*) kindly responded to a request to sample the new regime.

Peggy Bering Sea provides a platform for other investigators with self-contained instruments capable of long-term deployment to make upper-ocean observations in the Bering Sea in conjunction with our own measurements.

2AM1993-FIS17

MODELLING SHIFTS IN FISH STOCK ABUNDANCE IN THE EASTERN NORTH PACIFIC

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Time series of fish catch and biomass data indicate large-amplitude fluctuations on time scales of 10-50 years. These fluctuations are revealed in scale deposits from before the 20th century and therefore cannot be attributed solely to fishing pressure. In the North Pacific, fluctuations in

fish abundance correspond temporally with regime shifts in the marine environment. Often the shifts in fish abundance are abrupt, suggesting that the relationships between the environment and fish abundance are nonlinear. We consider the combined effects of a fluctuating environment and species interactions on fish abundance. For example, the biomass of Pacific herring *Clupea pallasi* off the southwest coast of Vancouver Island appears to be negatively related to sea surface temperature (SST) and the abundance of its predator Pacific hake *Merluuccius productus.* We use first-order differential equations to develop a two-species, predator-prey model forced with stochastic variability. Nonlinear trophic interactions result in the models having multiple equilibrium abundance levels. Environmental variability is simulated as "red noise" (variance is a decreasing function of frequency) with a spectrum derived from SST data. Stochastic variations cause the predator-prey abundances to shift between the high and low equilibrium levels with a pattern similar to that observed for Pacific herring. The effect of fishing is to increase the proportion of time spent at the low equilibrium. Even if these large-amplitude abundance shifts cannot be prevented, fisheries can amplify the shifts by precipitating the collapses and prolonging the time to recovery. While the model does not predict future abundance, it is useful for understanding how environmental variability, trophic interactions and harvesting interact to cause fluctuations in abundance. Model output, generated with realistic values of population growth rates, environmental variability and fishing, is compared with the observed abundance of Pacific hake and Pacific herring.

2AM1993-BIO01 INVITED

HIGH-RESOLUTION TREE-RING RECORDS FROM COASTAL ALASKA AND BRITISH COLUMBIA: ASSOCIATIONS WITH NORTHEAST PACIFIC CLIMATE

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Weather and climate fluctuations along the coastal regions of Alaska and British Columbia are largely influenced by coupled features of the ocean-atmosphere system in the northeastern Pacific. Temperature and precipitation anomalies over coastal and near-coastal land areas are influenced by changes in sea surface temperature (SST) and sea level pressure (SLP), which in turn are modified by such large-scale features as the intensity and position of the Aleutian Low, the system of ridges and troughs related to the Pacific-North American (PNA) pattern, and the El Nino-Southern Oscillation (ENSO). The magnitude and seasonality of the local response to these large-scale forcing factors varies depending on location along the western North American coast.

In this paper we investigate the growth response to land and oceanic climate variability as reflected in tree-ring width and density chronologies from coastal and near-coastal sites in south coastal Alaska and the Pacific Northwest. Correlation relationships are determined between the tree-ring data and variables of North Pacific atmosphere-ocean climate, including coastal surface air temperature and precipitation, sea surface temperatures or SST's, the Southern Oscillation Index (SOI), and the Aleutian Low Index (ALI). We also compare the response of these chronologies to those of other climatically-sensitive tree-ring records from sites further to the south, in central California, the southwestern United States and Mexico. The results reflect the varying nature and degree to which these large-scale features influence climatic conditions (and hence tree growth) along the western North American coast, both at present and in prior centuries.

2AM1993-POC03

COLUMBIA RIVER RESERVOIR OPERATIONS RELATED TO NORTHEAST PACIFIC SEA SURFACE SALINITY TRENDS, 1930-1990

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During the twentieth century, 201 reservoirs constructed in the Columbia River basin have resulted in the systematic reallocation from summer to winter of one-quarter of the Columbia's discharge to the Pacific Ocean. Oceanographic observations (1934-1990), analyzed in this report, demonstrate that increased winter discharge has increased near-surface salinities along the coasts of Oregon and northern California, and decreased those on the Washington, British Columbia and Alaskan coasts, and in the Gulf of Alaska gyre. Human intervention on the Columbia extends from

reservoirs far inland to modify ocean and estuarine dynamics at locations several thousand kilometers distant in and along the North Pacific Ocean.

2AM1993-SB14 INVITED

FISHING VESSEL OBSERVER PROGRAMS IN BRITISH COLUMBIA

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Fishery observers work aboard commercial fishing vessels to monitor fishing operations, collect biological data and ensure compliance to fishing regulations. In British Columbia, observers monitor coastal fisheries involving foreign fishing vessels within the EEZ, certain experimental fisheries requiring special permits, and traditional domestic fisheries including groundfish trawling and blackcod longlining. Most of vessels hosting observers are 20 to 30 metres in length and spend 10 to 14 days at sea. Fishery observer programs are funded by both government and industry with increasing contribution by the latter.

Fishery observer programs are typically administered through joint involvement of government and private contractors. Programs involve several organizational components including sampling program design and mobilization, observer selection and training, coordination and scheduling of observer sea assignments, processing of observer data products, and program evaluation. The fishing industry should be actively involved in program design, implementation and evaluation.

Data products from observers generally include biological sample material, information recorded for computer key punching, photographic data, and descriptive written information. Standardized procedures for data collection, reporting and verification are used within the observer program to ensure continuity of information among different vessels and observers involved. Observer program information has primarily been for fisheries research and management purposes. Collection of oceanographic information from fishery observer programs in British Columbia has been under utilized.

2AM1993-FIS18 POSTER

A ROLE FOR ROBOTICS IN FISHERY RESEARCH

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The recent problems associated with declining fish stocks in the Western North Atlantic and the North Sea have received international attention. There are many other areas of the world which hold the potential for similar problems. While countries have often laid the blame on overfishing, scientists admit that the problem is more complex and that a number of factors must be considered. Fundamental to such a consideration is the need to improve both the quantity and accuracy of fish stock data for the various species in question.

While this need is recognised, the cost of suitable research ships is on the rise. Many have outlived their useful lives and must be replaced. Others which are being retained in service must be maintained and this cost is also rising. Demonstration has proven that noisy ships scare fish away and it is thus important to conduct abundance surveys from acoustically quietened platforms. Experience in Europe indicates that the cost of building and maintaining ships to high standards of acoustic quietening can be prohibitive and the potential for using smaller, less costly robotic vehicles in fish stock assessment has drawn interest.

In the early 1980's, the Canadian Department of Fisheries and Oceans developed a semi-submersible robotic platform known as Dolphin. Intended for offshore hydrographic survey, the vehicle is capable of sustained stable operations in sea state 5 at speeds of up to 15 knots (25 kph). In the past decade, considerable development in hydrographic and military applications has been undertaken. More recently, scientists have been examining the potential to adapt the vehicle for fish stock abundance surveys and fish behaviour research.

A consortium consisting of Norwegian, UK and Canadian companies is funding the development which will demonstrate the feasibility of the vehicle in this application. This group

has expertise in fishery research, marine survey, hydroacoustics and underwater robotics. The paper describes the program which has been initiated and the benefits which the development will provide for fishery managers. The paper also invites input from fishery research experts regarding capabilities which the system should potentially have.

2AM1993-MEQ08 POSTER

WATER PROPERTIES ASSOCIATED WITH SOME HARMFUL ALGAL SPECIES IN BRITISH COLUMBIA COASTAL WATERS

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During ten years of sampling phytoplankton species composition and abundance in British Columbia coastal waters, data have been collected on the occurrence of a number of harmful species. The seasonal distribution is presented for some of these. Discriminant analysis is used to assess whether there are distinctive water properties associated with the presence of these taxa. Water properties included in the analysis include sample depth, temperature, salinity, chlorophyll, nitrate+nitrite, phosphate and silicate.

Among the taxa considered, *Chaetoceros convolutum / concavicorne* and *Heterosigma akashiwo* occur throughout the British Columbia continental shelf, although the latter is generally limited to southern areas. Dinophysis spp. is also widely distributed, although most frequent in inshore waters of the Strait of Georgia.

Samples were collected between April and October. *C. convolutum / concavicorne* occurred in over 70% of samples from the summer months of August and September, less frequently in other months, althouth these taxa most frequently cause problems in spring and autumn. *H. akashiwo* occurs most frequently in June, the month when serious blooms are usually first reported in any given year.

Discriminant analysis performs moderately well in predicting presence or absence based on water properties, with a success rate of 63% to 80% in correctly predicting absence of any particular species, and 58% to 66% in correctly predicting presence.

2AM1993-SB06

OBSERVATIONS OF CIRCULATION VARIABILITY IN THE BERING SEA USING GEOSAT ALTIMETRY DATA

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Altimeter data represents the only all weather source of observations in the Bering Sea at sufficient spatial and temporal resolution to adequately observe both the basin scale and mesoscale circulation in the region. In this paper we use Geodetic Mission (GM) and the first two years Exact Repeat Mission (ERM) altimeter data from the U.S Navy Geodetic satellite (GEOSAT) to investigate the circulation variability in the Bering Sea for the time period from April 1985 through December 1988. The GM data consists of crossovers computed from the height differences between ascending and descending arcs which have crossing tracks, while the ERM provided collinear sea surface height measurements along the ground track of the seventeen day exact repeat orbit. Compatible crossover and collinear techniques were used to provide a continuous time series which has been analyzed using standard and extended empirical orthogonal functions (EOFs and EEOFs).

The basin scale variability is dominated by a regular seasonal cycle in which the Kamchatka Current transport reaches a maximum in February followed by a minimum in early fall. The Bering Slope Current also exhibits seasonal variability in phase with the Kamchatka Current. The statistics of the mesoscale variability showed little interannual variation when comparing sea surface height data between the GM and ERM. However, the synoptic mesoscale structure along the Bering Slope current was quite different year to year. A wave train of eddies formed along the Bering Slope Current late in GM and propagated to the northwest along the shelf break. Outages during the ERM prevented adequate observations of the slope current eddy field development, but it appeared that the wave train was less pronounced during the ERM.

2AM1993-BIO09

A CASE FOR HISTORICAL SCIENCE IN LARGE MARINE ECOSYSTEM RESEARCH: TEASING ORDER OUT OF CHAOS

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There are two fundamental ways of doing science: the experimental-predictive and the historical-descriptive. The experimental-predictive approach uses the techniques of controlled experiment, the reduction of natural complexity to a minimal set of general causes, and presupposes that all times can be treated alike and adequately simulated in the laboratory. The historical-descriptive approach uses a mode of analysis which is rooted in the comparative and observational richness of our data, is holistic in its treatment of systems and events, and assumes that the final result being studied is unique - dependent, or contingent upon everything that came before. In the realm of the historical, the ultimate question boils down to the placement of a boundary between predictability under invariant law and the multifarious possibilities of historical contingency. We feel that it is the placement of this boundary that may determine the success or failure in our attempts to understand fundamental and long term change in large marine ecosystems.

In this paper, we discuss the necessity of viewing the characterization of order in large marine ecosystems from a historical scientific context and give examples of how the historical-descriptive approach has been used in other disciplines. Within this framework, we propose that rather than trying to reduce nature to fundamental entities, an alternative approach be taken whereby order in nature can be understood through fundamentally *consistent relationships*. We propose to study order not by dealing with the structure of objects, but rather the structure of movement in a historical context. It is these dynamic relationships, or pattems of relationships within large marine ecosystems, that are important. Examples will be drawn from our research on climate change and salmonid production in the North Pacific Ocean.

2AM1993-FIS24

INTERACTIONS BETWEEN SARDINE AND ANCHOVY POPULATIONS WITH SPECIAL REFERENCE TO THE DECADAL CHANGES IN THEIR LIFE CYCLES: A CASE STUDY IN THE ENSHU-NADA SEA, JAPAN

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In 1970, Japanese anchovy population started to decline corresponding to the increase of Japanese sardine population in the waters around Japan. During this declining phase, it was observed that the condition factor and maturity coefficient of the spring spawner of the anchovy decreased while those of the summer spawner increased; this led to the changes in the seasonal pattern of anchovy occurrence. The ecological niche for the spring spawner of the anchovy was replaced by sardine, which had started to explode since early 1970's. The absence of predatory planktons and competitive pelagic fish including anchovies during the main spawning period of the sardine (February to April in the Enshu-nada Sea located along the central Pacific coast of Japan Is.) seemed advantageous to the larval survival and recruitment success of the sardine population.

In the late 1980s, on the other hand, the sardine started to decline, being replaced by the anchovy. It is noteworthy that during this phase the spawning period of the sardine became unstable and was delayed a few months; this might enhance the possibility of encounters with other competitive and predatory species including anchovies.

There has been almost no difference in the abundance of copepod nauplii, favorable food for the first feeding larvae, in the Enshu-nada Sea between around 1980 and around 1990 despite the marked changes in the sardine abundance during 1980-1990. This suggest that the prey density would not be responsible for the shift in the dominant species. We may conclude that the prominent decadal changes in the life cycles of sardine and anchovy are closely related to the dominance shift. The possible mechanisms behind these changes are also discussed.

2AM1993-POC23

THE ROLE OF THE OKHOTSK SEA AND EAST-KAMCHATKA CURRENT IN THE NORTH PACIFIC INTERMEDIATE WATER

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In our report the quantitative contribution of the Okhotsk and Bering Sea waters in producing of low temperature and salinity signal in the North Pacific Subarctic Intermediate Water (NPSIW) is discussed. Analysis is based on the CTD-data of RV "Pr. Gagarinskiy" in the Kuril Straits region provided in the 9th cruise of the ship during June 1991.

We have used isopycnal analysis (the linear bicomponent model of mixing) to estimate thermohaline mixing of the intermediate water in Northwestern Pacific (the Oyashio and East-Kamchatka Currents region) and obtain the following conclusions:

1. In June 1991 water exchange throughout the Kuril Straits was severely baroclinic, may be due to non-tidal currents.
2. In June 1991 the Oyashio waters near the central Kuril Islands were mainly formed (60-70 %) by advection of the cold fresh Okhotsk Sea waters on the 26.9 - 27.0 σ_θ isopycnal surfaces.
3. In June 1991 the East-Kamchatka Current (the Bering Sea) was the most possible source of North Pacific Low Salinity Intermediate Waters (26.6 - 26.8 σ_θ).
4. In June 1991 the Warm Soya Current reached to the Etorofu Island along the Kuril Island Chain in the Okhotsk Sea.
5. In June 1991 the cold (anticyclonic) Kuril eddy situated on the beam of the Bussol Strait (45N) advected the lenses of the subtropical water in the layer 50-150 m.

2AM1993-MEQ05 INVITED

POLLUTANTS AND CONTAMINANTS IN MONITORING PROGRAMS FOR THE ASIAN PACIFIC WATERS

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The extension of the International Mussel Watch to Asian/Pacific coastal waters has been examined by scientists from six concerned countries at a meeting sponsored by the United Nations University. The distinction between pollutants (those substances entering the marine environment that can impact upon public health and the composition of ecosystems) and contaminants (those substances entering the marine environment that merely alter its composition) is emphasized. Novel substances (organically bound metals, dioxins and coplaner PCBs) are proposed for inclusion in the program in addition to the chlorinated hydrocarbons and artificial radionuclides of previous activities.

Conventional mussel watch strategies will be carried out including the extensive use of primary standards and intercalibration exercises. There will be a directed involvement of the press and public in the forthcoming activity.

2AM1993-BIO04

PALEOOCEANOGRAPHY OF THE FAR NORTHWESTERN PACIFIC AND THE BERING, OKHOTSK AND AJAPAN SEAS THROUGHOUT THE PAST 25,000 YEARS

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$CaCO_3$ content, C_{org}, terrigenic components and d180 foraminifera data in the bottom sediments in the cores of far northwestern Pacific, the Bering and Okhotsk seas show general and interconnected pattern of paleoenvironment in this region throughout the past 25,000 years. As d180 planktonic foraminifera curves suggest, the accumulation of ice-rafted debris in the regional sediments decreased abruptly before the first melt water pulse of land glacier (MWP1A) due to the opening of the Bering Strait, while after the first and the second melt water pulses (MWP1A and MWP1B) $CaCO_3$ and C organic accumulation in the regional sediments increased probably because of the vertical water stratification strenthening and less deep water aeration.

The variations of water exchange with the Pacific Ocean have a strong impact on paleoenvironment of surface and deep waters of the Japan Sea under glacioeustatic changes of the sea level with respect to shallow water of the straits. The comprehensive isotopic, geochemical and micropaleontological analyses (d180, d13C, $CaCO_3$, C_{org} content) enable one to recognize nine successive steps in surface and deep waters development with inflow of Kuroshio warm waters and Oyashio cold waters through the Tsushima and Tsugaru straits respectively, and global climatic changes.

2AM1993-SB19 POSTER

STABLE ISOTOPES IN MARINE RESEARCH: $\delta^{15}N$ AND $\delta^{13}C$ IN MARINE BIRDS OF THE NORTH PACIFIC

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We are currently examining $\delta^{15}N$ and $\delta^{13}C$ of marine animals, especially birds, and their food in the North Pacific. The high average of black-footed Albatrosses (15.0‰, sd=0.8) indicates that they are feeding one trophic level above Laysan Albatrosses (12.2‰, sd-1.3), possibly a result of a heavier reliance of black-foots on waste and offal from commercial fishing operations. In both Alaska and the Transitional North Pacific, horned puffins feed principally on small fish supplemented with crustaceans and a few squid. The large difference in $\delta^{15}N$ (3.5‰) between the two groups suggests a difference in pathways of nitrogen transfer between the two ecosystems. Three early June specimens of sooty shearwater from the eastern Transitional Pacific had average $\delta^{15}N$ and $\delta^{13}C$ values 4.9‰ and 3.0‰ higher, respectively, than the average of twelve late May - mid-November specimens. The three unique specimens may represent newly arrived migrants, possibly from South American as opposed to New Zealand origins of birds associated with high seas fisheries as well as to the impact of offal from these fisheries on marine bird populations.

2AM1993-SB01

A SEMI-CONTINUOUS ENVIRONMENTAL MONITORING AND ASSOCIATED CHEMICAL AND BIOLOGICAL MEASUREMENT USING SEAWATER INTAKE OF JAPAN-KOREA FERRY

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[7]*Korea Ocean Research & Development Institute*

A ferry mounted monitoring system was developed and deployed to investigate the temporal and spatial variations of biogeochemical parameters (dissolved nutrients, fluorescence, temperature, salinity and pH) along the ship's regular route between Pusan, Korea and Kobe, Japan. Semi-continuous data recording (every 10 seconds, 4 transect cruises per week) and automated bottle sampling with filtration (24 cruises per year) were performed using the seawater taken continuously from the engine cooling system intake at 6m depth. These data are expected to clarify the natural variability in and anthropogenic changes to the coastal and marginal seas and the mechanism of algal blooming and to supply the ground truth data for the calibration/validation of algorithms to calculate pigment concentrations from ocean color remote sensing data. In addition, several research cruises were performed to develop the measurement of pCO_2 and dimethyl compounds, phytoplankton particle size spectra by laser technique, phyto- and zooplankton sampling for taxonomy based on the identical intake.

The monitoring was kept up from June,1991 to January,1993. During this period, initiation and termination of algal blooming and associated variation of nutrients, pCO_2 DMS, phytoplankton genus composition were observed. There was a contrast between the phenomena in the Inland Sea

area and that in the continental shelf area and between the initiating and terminating phase of blooming. The ferry-based monitoring was found to be feasible and applicable to the variety of the marine environmental issues particularly of the marginal seas.

2AM1993-FIS02

QUANTIFYING THE TEMPORAL AND SPATIAL ASPECTS OF CLIMATE CHANGE AND ITS POTENTIAL IMPACT ON MARINE FISH POPULATIONS

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The impact of climate change on marine fish populations is the subject of much current intensive research. In particular, numerous researchers have hypothesized that climate change, reflected in atmospheric and oceanic processes, is the driving force behind decadal scale variability in marine fish populations. However, due to the non-experimental nature of the studies, conclusive evidence of such an impact cannot be provided. In this study, I examine the relevant aspects of climate change and discuss physical processes that are capable of generating the observed variability in marine fishes with particular emphasis on Pacific salmon. Several difficulties generally arise in attempts to link climate change with large scale population fluctuations. One problem deals with the spatial nature of climate data and statistical techniques to handle the three dimensional variability. I show that a technique, developed in the field of meteorology, rotated empirical orthogonal function (REOF) analysis, is well suited to this problem. The output of REOF analysis is a set of physically interpretable modes of spatial variability and loading coefficients that illustrate the temporal evolution of each mode. I apply REOF analysis to fields of north Pacific sea level pressure, sea surface temperature, observed winds, wind stress and wind stress curl. I also demonstrate why the traditional method of non-rotated EOF analysis can generate spurious results. A second problem arises over attempts to explain how high frequency (interannual) atmospheric and oceanic variation can result in low frequency (interdecadal) variability in fish populations. To address this question, I review the theory of stochastic climate models and relate them to random walk models. The loading coefficients from the REOF analysis are then used as input to stochastic climate models.

2AM1993-FIS21

INTERANNUAL AND DECADAL VARIATION IN ABUNDANCE OF PACIFIC HAKE AND PACIFIC MACKEREL IN BARKLEY SOUND, B.C., AND EFFECTS ON MORTALITY OF JUVENILE SALMON

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Remarkably little is known about the processes which control the mortality of salmon in the ocean. One hypothesis is that variation in ocean conditions affects survival of juvenile salmon mainly by changing the abundance, distribution, or species composition of predators. Recent multi-disciplinary studies in British Columbia coastal waters confirm that large shifts occur in the abundance and species composition of several migratory fish species, associated with both interannual and decadal variations in ocean conditions. Pacific hake migrate into B.C. waters every year, but their abundance, migration timing, and distribution appears to be strongly affected by interannual variation in ocean conditions. Stronger variations in ocean conditions which occur on longer time scales (e.g. major El Nino events) can result in the sudden influx of other fish species, such as Pacific mackerel and Pacific sardine. Pacific hake and Pacific mackerel both preyed heavily on juvenile salmon and herring in near-shore waters. Variability in ocean conditions, and resulting changes in predator-prey interactions, may explain much of the variation in mortality of juvenile salmon, herring, and other pelagic fishes in B.C. coastal waters.

2AM1993-FIS08

POTENTIAL EFFECTS OF CLIMATE CHANGE ON ADULT FRASER RIVER SOCKEYE SALMON

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Global climate models predict that within 50 to 100 years, CO_2 concentration in the atmosphere will double and it is likely that climate patterns will change as a result. Changes to the climate of the northeast Pacific Ocean may affect the production of Fraser River sockeye (*Oncorhynchus nerka*), the most valuable commercial salmon species in British Columbia. We used output from the Canadian Climate Centre global climate model and an empirical relationship between zooplankton biomass and wind strength to develop temperature and food abundance scenarios that sockeye are likely to experience in the northeast Pacific as atmospheric CO_2 increases. The response of sockeye to temperature scenarios was determined by projecting results from 40-year empirical correlations between sea surface temperature, and abundance and mean weight of one Fraser River sockeye stock, the Early Stuart. The response of sockeye to the food abundance scenarios was evaluated with a bioenergetics model that predicted monthly specific growth during the ocean phase of life for Early Stuart sockeye. Under a doubling of atmospheric CO_2 our climate scenarios suggest a 2-4°C warming of sea surface temperature and a 5-10% reduction in zooplankton biomass in the northeast Pacific Ocean. Projections from the empirical correlation analyses and the bioenergetics model suggest that sockeye biomass will significantly decrease under our doubled CO_2 climate scenarios.

2AM1993-BIO10

BIOLOGICAL AND ENVIRONMENTAL HABITAT FACTORS FOR MARINE MAMMAL SPECIES CAUGHT IN THE NORTH PACIFIC DRIFTNET FISHERIES FOR SQUID

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Habitat requirements for northern right whale dolphin, *Lissodelphis borealis*, Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, Dall's porpoise, *Phocoenoides dalli*, and northern fur seal, *Callorhinus ursinus*, are identified via canonical correlation analysis comparing bycatch data for the high seas driftnet fisheries of the North Pacific and sighting survey data with associated biological and environmental data. Biological data include gut content analysis, other catch species, sighting surveys and midwater trawl samples from research cruises. Environmental data include data collected with each net observation and sighting, satellite images and ship of opportunity data. Canonical correlation analysis identifies the intervals within a set of continuous variables that is associated with the presence of individuals and estimates the probability that individuals are present for specific habitats within these ranges. Preferred habitats are those with a relatively high probability of having individuals present.

2AM1993-BIO02 INVITED

LATE 19TH CENTURY ANTHROPOGENIC INFLUENCE ON THE NORTHERN HEMISPHERE ATMOSPHERE

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Ice core data from Mt. Logan (Yukon) and from the Greenland Ice Sheet indicate elevated levels of several trace gases (CO_2 CH_4 N_2O) as well as chemical species, during the period 1850-1915. The Greenland core sites are believed to record anthropogenic signals from North America, which is the assumed main source for the "pollutants".

The data points to large scale biomass burning in the last five decades of the 19th century tapering off into the early 20th century. This is in agreement with an earlier hypothesis for the late 19th century "Pioneer Agricultural Explosion" by A.T. Wilson (1978). The atmospheric effects seem to be largely confined to the northern hemisphere.

Climatic and oceanographic data for the northern hemisphere during this period indicate a cold interval from 1860-1880, evidently the coldest time for the entire "Little Ice Age" that ended by the turn of the century. There is a strong suggestion that anthropogenic activities (burning of forests and planting of crops- mainly in North America) may have changed surface albedo in winter and atmospheric optical depth in summer (due to smoke) sufficiently to cause a small climatic anomaly over about 5 decades.

This climatic anomaly may have been reinforced by feed-back mechanisms. As glaciers temporarily expanded in many alpine areas during this time, and as stronger atmospheric meridional flow seemed to be prevalent then, crustal reloading and the rotation rate of the earth may have changed sufficiently to induce trigger stresses in the earth's crust. Enhanced volcanism would provide a positive feedback for cooling. Any greenhouse warming would have been overwhelmed.

2AM1993-POC01
DYNAMICS OF CIRCULATION IN THE NORTH PACIFIC
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Circulation in the North Pacific exhibits a number of distinct features which have largely eluded previous numerical modelling studies. These features include poleward eastern boundary currents which feed into a deep Alaska Stream. A strong counter-current lies seaward of the Alaska Stream. Current meters show southward flow along the western margin of the North Pacific whereas nutrient tracers imply northward flow. Models tend to carry Kuroshio water too far to the north, suffering excessive heat loss and failing to realize a southward East Japan Current. Modelled flows within the Sea of Japan, the Okhotsk and the Bering Seas are underdeveloped and often of the wrong sign. Why do models perform so poorly? We believe the equations of motion assumed for conventional modelling are wrong. The "missing physics" appears to result from interactions of myriad eddies with the shape of bottom topography, resulting in strong tendencies to drive large scale mean flows. We have studied this process from statistical dynamical theory, learning to bring the "missing physics" into corrected equations of motion. When this modification is applied to a traditional ocean model, the several defects are much reduced or eliminated. Among other results, the modification shows southward deep flow along the western margin with northward flow (carrying tracers) just seaward of the southward flow, implying recirculation over the trench systems.

2AM1993-FIS31
DECADAL SCALE SHIFTS IN OCEAN CONDITIONS AND THEIR IMPACT ON THE ABUNDANCE OF NORTHEAST PACIFIC FISH STOCKS
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Analysis of sea surface temperature data collected off the coast of the U.S. and Canada shows oscillating warm and cool ocean conditions on a decadal scale. Recruitment patterns of several marine fish stocks vary with ocean temperature conditions. These apparent temperature preferences are strong for the dominant species in the northeast Pacific, suggesting that large scale ocean variations may influence patterns of species dominance. We examine the impact of decadal scale shifts in the production of strong year classes on the relative abundance of selected marine fish stocks and explore two potential causes for shifts in abundance: a) those based on density dependent relationships, and b) those base on climate driven responses. This analysis suggests that climatic conditions should be taken into account when long term fishing strategies are recommended.

2AM1993-FIS03

NEW TECHNIQUE FOR MARINE ECOSYSTEM FORECAST AND MANAGEMENT: MARINE ECOSYSTEM MODELLING WITH GREY SYSTEM THEORY

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Grey system is defined as an abstract system characterized as no physical protoplast, no clear operation mechanisms and the model regarded as a representation for a certain abstract system is only an isomorphism with the original system by a given criterion.

Grey system theory is different from traditional system theory in ideology and equation form, classical system theory describes ecosystem mechanically in Aristotelian positivist point of view. Grey system theory, however, understands ecosystem with grey models, which are groups of abnormal differential equation adapted to the variance of the marine ecosystem rather than the first-order differential equations, are groups of the abnormal difference equations with variations in structure and time rather than the normal difference equations, and are of the approximated exponential law rather than the normal exponential law.

In terms of traditional ecosystem protoplast and the analysis of the contents of 2607 stomachs of 53 main species of fish, the Jiaozhou By (along the south Yellow Sea coast of China) ecosystem is divided nine sorts of subsystems:
1.phytoplankton 2.zooplankton 3.benthos 4.detritus feeders 5.zooplankton feeders 6.zoobenthos feeders 7.nekton feeders 8.bacteria 9.organic matter in sediment. Environmental factors in ecosystem are considered, such as:
1. geological factors: fault activity, sedimentary types;
2. structure and variation of hydrographical properties: temperature, salinity, water colour and transparency, tidal currents;
3. seawater chemistry: dissolved oxygen, PH value, total inorganic nitrogen and P, dissolved and particulate organic carbon (DOC, POC), particulate amino acids (PAA).

The relation among subsystems and environmental factors is modelled by GM (1, N) models. The amount of every living resource is forecast and programmed. Ecosystem and subsystem developing character is analyzed on basis of grey forecasting control theory.

2AM1993-POC15

STUDIES OF PROCESSES FOR THE INTERMEDIATE WATER MASS OF LOW SALINITY TO BE GENERATED IN THE NORTHERN PACIFIC

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One of the main problems concerning circulation in the Northern Pacific is formation mechanism and dynamics studies of the Northern Pacific intermediate water mass (NPIW) characterized by high oxygen concentration and low salinity. The NPIW conditions a series of processes related to the climatic and ecological problems of the Asian part of Russia and the U.S.A., to the biological resources of pelagic area and to the energy transformations of synoptical and climatic character in current systems.

The process of NPIW formation possesses a complex nature and it's conditioned by winter convection (deep waters ventilation from the sea surface) in the north-west of the region, the NPIW being further transformed by a complex system of the Northern Pacific currents. It probably exists three non-equivalent places for winter convection of deep waters, they are:

1. Kamchatka-Aleutian region of the Pacific Ocean. Here the NPIW formation is conditioned by two causes: winter convection occurring immediately in this region and water advection from the Bering Sea through the Aleutian Arc straits by Kamchatka Current.
2. There is no unique opinion about inner circulation of the sea and the winter convection power. Probably, there is a cyclonic type circulation at the background of circulation structures characterized by different signs of vorticity. In Karagin part of the Bering Sea the circulation structures of cyclonic vorticity are likely to predominate; they from the Kamchatka Current taking important part in advective process of the NPIW generation.

3. The sea of Okhotsk. Extreme properties of the Okhotsk Sea waters play an important role in forming the peculiarities of the Pacific Ocean circulation, and probably, a decisive role - in the NPIW generating.

In the bounds of the problem considered, the Pacific Oceanological Institute, FEBRAS, has carried out cruise and theoretical studies of currents in the Okhotsk Sea and Kuril-Kamchatka Region of the Pacific Ocean. The report presents dynamic structures of the mentioned regions, they are obtained on the basis of numerical modelling; it's analyzed water exchange in the South Kuril Straits.

2AM1993-POC06 POSTER

THE MODELING OF CROSS-STRUCTURE OF THE PACIFIC SUBARCTIC FRONTAL ZONE

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A variational approach for studying stationary states in ocean is proposed. General stationary equations of hydro- and thermodynamics are used in Euler's concept of the problem of functional extremum finding. This functional is settled in local potential form.

There is the physical essence in this approach. Minimum of the general entropy production takes place in any stationary state in the ocean. The local potential concept is similar to the Prigogine variational principle of minimum production of entropy.

Applications of the method are shown. The problem of the width of stationary geostrophic and thermo-haline fronts calculation is presented. The physical essence of the equilibrium width follows - the width corresponds to the state when the local potential (the general entropy production) has its minimum value. There are approximate solutions of cross-velocities at the fronts of subarctic frontal zones.

2AM1993-POC07

THE HORIZONTAL STRUCTURE OF THE NORTH PACIFIC INTERMEDIATE WATER OF LOWERED SALINITY

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New data on the structure of intermediate lowered salinity water of the North Pacific are considered. This layer has a regular horizontal structure to meridional direction. Each ~170 miles limited zones of lowered salinity were observed.

In winter such zones are assumed to be formed because of intensive downwelling at the Subarctic Front. There are two reasons of intensive downwelling of waters of lowered salinity to the intermediate depth in the winter season. First reason of seasonal maximum in winter, minimum in summer, is shown. The second reason is winter convection. The energy estimations are proposed.

2AM1993-POC26 POSTER

ON SOME PECULIARITIES OF CROSSFRONTAL STRUCTURE OF THE PACIFIC SUBARCTIC FRONTAL ZONE

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The following results of investigations are proposed:

1. Variational method of local potential for the study of the ocean stationary processes.

2. Variational model of three-dimensional circulation in density front (applied to Kuroshio). Dissymmetry of the crossfrontal structure of the flow. Displacement of stream axle to the North.

3. Seasonal variations of cabbeling in the Subarctic front. The formation peculiarities of intermediate layer with reduced salinity in the Subarctic Pacific.

2AM1993-MEQ11
RESULT OF MONITORING OF ADJACENT SEA OF JAPAN IN 1992
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The Environment Agency has carried out the monitoring of the state of the marine environment since 1975. The latest report of that monitoring is revealed after the examination of advisory group. The report says that the concentration of COD and Nutrient in sea water is almost equal to the average of the past, however TOC of sea water seems to be decreasing. Seeing the distribution of concentration of heavy metals of sea water, heavy metals in coastal sea water are higher than that of ocean. As for the annually trend of metal of each coastal and ocean waters, there is no difference and the level are keeping flat, PCB in sea water is not detected this year as usual. Ignition loss, sulfite and heavy metals in sea bed are all keeping the same level of the past. PCB contained in sea bed is decreasing from the level of previous year.

TBT and TPT are the hazardous materials for the marine environment and the production of TBT and TPT is restricted by law. Environment Agency has started the monitoring activity since 1988 and set the criteria for the environment in 1991. The monitoring activity is on going now. The report says concentration of TBT and TPT change accordingly to the zone or sample location, the coastal zone shows rather high concentration than that of ocean zone. The latest data show that TPT is not detected in sea water and TBT level is decreasing from the level of the previous year. TPT in sea bed is also decreasing, however TBT in sea bed are not decreasing. More study is necessary to evaluate the improvement of the environment through the control of the production and consumption of TBT and TPT.

2AM1993-POC16
FORMATION PROCESS OF OYASHIO WATER
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Oyashio is a current flowing southwestward along Kuril Islands and carries subarctic water to south of Hokkaido and Tohoku area, which is southwest edge of north Pacific subarctic region. Recent studies suggest that this area is important for the formation of North Pacific Intermediate Water. The formation process of Subarctic water carried by Oyashio Current needs to be clarified to make clear the interaction between the subarctic and the subtropical circulations, accordingly. In this study, Oyashio Current path, waters distribution along the path, and water mass fine structure are illustrated around Kuril Islands using CTD observational data in September 1989, 1990, 1991 and 1992. The purpose is to clarify where the sources of Oyashio Water are originated from, where the source waters are mixed, and how those waters are carried. The water flows out from Okhotsk Sea and mixed with the water originated from Bering Sea, carried south-westward along Kuril Islands. Isopycnal mixing between source waters is remarkable in both Okhotsk Sea and Pacific Ocean along Oyashio Current path in the subsurface temperature minimum layer, where sigma-t is 26.55 - 26.65, while it is remarkable only in Pacific Ocean in the subsurface temperature maximum layer, where sigma-t is 26.85 - 27.30. It signifies that the role of Okhotsk Sea as the formation area of Oyashio Water is more important in less dense layer.

2AM1993-MEQ16 POSTER
ANALYTICAL TECHNIQUES FOR ASSESSING ENVIRONMENTAL CONTAMINATION
M. M. **Krahn**, T. K. Collier, W. L. Reichert, J. E. Stein, S.-L. Chan and U. Varanasi

Over the past several years, the Environmental Conservation Division has invested considerable effort in developing reliable, cost-effective techniques for assessing chemical contaminants in environmental samples. For example, rapid high-performance liquid chromatographic (HPLC) methods have been developed to measure polynuclear aromatic hydrocarbons (AHs) in sediments, as well as AHs, AH metabolites and polychlorinated biphenyls (PCBs) in various tissues from a number of fish and marine mammals species. These methods have proven to be important tools for rapidly analyzing for contaminants in samples from coastal sites and were invaluable in assessing damage following the Exxon Valdez and Persian Gulf oil spills. In addition to the chemical methods, we have also developed biochemical techniques for measuring the effects of contaminants on biota. The levels of cytochrome P450 1A (CYP1A) increase

substantially in fish exposed to organic contaminants such as PCBs, dioxins, and AHs. We have evaluated the CYP1A response in fish exposed to a wide range of organic contaminants and our results showed that this enzyme system responds rapidly to very low levels of contaminant exposure. Moreover, we have found that contaminant-induced changes in CYP1A generally far outweigh changes due to other factors, such as species differences, time-of-year for sampling and gender in juvenile fish. The biotransformation of certain chemical contaminants, such as AHs, can lead to formation of reactive metabolites that bind to cellular DNA and this is believed to be the initiating step in chemical carcinogenesis. Laboratory and field studies with fish using the extremely sensitive ^{32}P-postlabeling assay have shown that DNA adduct levels in hepatic tissues are related to contaminant exposure in a dose-dependent manner and that DNA adducts are persistent. The use of CYP1A response and DNA adduct measurements, together with chemical techniques, in monitoring studies has significantly improved our ability to link chemical contaminant exposure of biota to biological effects, such as disease and reproductive effects.

2AM1993-POC18 POSTER

SEA SURFACE TEMPERATURE ANOMALY FLUCTUATIONS IN THE NORTH PACIFIC

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Spatial and temporal structure of sea surface temperature anomaly variations in the North Pacific for the 1957-1992 period has been studied. For each season several large-scale subdomains with coherent character of the SST anomaly fluctuations were defined on the basis of the hierarchical clustering method. In winter the spatial structure of the SST anomaly variations is characterized by existence of two independent patterns: there is an apparent out-of-phase relationship between the eastern and central North Pacific, and between its northwestern and southwestern parts. These patterns correspond strongly to the well-known winter teleconnections in the middle troposphere. During other seasons the correlations between the SST anomaly variations in different subdomains are weaker. However as in winter, these variations are associated with midtropospheric variability patterns. For all seasons the four groups of years with the essentially different regime of anomaly fluctuations were distinguished. For any season transition from one regime to another occurred rather abruptly and was observed in the same year in all subdomains. Changes in atmospheric circulation and heat fluxes at the ocean-atmosphere boundary during the shift from one climatic regime to another have been considered. The hypothesis about mechanism governing the large- scale SST anomaly fluctuations in the North Pacific is suggested.

2AM1993-FIS13

SIGNIFICANCE OF ABIOTIC AND BIOTIC FACTORS IN SHIFTS IN SPECIES DOMINANCE IN COASTAL PELAGIC ICHTHYOCENOSES IN NORTHWEST PACIFIC

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Sardine (Sardinops sagax melanosticta) and pollock (Theragra chalcogramma) are the most abundant and commercially important fishes in the coastal waters of the Northwest Pacific. These species are euryphags feeding not only in coastal waters but in adjacent areas of deep sea. The species are characterized by K-strategy (Odum, 1986), relatively long life cycle, steadyness to short-term unfavorable climatic and oceanographic impacts. The critical trait of their ecology is spawning in shelf waters which are inhabited by high abundant populations of smaller fishes, mainly r-strategists. These species utilize feeding resources of ajacent pelagial in less degree. Populations of these species are characterized by high intrinsic growth rate. However they never reach very high biomass.

Under unfavorable long-term climatic and oceanological conditions abundance of highly productive species decreases, resulting in partial unoccupation of their ecological niches and favouring sharp increase in abundance of small coastal competitive species. The presence of large concentrations of these species in spawning areas hardens the process of reproduction of the highly productive K-strategists. Then more or less long-term successional process occurs resulting in replacement of r-strategists by K-strategists in ichthyocenosis.

Due to autogenic processes in biological communities usually there is not close correspondence between abiotic factors and fish abundance. These factors serve as starting (when strong anomaly develops) or modifying mechanisms affecting biological processes.

These statements are illustrated by two examples. The first is the coastal pelagic ichthyocenosis of the Kuroshio region where climax state is associated with dominance of sardine with main competitors of anchovy and saury in spawning aresas. The second one is the ichthyocenosis of the Western Bering Sea where climax is associated with dominance of pollock with main competitors of capelin and smelt.

2AM1993-MEQ09

TRENDS IN ORGANIC CHEMICAL CONTAMINANTS IN SEDIMENT AND FISH ON THE WEST COAST OF NORTH AMERICA FROM 1984 TO 1989: RESULTS FROM THE NATIONAL BENTHIC SURVEILLANCE PROGRAM

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The National Benthic Surveillance Program began monitoring organic chemical contaminants in sediment and fish from 40 sites on the West Coast of North America in 1984. Data from 13 sites collected annually during the first six years of this program were analyzed for trends using Spearman rank correlation. Trends in several classes of contaminants, including polycyclic aromatic hydrocarbons (PAHs) and their derivatives, and a variety of chlorinated hydrocarbons such as polychlorinated biphenyls (PCBs), DDTs, and a number of non-DDT pesticides, were assessed in three types of "compartments" (sediment, fish stomach contents, and fish liver or bile) at each site. Meta-analysis was then used to assess overall trends in each class of contaminants at each site by combining the results from all compartments. Finally, results for each class of contaminants were combined for all sites to assess coast-wide trends. Examples of results include significant increases in concentrations of PAHs at two nonurban open coastal sites (Bodega Bay and Dana Point, CA), as well as at three sites in urban bays -- Commencement Bay (Tacoma), Hunters Point (San Francisco Bay), and San Pedro Bay (Los Angeles); significant decreases were found in sites from four urban bays -- Coos Bay, OR, Southampton Shoal and San Pablo Bay (both north of San Francisco Bay), and south San Diego Bay. Findings for the chlorinated hydrocarbons will also be presented. Possible mechanisms for offshore transport of organic contaminants will be discussed.

2AM1993-SB03

MONITORING OF THE BERING SEA AND GULF OF ALASKA USING TOPEX AND ERS-1 ALTIMETER DATA

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With the ongoing successful missions of the European Space Agency (ESA) ERS-1 and the NASA/CNES TOPEX/POSEIDON altimeters it is now possible for the first time to use two altimeter satellites in tandem to describe oceanic circulation variability. Our initial investigations have used an existing mean sea surface (Dick Rapp, Ohio State University) based on GEOS-3, Seasat and Geosat altimeter data, for removal of orbit error and calculation of the sea surface height (SSH) anomalies from the two satellites. A technique has been developed to correct the along track Rapp mean surface for these short wavelength geoid errors. Briefly, the technique is as follows:

1.Along track gridded data from each cycle is high pass filtered by a local linear de-trending of the SSH anomaly with respect to the Rapp mean sea surface using 30 sec arcs (approx. 200 km). This retains the short wavelength (< 200 km) geoid and mesoscale signal which is not contained in the mean surface.

2.Detrended repeat cycles are averaged to obtain a mean short wavelength correction to the Rapp mean surface along both the TOPEX and ERS-1 ground tracks. The averaging minimizes the contribution of the time dependent mesoscale signal.

3.Standard detrending of the orbit error and optimal interpolation can then be performed relative to the corrected along track mean surface to produce high resolution mesoscale maps.

The primary advantage afforded by this collinear technique over standard crossover techniques is that the increased temporal and spatial sampling from multiple altimeter missions may now be exploited to provide both near real time and long term monitoring capabilities. Application of these techniques to the Bering Sea and Gulf of Alaska will be presented.

2AM1993-FIS15

THE FLUCTUATION OF THE FISH SPECIES DOMINANCE IN THE EAST CHINA SEA AND THE OCEANIC CLIMATE EVENTS

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Based on the commercial catch data during 1970-1988, the fluctuations of the fish species dominance in the East China Sea ecosystems are described. The studies comparing the timing and magnitude of change in eastern and western areas of the East China Sea, and linkage between dominance shifts and the Oceanic climate events are also discussed. The migration of fish species dominance, for example the hairtail (*trichurus haumela*), seems to relating the oceanic climate events.

2AM1993-FIS25 INVITED

FISHERIES AND THE REGIME PROBLEM

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Major fluctuations of abundance and/or availability if fisheries resources are of paramount importance to the growth and sustainability of coastal and island economic development. Historical collapses of the sardine fisheries off Japan and California in the 1940's and of the anchoveta fishery off Peru in the 1970's demonstrate this point. Most of fisheries management has been based on the idea of equilibrium models (perhaps with high frequency 'noise'), and assumes that long-term changes in abundance are the direct result of exploitation. Yet it is becoming clear that there is a distinct low frequency environmental component to many changes in exploited marine ecosystems, and its interaction with patterns of exploitation presents a severe challenge to ecology and fisheries science.

With support from the Mexican government, an international group of researchers began meeting in 1988 to explore and analyze the great and often synchronous changes sardine and anchovy fisheries around the world. This group, which has evolved into SCOR Working Group 98, identified the "regime problem" as the following:

1. Coherent fluctuation over a time scale of decades exists in productivity of fish and the structure of their ecosystems; transitions between states are typically abrupt.
2. Worldwide coincidences of such regime changes imply links to global climate.
3. Rapid regime transition is presently (1988-1992) occurring in several major oceanic ecosystems.
4. Regime change poses severe problems for sustainability of economic development.
5. Regime changes, of far greater magnitude than interannual variation, present fundamentally different problems than are usually considered by fisheries science; existing approaches of fishery science are inadequate for management of sardine and anchovy fisheries and associated economic development.

2AM1993-FIS05 INVITED

EFFECTS OF ENVIRONMENTAL FLUCTUATION AND INTERSPECIFIC COMPETITION ON THE SPECIES REPLACEMENT PATTERN OF PELAGIC FISHES

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We consider a mathematical model which incorporates two factors affecting long-term fluctuation of planktotrophic pelagic fish: environmental fluctuation and interspecific competition. Long-term catch data of pelagic fishes in Japan suggest that the chub mackerel (*Scomber japonicus*, labeled A) was replaced by the sardine (*Sardinops melanostictus*, labeled B); *S.melanostictus* was replaced by the anchovy (*Engraulis japonica*), Pacific saury (*Calorabis saira*) and horse mackerel (*Trachurus japonica* and *Decapterus muroadai*), and these species (labeled group C) were replaced by S.*japonicus*. If species A defeats B, B defeats C and C defeats A in interspecific competitive ability, the mathematical model predicts that the abundance of these three groups fluctuate forever and dominate in the cyclic order. We call this cyclic advantage hypothesis for species replacement. In this model, environmental fluctuation greatly affects when the next replacement occurs, whereas cyclic relationship in competitive ability determines what is the next dominant.

2AM1993-MEQ15 POSTER

PARALYTIC SHELLFISH POISONING: TOXIN ACCUMULATION IN THE MARINE FOOD WEB, WITH EMPHASIS ON PREDATORY SNAILS AND HUMAN EXPOSURE

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PSP is a potentially life-threatening syndrome caused by a complex of neurotoxins produced by some species of globally-distributed dinoflagellates belonging to the genus *Alexandrium*. Filter-feeding molluscan bivalves have been considered the classical vectors of PSP from phytoplankton to humans. However the vectors of PSP toxin transmission through the marine food web are more complex than originally thought. Numerous species of marine invertebrates, not merely molluscan bivalves, can accumulate PSP toxins. Thus the classical model of PSP transfer has been revised to include additional marine invertebrates, particularly carnivorous gastropods, which obtain PSP toxins from their filter-feeding prey, such as clams.

The accumulation of PSP toxins in carnivorous gastropods is the most well-documented of all non-bivalve marine invertebrates. Considerable health risk could be associated with consuming moonsnails, whelks and other predatory marine snails. Marine snails can become toxic after consuming bivalves containing PSP. Moreover, bioconcentration of PSP toxins can occur when carnivorous marine invertebrates ingest organisms containing the toxin. Therefore, it is possible for carnivorous gastropods to concentrate PSP toxins to dangerous levels even though the levels of toxin in their prey may fall below the detectable level of 40 μg PSP toxin per 100g shellfish tissue.

Documented PSP illnesses and/or deaths have resulted from the consumption of recreationally harvested marine snails in Massachusetts, Argentina, Canada and Malaysia (Elbusto et al. 1991; Jaffar and Subramaniam 1984; Kan et al. 1986; Sang and Ming 1984; Medcof 1966; Tufts et al. 1975; Yasumoto 1983). Beaches are closed to harvesting in the United States and Canada when PSP toxin levels exceed 80 μg PSP toxin per 100g shellfish tissue. Many field-collected samples of marine snails, including whelks (*Buccinum undatum*), northern moon snails (*Euspira heros*) and other marine snails (*Oliva vidua fulminans* and *Zidona angulata*) have exceeded this closure level.

Recent changes in the demographics of recreational harvesters and species being harvested in Puget Sound increase the risk of PSP to some shellfish harvesters/consumers. In addition, the spread of PSP into southern Puget Sound has increased the number of shellfish harvesting beaches potentially affected by PSP. The species of marine invertebrates that have tested positive for PSP toxins and are found in Puget Sound include: abalone jingles (*Pododesmus cepio*), barnacles (*Balanus* spp.), beach crabs (*Hemigrapsus nudus*), hermit crabs (*Pagurus* spp.), kelp crabs

(*Pugettia producta*), moon snails (*Polinices lewisii*), periwinkles (*Littorina sitkana*), red rock crabs (*Cancer productus*) and dogwinkles (*Nucella lamellosa* and *Nucella lima*).

Many species of non-bivalve marine invertebrates that have tested positive for PSP, and moonsnails and whelks in particular, are consumed by recreational and subsistence harvesters in numerous North American locations. However, the agencies responsible for public health protection and beach closures in California, Oregon and Washington include only clams, mussels, oysters and scallops in PSP closures. Even though moonsnails, whelks, turban snails, tritons and other predatory marine snails are not included in PSP closures. The major consumers of these recreationally harvested marine snails are Asian-American and are at risk for PSP because they often lack any knowledge about PSP, have language barriers, and they may customarily harvest snails for subsistence in their native countries.

Recreational harvesters have long grown accustomed to gathering clams, mussels and oysters from Puget Sound. The monitoring program conducted by Washington state Department of Health has protected these harvesters against PSP for the past few years. However, the current PSP monitoring program in Washington state fails to include several invertebrates that are harbested for consumption and can accumulate PSP. Since a new risk exists, regulatory agencies should re-evaluate the species for which they ban recreational harvest due to PSP.

This project was sponsored by the National Network for Environmental Management Studies (NNEMS), a federal government internship program. The study was conducted by Alicia Matter under the supervision of John Armstrong and Roseanne Lorenzana at the U.S. Environmental Protection Agency, Region 10, in Seattle, Washington.

2AM1993-SB10 INVITED

IN-SITU MONITORING OF THE NORTH PACIFIC

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A variety of techniques are used to monitor the North Pacific, including: 1) surface weather reports from merchant and other ships, 2) satellites, 3) observations from research vessels and ships of opportunity, and 4) tide gages and shore stations. Although each system suffers from various problems, a mix of systems provides useful information. In-situ observations from ships are vital as satellites cannot provide complete coverage alone because of lack of subsurface coverage and frequent cloud cover. In total there are far fewer observations of subsurface conditions than of surface condition.

A primary present monitoring system is XBT's dropped from ships of opportunity. Although XBT's provide good coverage at moderate cost, they have only fair accuracy and their use is reducing as military budgets are cut. XBT's do not provide salinity information which is vital in areas like the Gulf of Alaska where salinity is more important than temperature in determining density. Many more CTD casts are needed to monitor the North Pacific. Expendable CTD's will not be suitable because of their higher cost than XBT's. Expanded reporting of weather and CTD profiles on research and fishing vessels is proposed.

The speed of data reporting and assembly is increasing. In the past most data were reported in "delayed-mode" but an increasing amount of data are reported in real-time along with weather data. Communications have advanced from HF radio telegraphy to GOES and INMARSAT A and C satellites. Data quality control and assembly is also improving and data are available on CD-ROM's, dial-up systems and Internet.

But the data are scattered in many different formats in different organizations and countries. An internationally distributed network of databases is needed, all sharing data in a common way for mutual data entry and access. Such a network of database management systems is evolving, based on standards being developed by the World Meteorological Organization for global real-time exchange of weather data. Compatible database systems are being installed at weather forecasting centers and climate research organizations and tested at fisheries laboratories. Users will be able to browse the databases over Internet and download data sets of interest.

2AM1993-SB18 INVITED

THE IMPORTANCE OF EASY ACCESS TO LONG-TERM OCEANOGRAPHIC DATASETS WHEN EXAMINING TRENDS AND CHANGES IN VARIABILITY

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The COADS dataset consists of the individual surface weather observations collected by merchant ships and other platforms of opportunity over the world oceans since 1854 until the present. About 100 million individual observations coming from various sources were compiled and validated through NOAA and the Cooperative Institute for Research in Environmental Sciences (CIRES). Thirteen parameters are available (sea surface temperature, air temperature, wind components etc.). The dataset utilizes about 2.4 gigabytes when stored in a compressed binary format.

For the Climate and Eastern Ocean Systems (CEOS) Project[1], the COADS dataset was rearranged and transferred to six CD-ROM disks, and a program to access the dataset was written. The access program allows one to select and summarize the raw data depending on the origin of the observation, the measurement procedure used or on some statistical properties of the observation. Problems in estimating trends in the data, or changes in variability, when compared to calculations not based on the raw data will be discussed, as well as spurious trends and misleading results from the raw data if the proper flags are not set. Such analysis would not be possible without the easy access to the 100 million individual observations in the COADS dataset.

[1]A research project on global change and coastal marine resources supported by NOAA (USA) and ORSTOM (France).

2AM1993-SB13

A HISTORY OF SHIP OF OPPORTUNITY OBSERVATIONS

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Ship of opportunity observations have been our only source of dense and prolonged serial data from distant reaches of the world oceans. This is particularly true of biological observations for which weatherships and freighters have been the only sources of extended data series. The Hardy plankton recorder programs in the Atlantic show intriguing long-term trends that require extreme care in interpretation. A review of the results and problems of the North Atlantic recorder programs will be presented, together with analysis of the differences that would be encounted in a North Pacific program.

2AM1993-FIS06 POSTER

ABUNDANCE OF 0-GROUP WALLEYE POLLOCK AND OTHER DEMERSAL FISHES OFF THE PACIFIC COAST OF EASTERN HOKKAIDO, JAPAN

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Juvenile of walleye pollock, *Theragra chalcogramma*; pacific cod, *Gadus macrocephalus*; and saffron cod, *Eleginus gracilis* were studied off the Pacific coast of eastern Hokkaido, to describe interannual variations in distribution and abundance, evaluate the feasibility of measuring year-class strengths. Beam trawl data were collected at a total 690 tows during the shishamo smelt survey in the autumn of 1983-92.

Walleye pollock were found in mainly the shallow areas at depths ranging from 40-70 m, and the maximum CPUE: catch per unit of effort at intervals of 10 m depth, of walleye pollock was 25.0 kg at depths ranging from 60-70 m in 1988. Pacific cod were caught in the areas at all intervals of 10 m depth in 1984, however, in the other years most of pacific cod were caught in areas at

depths ranging from 40-70 m. The year-class abundance index: the sum of the CPUE at each interval of 10 m depth, of pacific cod at the 0-group level varied greatly from 0.0 in 1992 to 294.2 in 1985. Saffron cod were found in the wide areas at depths ranging from 0-70 m, over the 10 years studied.

There were relationships between abundance indices of those three fishes and their catches by commercial fishing boats, respectively. The significant correlation was observed between the abundance index of walleye pollock and its 0-group abundance calculated with cohort analysis by other researchers. Therefore, this study suggested that we are able to measure the year-class strengths with the shishamo smelt survey.

2AM1993-MEQ07

COMPARISONS OF PCBs AND OTHER ORGANOCHLORINES IN CETACEANS FROM CANADIAN WATERS: SPATIAL AND TEMPORAL TRENDS AND DATA GAPS

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Since the mid-1980's we have measured PCB congeners, toxaphene (ΣCHB), chlordane, and ΣDDT group and other organochlorines (OCs) in pinnipeds and cetaceans from the Canadian Arctic, east coast (Gulf of St. Lawrence), and west coast (Strait of Georgia) with the objectives of documenting spatial and temporal trends of contamination in the marine environment and contributing to assessments of health of the species. Analysis of the Arctic animals, which are collected from annual native hunts, has permitted a detailed study of variations in contaminants in blubber with age, sex and geographical location. Samples from the east and west coasts are generally from limited numbers of dead, stranded animals which may not be representative of the population. Highest levels of OCs in Canadian waters are found in beluga from the St. Lawrence estuary where mean, ΣPCB concentrations in blubber of male beluga (N = 10; collected in 1988/89) were 94 ± 61 mg/kg. Blubber of killer whales and other cetaceans found dead in the Strait of Georgia and Vancouver Island region also contained mg/kg levels of ΣCHB, chlordane, ΣDDT, and PCBs. Arctic animals can be distinguished from those nearer pollution sources, using principal components analysis, by higher proportions of more volatile OCs such as chlordane and ΣCHB and lower proportions of higher chlorinated biphenyls.

2AM1993-BIO07

REPRODUCTION OF THE COPEPOD, *CALANUS PACIFICUS*, OFF SOUTHERN CALIFORNIA IN THEANOMALOUS WINTER-SPRING OF 1992, RELATIVE TO 1989-91.

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The positive correlation between the biomass of macrozooplankton and southward transport in the California Current is well established, as is evidence from "indicator species" of intrusion of southern water during Californian El Ninos. The relative contributions of advection of biomass and local alteration of the dynamics of endemic populations are less clear. Abundances and production of eggs by female *Calanus pacificus* were measured in the California Current System off southern California in winter and spring of 1989-1991, and in 1992 when El Nino-like anomalies in temperature and chlorophyll (a proxy for food supply) were present, especially in January. Effects on *per capita* reproduction were small, and were explanable in terms of the concurrent anomalies in chlorophyll. More important in overall effect on the population's reproduction were anomalies in the distribution and abundance of the female copepods. *Calanus* is a major component of the macrozooplanktonic biomass, and, in principle, its nauplii represent food for young fish. However, the distribution of larval anchovy is poorly correlated with egg production by *Calanus* even in non-El Nino years, so the potential impact on anchovy recruitment is difficult to estimate.

2AM1993-FIS23 POSTER

OCEAN GROWTH AND ABUNDANCE OF PACIFIC SALMON

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The Fisheries Research Institute (FRI), University of Washington, is conductiong new scale pattern and length studies on ocean growth of salmonids (*Oncorhynchus* spp.) using historical (1956-1991) collections of scales and length data from past high-seas research cruises by FRI and the U.S. National Marine Fisheries Service. This includes studies of changes in growth between years or periods of years and the relation of such changes to abundance of the same and other species of salmon, and to possible changes in oceanographic conditions. This paper summarizes methodologies and some initial results for pink salmon. A comparison of the scale patterns of maturing (even-year) pink salmon caught in the North Pacific Ocean (just south of the central Aleutian Islands) in July showed statistically significant differences in both early ocean growth and winter growth between years of low (1970-72) and high (1978) abundance of western Alaskan stocks. Fork lengths of fish in the two groups were not significantly different. The observed differences in scale patterns suggest that pink salmon in the high abundance group spent more time rearing in nearshore areas during their first summer at sea and had better winter growth than the low abundance group. Independent samples from other years and areas, as well as from other salmonid species, will be used to test relationships between coastal and winter growth patterns and abundance of Pacific salmon. The results are dicussed with respect to known ocean migration patterns of juvenile salmon and oceanographic conditions in coastal and winter rearing areas.

2AM1993-FIS32 POSTER

CATCH OF CHUM SALMON (*ONCORHYNCHUS KETA*) AND COHO SALMON (*ONCORHYNCHUS KISUTCH*) SOUTH OF THE SUBARCTIC BOUNDARY

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2AM1993-POC20 INVITED

POSSIBLE FORMATION MECHANISMS OF THE NORTH PACIFIC INTERMEDIATE WATER IN THE WESTERN NORTH PACIFIC

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The water heavier than 27.0 sigma-t is generated in the shelf region of the Okhotsk Sea due to active ice formation throughout winter. This water is believed to play important role in the formation of NPIW. However, the water is modified before it flows into the central part of the sea presumably mixed with cold fresh surface waters, and the intermediate Okhotsk Water flowing into the Pacific Ocean is too fresh to be the NPIW water. Therefore, there should be some mechanisms to increase its salinity values in the Oyashio or in the Mixed Water Regions. By using available observational data, I shall discuss several possible mechanisms:

1. horizontal mixing with Subtropical Waters such as the old salty NPIW carried back into this region by the Kuroshio and Kuroshio Extension,
2. salinity supply from deeper ocean due to upwellings related to abyssal global circulation, and
3. winter cooling of the salty Tsugaru Current Water or of the salty warm-core ring waters.

2AM1993-BIO11

EDDIES, FINE STRUCTURE AND ZOOPLANKTON ABUNDANCE IN THE NORTH PACIFIC SUBARCTIC FRONT ZONE

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Measurements and analysis of spatial-temporal distributions of plankton in oceans and seas revealed the fact that frontal and shelf zones are the most productive. Here are analyzed complex measurements from board the ship "Academic Nesmeyanov" in June 1987 in the region of the Pacific

Subarctic Front (the program "Megapolygon"). The main attention is given to relations between characterictics of the temperature field and distribution of zooplankton concentration. Detailed analyses of the data led to several important conclusions:
1) The full energy of the temperature fine-structure (the dispersion of vertical distributions fluctuations with scales less then 100 m) is not monotonous along the Subarctic and Polar fronts: maximum values adjoin fronts from north in zones of cyclonic eddies, minimum values adjoin fronts from south in zones of anticyclonic eddies.
2) Zones of maximum intensity of fine-structure and maximum zooplankton concentration coincide along the subarctic and polar fronts, that is the position of the maximum biomass coincides with the position of adjoined to the fronts cyclonic eddies and maximum intensity of vertical fine-structure.
3) Spectra of temperature vertical fine-structure are rather uniform in horisontal space in the range of vertical scales 20-30 m, at larger and smaller scales they form a sequence of closed maxima and minima. The gradients of small-scale components are almost everywhere higher than of large-scale components.
4) The detailed spectral analysis shows that zones of maximum abundance of plankton coincide with zones of maxima in fine-structure spectra in ranges 100-50 m and less than 20 m.
Several physical explanations for the dependence of bioproductivity on the hydrophysical parameters' vertical fine structure are given.

2AM1993-SB17
THE NORTH PACIFIC ECOLOGICAL MONITORING: SCIENTIFIC BASES, TECHNICAL POSSIBILITIES, ORGANIZATIONAL PROBLEMS
V.V. **Navrotsky**, A.A. Malyshev, *Pacific Oceanological Institute FEB RAS, Vladivostok*

There are before mankind two main problems concerning the ocean: 1) Effective use of biological, mineral, power and other resources; 2) Stability of ecosystems in the ocean, which is one of the principal components for securing equilibrium of natural processes on the earth. Till now these two problems are being solved to the detriment of one another: higher effectiveness of resources and production leads to higher damage in ecosystems. This is due first of all to the absence of integral models of the social-economical development, that would include ecological processes as a necessary and very important component. Elaboration of such models and conducting adequate politics are possible only on the basis of rather full information about resources, natural processes and anthropogenic impact on them. To receive such information, analyse the present state and forecast evolution of the ecosystems we have to conduct complex monitoring of the ocean. Several directions of using the Monitoring's results must be taken into account:
1) Hydrometeorology - interaction between the ocean and the atmosphere, that leads to the formation of weather and climate, influencing all processes of life on our planet.
2) Hydrophysics - the dynamics and structure of main hydrophysical characteristics, influencing hydrobiological processes and defining conditions for our activity in the ocean.
3) Hydrobiology - space-time laws of bioproductivity, based upon the interaction of biotic and abiotic processes.
4) Ecology - natural and anthropogenic processes, related to the consumption of different resources, as well as thermal, chemical, oil, radio-active pollution, energy production and various works construction.
The proposed program in its scientific and informational parts will tightly interact with existing international programs such as IGBP, JGOFS, WOCE, UNEP, WESTPAC, and must be conducted with participation of all countries of the region. Satellite, ship, aircraft, buoy and other observations can and must be united into general observational system directly interacting with the system for modelling, data assimilation and forecasting. The scientific problems, existing technological and methodological conditions for conducting complex ecological monitoring of the North Pacific are discussed as well as problems of financing and international organization of the works.

2AM1993-POC02

ZONAL TRANSPORT ESTIMATION FROM GEOSTROPHIC FLOW IN THE NORTH PACIFIC SUBARCTIC GYRE

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In order to estimate the zonal material transport in the subarctic gyre in the north pacific, we observed along longitude 180° from south edge of the subarctic gyre to the north one at same period on June in 1990-92 by T.S. OSHORO-MARU. CTD stations are over 30 points about 30 miles interval and 3000 m maximum depth. In this study we indicate the oceanographic conditions between both edges and the zonal transport of heat and salt carried with the volume transport referred to 3000 db. The geostrophic current in the transition domain is weak below 1500 db. In the surface layer, current direction turns to the opposite at some points and there seems mesoscale eddy. While in the subarctic current and the Alaskan stream, deep baroclinic field can be seen as B.A. Warren and W.B. Owens (1988) reported. Then geostrophic current is strong sometime over 10 cm/s at 1500/3000 db. The net volume transports of the subarctic current are 28.9-32.8 (sv), heat 396.2-457.5 (TW) and salt 1020.3-1148.0 (kt/s) eastward. And the net volume transports of the Alaskan stream are 23.9-33.1 (sv), heat 293.9- 430.7 (TW) and salt 836.8-1159.1 (kt/s) westward. In the past study, estimations about a volume transport of the Alaskan stream are very various, but it's made sure that it has over 23 (sv) at least in our study. The Alaskan stream volume transport in 1990, 33.1 (sv) is the largest value reported before and almost rewards the eastward volume transport of the subarctic current. With the object of a quantitative evaluation of a material circulation in the subarctic gyre, this study furnishes with much information.

2AM1993-FIS12 POSTER

COMPOSITION AND ABUNDANCE OF FISHES IN THE BATHYPELAGIAL OF THE OHKOTSK AND WESTERN BERING SEAS

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By now a level of fish catching in the traditional fisheries areas of the world ocean probably approached its limiting value. The further development of fisheries may be associated with use of new fishing areas and species. In this relation mesopelagic fishes are very perspective commercial species as they are wide-spread and have high abundance.

One of the main problems in development of their fishery is almost complete absence of data on their biomass and potential fishing grounds. Until now studies of these fishes were accentuated mainly on problems of systematic and zoogeography, and quantitative assessments were based in large extent on visual observations of their concentrations in the surface waters, percentage of various fish species in scientific catches, hydroacoustic data etc. This allowed to obtain only approximate estimates.

During October-December of 1990 the trawling survey was conducted in the bathypelagial (the 500-1000 m layer) of the Okhotsk and western Bering Seas. As a result, data on fish species composition were obtained and biomass of mesopelagic fishes was assessed.

In the western Bering Sea fishes of two families, Myctophidae and Bathylagidae, predominate in the 500-1000 m layer - 86.2% of total biomass (68.8% and 17.4%, respectively). The total biomass of mesopelagic fishes in the western Bering Sea was assessed as 2.96 mln tons (4.91 g/m^2).

In the Sea of Okhotsk fishes of the above two families also prevail in the ichthyocenoses of the investigated layer - 90.7% of total biomass (28.2% and 62.4%, respectively). The total biomass of mesopelagic fishes in the Sea of Okhotsk was estimated as 4.95 mln tons (5.68 g/m^2).

2AM1993-FIS14 INVITED

RECENT AND EXPECTED CHANGES IN THE ABUNDANCE AND GEOGRAPHICAL CENTERS OF ABUNDANCE OF THE DOMINANT EPIPELAGIC FISHES OF THE SUBTROPICAL NORTH PACIFIC

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The subtropical coastal regions of the North Pacific are not noted for the diversity of their epipelagic fish fauna. They are noted for the immense fisheries that this fauna has supported and for the regime scale nature of the biomass fluctuations of individual components of this fauna. The life history characteristics of the fauna are examined in relation to the physical and biological environment of the coastal transition zones of the North Pacific.

Life history features which appear to be associated with the regime scale nature of observed biomass fluctuations include indeterminate spawning, extensive seasonal migrations, and a unique type of stock structure. Growth rates and age at maturity also appear to be quite plastic; however, due to the length of the observed regimes (about 30 years) comparable data from different regimes is sparse.

Preliminary evidence suggests that the limiting factors on the Asian and American sides of the North Pacific appear to be different but linked by circulation. Nutrients appear to be limiting in the Kuroshio region and cold temperatures in the California Current region. Information on the California Current Region is presented which suggests that even a minor increase in global warming will result in extensive expansion of the subtropical fauna into the Oregon to Vancouver Island Region.

2AM1993-FIS16

JUVENILE SALMON AND PLANKTON TROPHIC INTERACTIONS DURING EARLY SUMMER MIGRATIONS ON THE B.C. CONTINENTAL SHELF

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There continues to be much debate over the importance of feeding and growth during early ocean migrations to the survival of juvenile salmon and their recruitment to adult populations. Large numbers of juvenile salmon migrating through an area may also be expected to severely impact local populations of zooplankton and larval flshes. We examine the diets and feeding rates of juvenile (mean length 115 mm) pink, chum and sockeye salmon collected from a large number of beam trawl samples off the west coast of Vancouver Island during early summer, 1992. Feeding success and dietary differences were examined on and off of the continental shelf, and between the northern and southern areas off Vancouver Island. The three salmon species differed overall on both short (stomach contents) and intermediate (^{13}C and ^{15}N stable isotope anomaly) time scales. Sockeye juveniles had low stable isotope anomalies and stomach contents dominated by euphausiids. Chum juveniles had high ^{15}N anomalies and stomach contents dominated by *Oikopleura* sp. Pink juveniles had high ^{13}C anomalies, but relatively little in their stomachs. Pink salmon also had unusually low stomach content weights relative to the other two species, and compared with literature values. The implications of these findings for growth rates and survival of these salmon species will be discussed.

2AM1993-FIS26 INVITED

PHYSICAL AND BIOLOGICAL CONSEQUENCES OF A CLIMATE EVENT IN THE CENTRAL NORTH PACIFIC

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A climate event in the central the North Pacific, which began in the mid-1970's, peaked in the early 1980's, and ended by the late 1980's, appears to have altered productivity at various trophic levels in the marine ecosystem in the central North Pacific. The event resulted in increased mixed layer depth and the frequency of deep mixing events, particularly during January - March. A number of biological time series for species ranging from primary to apex levels in the Northwestern Hawaiian Islands show corresponding declines in productivity of 30-50 percent from the early 1980's to the present. We hypothesize that during the early 1980's, increased mixing due to the

climate event resulted in greater nutrient input into the euphotic zone and ultimately increased ecosystem productivity. Productivity over a range of trophic levels declined when the climate event ended.

2AM1993-POC32
THE NUMERICAL SIMULATION OF THE THREE-DIMENSIONAL BAROCLINIC CIRCULATION ON YELLOW AND BOHAI SEA
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+*Institute of Oceanology, Academia Sinica, China*

Today the studies and forecasts of ocean environment, especially coastal ocean environment have got much attention all over the world, the theoretical and numerical studies on ocean environment of East China Sea is one of the focus researched by Chinese oceanologists.

A three-dimensional baroclinic circulation model on Yellow and Bohai Sea has been established n this thesis, and the numerical simulating studies of circulation on Yellow and Bohai Sea has been carried on.

In the three-dimensional baroclinic numerical circulation model on Yellow and Bohai Sea, the turbulent energy density considered in turbulent closure model has not been involved, the model is more simple than closure model and the amount of calculation has been reduced. In simulating study of circulation in winter and summer on Yellow and Bohai Sea, the influence factors like wind stress, thermohaline effect and boundary force infecting the circulation have been studied. From the results, we analyzed the character and the causes of formation of the density circulation of Yellow Sea cold water mass, Yellow Sea warm current, coastal current and Bohai Sea circulation.

By simulating, we can see upwelling exit in the centre and edge of Yellow Sea cold water mass, and between them is downwelling. The vertical circulation is exit in cold water mass from surface to bottom. The character of "jet" current of Yellow warm current has been verified, the characteristic and the way of Yellow Sea warm current in winter and summer has been drawn. In addition, using this baroclinic model, we have simulated the tidal Euler residual current on Yellow and Bohai Sea, and the characteristics of tidal residual current in winter and summer have been given.

2AM1993-FIS01
LONG-TERM VARIABILITY IN THE BERING SEA SURFACE GEOSTROPHIC CIRCULATION AND ITS POSSIBLE INFLUENCE ON THE PELAGIC FISH COMMUNITY
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Data of 1990-92 expeditions showed, that the Bering Sea surface geostrophic circulation is significantly changed in the comparison with data of 1986-89. The north-western flow from Near Strait to Kamchatka Strait took place from the fall 1990 (Verchunov, Tkachenko, 1992). The marked anomaly in the Bering Sea current pattern was fixed in previous studies: by Arsen'ev (1967) in winter 1952-53, by Natarov (1963) both in winter 1961 and in summer 1958-59. Alternatively, such flow was absent on schemes of the Bering Sea currents, as suggested by other authors: Ratmanov (1937) for 1932-33, Dobrovol'sky, Arsen'ev (1961) for 1950-56 with the same data of 1936-37, by Khen (1988) for 1954-84 summer, mainly from 1970's (mean data).

According these sources, following periods may be discerned in the Bering Sea circulation system dynamics: 1950-60's and 1990's when the north-western flow from Near Strait was mainly developed, and 1930-40's, 1970-80's, when it was not fixed. We offer, main reason of this anomaly is the Alaskan Stream flowing fluctuation under influence of the fluctuated sea level pressure field (Favorite et al, 1976). The Alaskan Stream slackening would determine the change of ratio between water volumes, transported through near Strait by the Alaskan Stream and Western Subarctic Gyre. Accordingly, in 1990's the interaction of north-western flow from the Near Strait and Kamchatka Current would form wide convergence in the confluence zone, and compensational divergence westernly. In the central Kamchatka Basin cyclonic Bering Sea gyre would have been dislocated eastly.

The circulation features, determining the direction and intensity of the transport of fish roe, larvas and juveniles, are the most essential for the influence on the fish communities. Eastern shift of the Bering Slope Current will increase inflow intensity of the walleye pollock larvas and fry into Anadyr Gulf, where feeding conditions are less favourable than in the Navarin region. The ocean water direct inflow into the Kamchatka Basin has already increased the occurrence frequency and abundance of the pacific mesopelagic fishes (Balanov, 1992), and changed the distribution of the immature sockeye and chum salmon in the feeding period in 1992.

2AM1993-POC22 INVITED

VARIABILITY OF CIRCULATION IN THE WESTERN SUBARCTIC GYRE, 1990-1992

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Data since the early 1950s have consistently shown the Alaskan Stream flowing northward into the Bering Sea through Near Strait. The stream thus provides low-salinity surface water and relatively warm (>4° C) subsurface water to the region. In late 1990, a satellite-tracked drifter moved with the Alaskan Stream due westward rather than northward through Near Strait. Concurrently, a Russian hydrocast survey showed a weakened Kamchatka Current compared with spring 1990.

In August 1991, a PMEL survey, with Russian participation, showed southward movement of the Alaskan Stream off Attu Island with the absence of any pure stream water in Near Strait. This resulted in relatively cold subsurface conditions in the western Bering Sea. Also, the Kamchatka Current transport (~6Sv) was only about half its normal value.

In September 1992, another PMEL survey indicated the Alaskan Stream moving north through central Near Strait, with an inshore branch moving eastward and through Buldir Pass. Data from three current moorings, of 13 month's duration, in Near Strait showed a complex, evolving flow field quite unlike the stable upstream flow of the Alaskan Stream. Stream inflow started in eastern Near Strait in October 1991; after early 1992, it was better developed in central Near Strait, in agreement with hydrocast results and drifter trajectories. No mechanism to induce this variability was found, but inertial effects may be a possibility.

2AM1993-POC29 INVITED

THE OKHOTSK SEA AS A VENTILATION SITE FOR THE INTERMEDIATE WATERS OF THE NORTH PACIFIC OCEAN

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Based on the field of density, it appears that below depths of a few hundred meters the waters of the North Pacific Ocean are in general not directly exposed to the atmosphere. There is ample evidence, however, from the distribution of chemical tracers that these waters have indeed been in contact with the atmosphere somehow within the past 25 years. This apparent discrepancy between the large-scale physical and chemical properties of the North Pacific can be resolved by examining the importance of marginal seas such as the Sea of Okhotsk and Japan Sea in the ventilation of the waters of the North Pacific thermocline. An examination of the distribution of dissolved oxygen and chlorofluorocarbon species in the intermediate waters of the North Pacific suggests the possibility that these waters were ventilated in the Sea of Okhotsk and then modified and advected into the North Pacific. By constructing simple budgets for mass, salt, and these tracers, it is shown that the property distributions are not inconsistent with the hypothesis that the Okhotsk Sea and possibly Japan Sea are the most important sites for active thermocline ventilation in the vicinity of the entire North Pacific Ocean. While this hypothesis can be verified indirectly by an examination of the tracer data, it is shown that this idea could likely be tested directly from a few high quality direct current measurements in the straits between the Sea of Okhotsk and the North Pacific.

2AM1993-FIS07 INVITED

TRENDS IN FISH CATCH AND OCEAN CLIMATE IN SOUTHERN BRITISH COLUMBIA DURING THE 20TH CENTURY

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This study evaluates relationships between ocean climate and the catches of thirteen coastal marine fishes and two mammals taken off southwestern British Columbia during the 20th Century. Ocean climate off southwestern BC was characterized using annual and quarterly sea surface temperature and annual air temperature anomalies. All temperature series show low frequency fluctuations with warmer eras extending from the mid 1920's to mid 1940's, mid 1950's to late 1960's, and late 1970's to present. Cooler eras dominate the temperature series from the early 1900s to mid 1920's, mid 1940's to mid 1950's, and late 1960's to late 1970's. Associated with the fluctuations in ocean climate are changes in the qualitative and quantitative trends in fish catch. Most resident species, like Pacific herring and Chinook salmon, were found to be more abundant in cooler eras. Conversely, catches of most seasonal migrants, like Pacific hake and sardines, were found to be greater in warmer eras. Several factors are likely responsible for observed differences in fish catch between warm and cool eras including, variable recruitment due to different prey production potential, availability to the fishery, and impacts of predation and/or competition from seasonal migrants.

2AM1993-POC04

CLIMATE-RELATED PHYSICAL AND BIOCHEMICAL PROCESSES IN THE PACIFIC WESTERN SUBARCTIC GYRE

K. **Rogachev**, P. Tishchenko, A. Bychkov, Pacific Oceanological Institute, Vladivostok, Russia.

The climate-related investigations for the region of western Pacific subarctic in Russia, on-going or completed recently in cooperation with Canada, is reviewed. Two years of surveys in the area of Kuril and Kamchatka currents include detailed physical and hydrochemical, mainly of CO_2/climate issues, observations for both large-scale and synoptic-scale processes. The research work focuses on the role of anticyclonic rings in the structure and dynamics of Kuril and Kamchatka currents. We show the extremely long life of the rings and the differences in dynamics of the Kamchatka and Kuril rings. Detailed hydrochemical observations for winter anticyclonic rings of western subarctic gyre were conducted by POI. Extremely high values of pCO_2 were found in the region of western subarctic boundary currents. High values correspond to the regions of anti-cyclonic rings associated with these currents and to Kamchatka Bay. It is shown that two physical processes are responsible for these high surface pCO_2 values. The first is connected with intensive vertical mixing in the ring's core, which is due to resonance of inertial motions with diurnal tides. The second process associates with the mechanism of deep water renewal in the region. These processes are probably the main mechanisms for high concentrations of nutrients in upper oceanic layers far from the shelf. Comparison of the hydrochemical parameters of anticyclonic eddies registered in summer and winter demonstrates that winter pCO_2 is 100 ppm higher than in the atmosphere, and the maximum difference is in the area of rings. In summer, a CO_2 flux is directed from the atmosphere into the ocean only in the area of the anticyclonic ring. Since 5-6 anticyclonic rings may exist in the region simultaneously, their CO_2 consumption is an important feature of the subarctic waters during warm season.

2AM1993-POC08 POSTER

OCEANOGRAPHIC DATA BASE ON THE NORTHERN PACIFIC AND MARGINAL SEAS: CONTEMPORARY CONDITIONS AND PROSPECTS OF DEVELOPMENT

I.D. **Rostov** and E.V. Dmitrieva, *Pacific Oceanological Institute, Vladivostok, Russia*

At present historical data of long-term oceanographic observations carried out by different organizations under regional, national and international programs are dispersed between holders both national and international levels. Many of these data may be at risk of being lost from many reasons. Some data have not been recorded at modern data medium, they are stored as manuscripts, on paper tapes and on magnetic tapes of outdated computers. It is a great interest to

improve the accessibility of these data by means of integration all data which are available and creation of timely and complete data sets.

In bounds of WESTPAC Project and in according to International Oceanographic Data Archaeology Project by initiative and support of US NODC/WDC-A have been prepared a joint data set on North Pacific Ocean in support of national and international marine research programs. POI possesses several massives of oceanological data. They comprise CTD data, obtained in POI cruises for 1975-1992, data bases archive material and copies of historical data of various origin for the period from 1900.

All these data reorganized in standard form of special data base. Next steps of data collection and data processing are following:

1. To implement data quality control and control on duplication, data editing and data set formation on regular grid on standard depth levels. Finding and saving new historical data.
2. To studying dynamics and water masses characteristics variability on WESTPAC and other projects.
3. To adapt and to work out new methods sea variability modelling, monitoring and prediction.

To prepare of computer atlases.

4. To establish Regional Data Centre for acquisition and storage of data.

2AM1993-POC09 POSTER

INTRUSIVE LAYERING AND WATER MIXING IN FRONTAL ZONES AND EDDY FORMATION AREA OF KURIL-KAMCHATKA REGION

I.D. **Rostov**, G.I. Yurasov, I.A. Zhabin, V.P. Tapinov and E.M. Boyko, *Pacific Oceanological Institute, Vladivostok, Russia*

The special mode of small-scale water interlayering in the Kuril-Kamchatka region is closely connected with special dynamic processes near passes, on the island ridge shelf and in the adjacent areas. It is caused by interaction and mixing of the Pacific, Okhotsk Sea and coastal waters, instability of the East-Kamchatka and Kuril (Oyashio) currents, long wave spreading and eddy formations.

By CTD data of seasonal and satellite infra-red observations, the local hydrological fronts and eddy formations are identified in the area of subarctic waters transformation in Kuril-Kamchatka region. The results of joint analyzing the dynamic topography charts, spatial distribution of the thermoclinity and baroclinity values, parameters of inversion layers and Cox fine structure number are discussed.

In near-Kamchatka region two main frontal margins are distinguished: near-surface slope-shelf front and subsurface circulation-intrusional front on the western margin of the East-Kamchatka Current, and also secondary fronts, located on margins of eddy formations. In frontal zone of the East-Kamchatka Current and at the periphery of eddy formations, higher levels of fine structure intensity have been observed, being related to the intrusion interlayering of waters. Intrusion-inversion layers are traced here up to the depths of 500-650 m. Horizontal and vertical heat flows, conditioned by intrusion dissipation, have been calculated.

In near-Kuril region intrusion-inversion formations reach the depths of 800-1000 m and are concentrated in water thickness of the cold and warm intermediate layers. The highest values of the thickness for the inversion layers and anomalies of temperature are observed in the Kuril-Oyashio currents system area. The processes of double-diffusion and dynamic factors promote to intensive mixing and transformation of water masses interacting.

2AM1993-POC10 POSTER

FINE STRUCTURE OF WATER MASSES IN THE NORTH-WESTERN PACIFIC: STATISTICAL GENERALIZATION

I.D. **Rostov**, *Pacific Oceanological Institute, Vladivostok, Russia*

By the present time reliable data proving the existence of a close relationship between the distribution of parameters of the fine structure, space inhomogeneity, dynamic conditions and characteristics of biological productivity of sea water have been obtained.

On the basis of a many years' CTD-sounding data the peculiarities of space distribution and space-time variability of fine structure characteristics in the main structural zones of the North-western Pacific are revealed. It is established that the regions with different conditions of the fine structure generation are distinguished by their forms and values of statistical characteristics.

For the experimental data processing, the basic attention was paid to the study of inversion characteristics, distribution of layers with different vertical temperatures and salinity gradients which were derived from initial realizations by piecewise-linear approximation of profiles as well as of the amplitude composition of fine-structural perturbations.

Basing on the average values of many year temperature and salinity data, the structural zones and layers, when double-diffusive processes can be active, have been obtained. It is shown that these zones and layers are associated with boundary position of intermediate water masses and fronts. The constancy of density ratio R for certain regions was found out. The results obtained are in good agreement with CTD-measurements.

It is shown that combination of various mechanisms generating individual elements of fine structure leads to interleaving and stirring processes in water. We have found some evidence for the presence of relatively stable and typical small-scale structures in various regions. The structures are characterized by different forms, space-time scales and profile disturbance amplitudes. Close relationship is observed between the variability of fine structure statistical parameters and the main peculiarities of stratification and dynamic conditions of water. Thus, a preliminary classification of the water area according to the vertical distribution and intensity of fine structure can be based on traditional ideas about the main structural zones of the ocean.

2AM1993-POC25 INVITED

TIME SERIES MEASUREMENTS IN THE NORTHERN NORTH PACIFIC

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Temperature and salinity versus depth at the mouth of Resurrection Bay provide evidence that temperatures in the upper 250 m increased by more than 1°C from 1972 to 1986, but are now decreasing. Subsurface temperature anomalies are well correlated (~ 0.58) with the air temperature anomalies at Sitka, Alaska, so coastal air temperatures have been used as a proxy data set to extend the ocean temperature time series back to 1828. Up to 30 percent of the low frequency variance can be accounted for with the 18.6 year nodal signal. Similar low frequency signals have been reported for other high latitude sites. These low frequency ocean-atmosphere variations must be considered in high latitude assessments of global climate change since they are of the same magnitude as many of the predicted global changes. ENSO events are evident in the thermal records but are relatively short lived as compared to the interdecadal temperature variations.

The 18.6 year lunar nodal tide can also account for 59% of the variance of the halibut biomass in the Gulf of Alaska. The actual linkages of tidal variability and halibut biomass are uncertain and responses of other fisheries are being investigated. To extend our knowledge of these temperature fluctuations to understand better the fluctuations of the marine ecosystem, we must expand, on interdecadal time scales, the measurements to include nutrients, primary production and larval fish. The conclusions of these studies should be applicable to other high latitude regions in the world.

2AM1993-FIS30 INVITED

VARIABILITY AND SUSTAINABILITY OF BIOMASS YIELDS IN LARGE MARINE ECOSYSTEMS

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A significant milestone in marine resource development was achieved in July 1992, with the adoption by a majority of coastal countries of follow-on actions to the United Nations' Conference on Environment and Development (UNCED). The UNCED declarations on the ocean explicitly recommended that nations of the globe: (1) Prevent, reduce and control degradation of the marine environment so as to maintain and improve its life-support and productive capacities; (2) Develop and increase the potential of marine living resources to meet human nutritional needs, as well as social, economic and development goals; and (3) Promote the integrated management and sustainable development of coastal areas and the marine environment. The UNCED declarations on the world ocean are consistent with the UN Law of the Sea Convention that established Exclusive Economic Zones (EEZs) up to 200 nautical miles from the baselines of territorial seas, granting coastal nations sovereign rights to explore, manage and conserve the natural resources of the zones. Within and extending seaward beyond the boundaries of the zones are large marine ecosystems (LMEs) that are being subjected to increased stress from growing exploitation of fish and other renewable resources, coastal zone damage, river basin runoff, dumping of urban wastes and fallout from aerosol contaminants. Results of LME studies on variations in biomass yields are examined in relation to principal driving forces including natural environmental perturbations, coastal pollution, habitat degradation and overexploitation of living marine resources. Among the LMEs compared with regard to the driving forces affecting sustainability of biomass yields, are the Kuroshio Current, the Oyashio Current, the Gulf of Thailand, the South China Sea, the California Current, the Humboldt Current, the Okhotsk Sea, the Great Barrier Reef, the Gulf of Mexico and the Yellow Sea. The designation and management of LMEs is, at present, an evolving scientific and geopolitical process. Sufficient progress has been made to allow for useful comparisons among different processes influencing large-scale changes in the biomass yields of LMEs.

2AM1993-POC36 POSTER

ON BIOLOGICAL PRODUCTIVITY AND DISTRIBUTION OF MARINE ORGANISMS

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The investigation of the relation between hydrophysical and biological occurrences was carried out on areas and long meridional sections in the western Pacific Subarctic zone and in the Okhotsk and Japan seas.

Multifrequency signals (frequency band 10-140 kHz) were used for remote acoustic sounding. Energy and frequency characteristics of volume sound scattering caused by small scale turbulence, hydrophysical field microstructure, biological assemblies and small-scale processes attendant on large-scale events (eddies, frontal zones, internal waves etc.) are measured. Moreover average and pulsations quantities of temperature, salinity, sound velocity and current velocity horizontal components are measured on a lot of discrete locations.

The obtained data enable us to see regular latitude large scale changes of volume sound scattering caused by biological objects and to determine the inherent features of sea water sound scattering properties in studied regions. Influence of various scale hydrophysical processes activity on biological productivity was estimated by using acoustic sounding. This data have made possible the study of biological objects distribution in oceanic eddies, local fronts etc. and obtaining migrant animals reaction on hydrophysical field finestructure and their location in the thermocline at night.

2AM1993-POC13

ANTICYCLONIC WARM EDDY IN THE WESTEM PART OF THE EAST SEA (JAPAN SEA)

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The circulation of water in the western part of the East Sea (Japan Sea) was examined during the spring of 1992 from March to June. Several warm eddies were observed near the Ullung

Island using the ADCP current measurement and CTD castings. One of these eddies was found at 38° 30' N, 129° 40' E in March. In the center of this warm eddy, thick homogeneous layer of 10°C water were shown from the surface to about 230 m depth. Maximum velocity around the eddy was 60 cm/sec. This eddy showed similar temperature and salinity structure of the typical over-winter warm eddy originated from the Kuroshio area. It had a diameter of 190 km and depth 300 m. In June, the isotherm of 10°C was found at below 50 m depth due to the stratification by the surface heating. This anticyclonic warm eddy was moved northward very slowly from March to June. It seems the location of this warm eddy moved northward more than 38°N.

2AM1993-BIO06

ON THE BEGINNING OF LARGE REFORMATION IN COMMUNITIES OF PLANKTON AND NEKTON OF THE FAR EASTERN SEAS

V.P. **Shuntov**, E.P. Dulepova, V.I. Radchenko and O.S. Temnykh, *TINRO, Vladivostok, Russia*

From the beginning of the 90-th there observed the significant changes in composition and structure of pelagic communities of the far Eastern Seas, evidently, connected with the beginning of colder winter.

Last years in Russian economic zone the summary fish biomass decreased on 13-14 mln t. mainly at the expense of walleye pollock and sardine-ivashi. These species are the mass consumers of zooplankton both on the shelf and in deepwater hollows. On the other hand the abundance of predatory plankton, especially Sagitta, increased in most areas of Far Eastern Seas (table).

Reduction of abundance of fishes can be considered as one (only one) of the reasons of increasing of predatory zooplankton quantity. The last one caused the decreasing of real production of plankton communities.

The authors consider that mentioned changes in biot are connected with synchronous break in 22- and 40-60 year cyclic in climate at present period.

Biomass (g/m2) and production (g/m2) of zooplankton in the Okhotsk and Bering Seas in summer of 80-th (1) and 90- (2)

Area	Peace plankton biomass production				Predatory plankton biomass production			
	1	2	1	2	1	2	1	2
Olyutorsko-Navarinsky	196	82	595	271	98	58	156	181
Karaginskiy shelf	18	56	34	195	1	17	1	82
Komandorskaya Hollow	118	108	419	392	46	75	157	220
North-East Kamchatka	289	104	1760	517	68	50	221	164
South-East Kamchatka	123	121	494	602	50	73	179	256
Central Okhotsk Sea	249	86	877	490	49	58	162	192
South Okhotsk Sea	206	145	968	623	50	123	95	407

2AM1993-POC17 POSTER

THE STATISTICAL ANALYSIS AND DYNAMIC INTERPRETATION OF TEMPERATURE VARIATIONS NEAR THE SHELF BOUNDARY

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The theory of empirical ortogonal functions (EOF) is used for exlaining the vertical structure of temperature variations near the shelf boundary of Japanese Sea.

The statistical nature of temperature variations is summarized by correlation tenzor of temperature variations. The presentation of the correlation tenzor in the series on EOF (Obuhov, 1959) and in the series on the tidal eigen function (TEF) of the boundary value problem gives the connection between EOF and TEF.

In the present work examined the relationship between EOF and TEF for time periods corresponding to the tidal period and to the several tidal periods. It is established that the using of

the EOF allows to obtain the mode structure of temperature variations and energy of each internal mode. The method allows to obtain the energy predominance of the second mode osilation for some periods with respect to the first mode that may be accounted for by the formation of internal hydraulic jump (IHJ) of the second mode.

A three layer nonlinear hydraulic model is proposed to explain the observed peculiarities of the thermocline structure. The generalization of the Long's (1972) model gives the deepening and thickening of the thin thermocline as a result of the IHJ formation of the first and second modes.

2AM1993-SB09 INVITED

ON A USE FOR LONG-TERM OBSERVATIONS ON PLATFORMS OF OPPORTUNITY FOR SIMPLE POPULATION MODELS OF FISH

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The encounter of the West Wind Drift (WWD) of the North Pacific (NP) ocean with the North American continent may have a profound influence on long-term changes in the recruitment and hence growth rates of fish populations. The tests of hypotheses under this paradigm would require a massive multi-scale set of observations on fish population parameters, satellite time series, and shore-station measurements. Existing data implicates important controlling characteristics in the decade to century time scales; the NP survey in 1955 had the appropriate spatial scale and CalCOF1 has the appropriate time scale but no effort has been assembled to monitor the large spatial scale that the multi-decade time scale of fish population change implies.

What do we expect at the larger space scales and longer time scales? Will the environmental changes be sustained and subtle? Will the environmental changes be marked by the frequency of substantial events like 'ENSO' or super-cyclonic storms in the transition zone of the Northeast Pacific? How do the chronic or episodic changes interact with the various fish population life-histories?

Even if only crude measures of temperature, biomass and advection are made available from platforms of opportunity, we could see material improvement in the efficacy of simple population models. Ships of opportunity with ADCP's recording both amplitude and frequency domain data and moored ADCP's would be the most useful platforms of opportunity but virtually any ship reporting GPI navigational drift, surface temperature, XBT profiles, and/or water color would be worth archiving for the purpose interpreting long-term changes in the rate of population growth of major fish populations.

2AM1993-MEQ02

EFFFECTS OF SEAFOOD WASTE DUMPING ON THE MICROBIAL AND MEGAFAUNAL COMMUNITITES OF AN ALASKAN BAY

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A submersible was used to count epibenthic organisms along 35 transects within Chiniak Bay, Kodiak Island, Alaska, where fish processing wastes have been dumped by barge regularly through the past decade. Control transects (15) were examined in nearby Monashka Bay, which had received no dumping, and had similar water quality (DO, pH, temperature, salinity) but a slightly greater sand/silt ratio. One dive was made to follow a waste to the bottom; fish waste settled to the bottom (150 m) during an hour after dumping. Consumption and decomposition was rapid; half life of a waste abundance index was 8.7 days at 3.6°C, reaching a non-detectable level 43 days after dumping. Diversity and species richness were greater in Chiniak Bay (the dumpsite) than in Monashka Bay, due to dominance of the latter by Caridean shrimp, mostly *Pandalus borealis*, which accounted for 80% of individuals there. Fourteen taxa (of which 8 were rare) showed significant differences between the bays, but were about equally divided between increases and decreases. Cluster analysis showed that samples tended to be most similar to adjacent samples; there was no clustering effect due to fishwaste. Discriminant analysis produced correct re-classifications for only 67% of samples where waste occurred. Microbiological analysis of water and

sediment samples from three sites in each bay showed no significant differences in concentrations of bacterial flora in water samples, but sediment loads were significantly greater in the dumpsite, and of similar quality to samples from fresh fishwaste. Results suggest that long-term waste dumping has resulted in increased bacterial concentrations in the sediment, probably due to the increased nutrient load, and which probably contribute to the high decomposition rate. However, long-term impacts on the community of epibenthic megafauna could not be conclusively demonstrated; observed differences between the two bays were biologically minor, and possibly due to physical differences in the substrates sampled.

2AM1993-SB11 INVITED
OPPORTUNITIES FOR COOPERATIVE USE OF NOAA PLATFORMS
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The National Oceanic and Atmospheric Administration operates a fleet of 18 research, fisheries, and charting ships to respond to the needs of its various programs, some of which require routine or occasional operations in the North Pacific and Alaskan waters. These ships carry a variety of oceanographic and meteorological data collecting instruments and are capable of operating under a variety of sea regimes. It is possible for non-NOAA programs to conduct cooperative research and monitoring, either by working directly with NOAA programs in integrated studies, or when appropriate, directly with NOAA's fleet operator by collecting data on a basis that does not interfere with the primary objectives of a cruise. These data collection efforts can include a variety of standard oceanographic measurements.

A brief description will be presented of typical recent cruises that support ongoing NOAA programs in the North Pacific and Alaska, a general overview of the shipboard data collection capabilities, and procedures by which further information can be obtained.

2AM1993-FIS27 INVITED
EFFECT OF CLIMATIC AND OCEANIC EVENTS ON LONG-TERM VARIATIONS IN PELAGIC FISH POPULATIONS FOCUSING ON JAPANESE SARDINE
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In the eastern boundary areas of the Pacific, variations in equatorward winds which induce coastal upwelling are considered to be the most influential to year-to-year variations in the recruitment and replacement of the dominant species of the pelagic fish. Whereas, in the western boundary areas, effect of the variations in the current patterns of the western boundary currents, such as the Kuroshio, is considered to be the most influential factor the variations in the recruitment of the pelagic fish, such as Pacific sardine and anchovy. However, the main spawning season of the Japanese sardine is during mid winter ~ early spring when the surface water is cold and rich in nutrients because of winter cooling and mixing. Hence, winter monsoon may also have an important effect on the primary production, offshore transport of larvae and turbulent motion.

In this paper, possible effects of climatic and oceanographic events on long-term variations in the Pacific sardine population around the Japanese Islands in this century are discussed. The focus is firstly on the combined situation of extremely calm winter monsoon and straight path of the Kuroshio, which induced a dominant year class in 1972 and rapid increase of the sardine stock in early 1970's. Second is the effect of upstream expansion of the main spawning ground along the Kuroshio. This was caused by an abnormally cold winter in 1963 and by the start of the Kuroshio meander in 1975, affecting on the rapid increase of the sardine stock in the early 1970's and in early '80s. The third conspicuous event are the offshore shift of the sardine's spawning ground into the Kuroshio water after mid '80s and northward retreatment of the Oyashio water in 1988-91, which might cause catastrophic decrease of the recruitment rate, respectively.

2AM1993-POC27 INVITED

ON NORTH PACIFIC INTERMEDIATE WATER FORMATION

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North Pacific Intermediate Water (NPIW), as recognized by its salinity minimum, is formed in the Mixed Water Region. Ventilation of the waters in the NPIW density range and down to a density of 27.6 σ_θ occurs in the Okhotsk Sea, based on salinity and oxygen distributions on isopycnals. No salinity minimum is produced with this ventilation. A portion of the ventilated water from the Okhotsk Sea is advected southward by the Oyashio and a portion of this enters the Mixed Water Region.

New NPIW is defined as that which is flowing eastward out of the Mixed Water Region at 152°E, between the Subarctic Front and the Kuroshio Extension. It is composed of about 45% Oyashio Water, whose ventilated signature comes from the Okhotsk Sea, and 55% Kuroshio water. The net amount of Oyashio water which thus enters the subtropical gyre in the density range of 26.65- 27.4 σ_θ is about $3x10^6 m^3/sec$.

The predominant cause of formation of the NPIW salinity minimum in the Mixed Water Region is intrusion of Oyashio water into warm core rings composed initially of Kuroshio water. Winter modification of the warm core ring's pycnostad is not a factor. However, air-sea fluxes in the Mixed Water Region may determine the density of the predominant salinity minimum by setting the maximum average winter surface density. This maximum occurs in water of Oyashio origin to which more saline Tsugaru Water has been added, allowing the surface density to be greater than in the Oyashio water itself. Vertical mixing between the Oyashio and Kuroshio water after formation of the salinity minimum is also viewed as essential to production of the observed new NPIW.

2AM1993-SB02

***IN SITU* MONITORING OF CHLOROPHYLL-*A* AND SIZE SPECTRA OF PHYTOPLANKTON VIA LASER-INDUCED FLUORESCENCE THROUGH AN OPTICAL FIBER ON JAPAN-KOREA FERRY**

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We developed a prototype laser/fiber-optic system for measuring *in vivo* chlorophyll-*a* fluorescence and size spectra of phytoplankton. This system is compact enough to be operated in ships of opportunity. Tests have been done on a ferry shuttling between Kobe (Japan) and Pusan (Korea). This produced additional data to measurements of basic environmental factors being attained on the ferry as mission-oriented baseline monitoring by Center for Global Environmental Research, NIES. Analyzing seawater pumped directly from beneath the ferry into the engine room, measurements were continuously recorded every ten minutes during each cruise of 20 h covering 700 km. Spatial resolution is hence calculated to be 5 km. There seems to be some relationship between environmental factor distributions and spatial patterns in chlorophyll-*a* fluorescence plus size spectra of phytoplankton. For example, higher fluorescence and larger size spectra are seen at nutrient rich areas, and vice versa. Deploying such an advanced sensor technique for monitoring on ships of opportunity will give us basic knowledge on the relation between phytoplankton characteristics and global environmental changes.

2AM1993-FIS19

THE INFLUENCE OF OCEAN CURRENTS ON SOCKEYE SALMON RETURNING TO THE FRASER RIVER

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Spatially-explicit, individual-based biophysical models were used to examine the hypothesis that northeast Pacific Ocean surface currents affect latitude of landfall, coastal migration route, and return time of Fraser River sockeye salmon (*Oncorhynchus nerka*). The effects of anomalous prevailing surface currents and eddies were modelled for sockeye with compass-orientation, bi-coordinate navigation and rheotactic behaviours. Except for a specific combination of goal orientation and positive rheotaxis, all model fish were deflected from "intended" migration paths by ocean currents and eddies, regardless of navigational precision. Using the Ocean Surface Current Simulations (OSCURS) model, sockeye return migrations were simulated for the period from 1950 to 1990. Simulated latitude of landfall and return time anomalies had ranges of up to 550 km and two weeks, depending on modelled swim speed, compass orientation, and most particularly, pre-migration distribution. The Subarctic Current was primarily responsible for affecting return times, while the Alaska Current was primarily responsible for north-south deflections of simulated sockeye. Correlations of current speed indices with Northern Diversion Rate (percentage of sockeye returning go the Fraser River around the north end of Vancouver Island) and sockeye return times show that a strong Alaska Gyre curculation tends to yield higher diversion rates, earlier return times for the Early Stewart Lake and Chilko River stocks, and later return times for the Adams River (dominant cycle) stock.

2AM1993-MEQ01 POSTER

ANTHROPOGENIC CHEMICALS AND MAN-MADE CHANGES IN THE NORTH PACIFIC ECOSYSTEMS

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Comprehensive marine ecology investigations have been carried out by FERHRI scientists in the coastal areas of the Okhotsk and Japan Seas and in the north Pacific Ocean during last decade. The state of the west Kamchatka Peninsula shelf environment is characterized by background pollution level of sea water and sediments. Recorded biological changes in bottom biocenoses are associated with the indirect anthropogenic influence (disturbance of natural equilibrium between some species because of extensive fishing). The average contaminant content in sea water and bottom sediments in the North-east Sakhalin Island shelf are little higher, but also close to the background level. Highest pollutant concentrations were recorded near movable drilling rigs. Though the status of bottom communities was estimated as rather well-being, serious disturbances in planktonic populations were detected. At one station more than 40 % of plankters were destroyed due to local oil spill. Unique long-term data from the coastal zone around Vladivostok have shown that very high load of suspended solids, nutrients and pollutants with waste waters lead to serious negative changes in pelagic and benthos biocenoses. Phytoplankton productivity has doubled during the last decade. "Red tides" in the coastal zone became usual. Structure and productivity of bottom communities also changed drastically. Investigations in the north Pacific Ocean did not allow to detect anthropogenic changes in the state of marine environment yet.

2AM1993-MEQ12

OCEANIC DISTRIBUTION OF 110m-Ag, 108m-Ag AND 60-Co ESTIMATED WITH SQUID HEPATOPANCREAS

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In order to monitor marine pollution of the world oceans, we have been investigating a feasibility of using squid liver. This active carnivore is in high on the trophic level, and hence pollutants which are concentrated through the food chains are readily accumulated in fatty livers (=midgut gland). Furthermore, the life span is about one year so that pollutants in livers can reflect a current state of pollution. In the Japanese flying squid, the ash content is about 1.3% and the major component of the ash is oxides of P, Na, K and Cl as chlorides constituting about 80% and the rest is Mg, Ca, Sr, Fe, Zn and S. Most of the elements dissolved in sea water indeed accumulated in squid livers.

We have detected 2-7 mBq/g ash of 110m-Ag (a half-life of 250 days, mainly derived from the Chernobyl accident) in the specimens from the Japan Sea, however could not detect it in livers from the Pacific coast of Japan in 1992. Moreover, we have been able determine 2-5 mBq/g of 110m-Ag with a half-life of 127 years severalfold more than the Japanese flying squid can (Pacific coast squid: 3-5 mBq/g, Japan Sea squid: 6-8 mBq/g). 108m-Ag is slowly spreading out to the New Zealand waters. 60-Co is detected in all specimens from the world. A calculation with stable Ag in livers and sea water shows that the bioaccumulation is about 10^6 and thus we can estimate radio-silver concentration in sea water with squid livers.

2AM1993-MEQ13

DISTURBANCE OF GAMETOGENESIS OF SEA URCHINS AND SCALLOPS AS AN INDEX OF ECOLOGICAL SITUATION IN POLLUTED COASTAL WATERS

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Previously we found that gametogenesis in sea urchins is 1-2 orders more sensitive to hydrocarbons and heavy metals pollution than embryonic and larval development in the acute experiments. Based on this find we hypothesized that disturbance of gametogenesis in marine invertebrates inhabiting polluted coastal waters may lead to decrease in population reproduction and degradation of communities. In 1984-1992 we studied the reproductive function of sea urchins and scallops from clean and polluted by heavy metals and wastes areas of Peter the Great Bay (Sea of Japan).

The state of reproductive function was defined according to the following parameters: histological characteristics of gonads, content of heavy metals in the gonads and development of offspring. Development of offspring was found to be the most reliable index of reproductive function state as well as to be very sensitive to pollution. Biotesting of marine sediments collected at the same stations revealed that their toxicity to sea urchin embryos correlated with the degree of disturbance of animals reproduction. We have hypothesized that there are some levels of disturbance of the communities of bottom marine invertebrates under environmental pollution:

1. Limited selfreproduction of the populations of marine invertebrates.
2. Cessation of selfreproduction (in this both cases populations may be supported by the larvae entering from the clean regions).
3. Cessation of population restoration by the larval entering from the clean region.
4. Decrease of viability of adult specimens and disappearance of population.

2AM1993-POC14 POSTER

PROXIMATE MONITORING OF DYNAMIC STRUCTURES IN THE NORTHERN PACIFIC

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Regarding the problem of the mathematical modelling of marine ecological systems, one of the main tasks is the reconstruction of main physical fields (currents, temperatures, salinity, density) in the mode of continuous observation of the current processes. Mathematical models of diagnozing medium state with the aim of continuous monitoring should answer a series of requirements: rapid realization at computers of small capacity; necessity of considering region

orography and topography, water exchange in the straits and through the "liquid" margins; possibility of using data on satellite probing of the ocean surface and data on standard hydrometeorological monitoring of atmospheric pressure. In the report it is considered a mathematical model allowing to solve the given problem. For this the principles of self-similarity of the second order are used. This term presupposes using some class of functions allowing to perform separation of variables by spatial coordinates in dependence on self-similarity functions. To their determination it's resumed the problem of calculating spatial-temporal distribution of physical system parameters. After determining self-similarity functions, a spatial distribution of currents, temperature, salinity and density are determined by the explicit formula. A similar approach can be used for calculating gases dissolved in water and biogenic elements. On the basis of satellite data on the ocean surface temperature and on the atmospheric pressure, main physical fields of the Northern Pacific are reconstructed with the help of the mathematical models. Statistics of created subsequent scripts of the medium state allows to use them (with the help of the adaptive-learning models) for forecasting the thermodynamic structures evolution and biota behaviour and also in the controlled marine experiment.

Mathematical formulation of the problem is given. Results of numerical experiments in the Northern Pacific and Subarctic front are analyzed.

2AM1993-FIS10

ADAPTIVE-LEARNING SYSTEMS FOR FORECASTING MARINE BIOTA STATE AND PHASE TRANSITION (ON THE EXAMPLE OF SAURIES IN THE WESTERN PACIFIC)

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Marine ecological system is characterized by the complex spatial-temporal relations between the components of the organisms' trophic chain and the medium. In main cases the determination of these relations is not identical. Besides, the interrelation between biotic and abiotic components of the ecological system is not stable in time.

The absence of the fundamental laws for the evolution of the ecosystem's biotic part strongly restricts the opportunity of modelling with the help of traditional methods. For instance, using Lyapunov's balance relationships which are used in the models of "victim-predator" type, we can construct only space-averaged deterministic models of the ecosystem evolution.

These models being nonstationary according to their structure, are not prognostic, because for using them as prognostic ones, it is necessary to possess the prognosis of the model external factors with the aim of determining the boundary conditions.

One of the main difficulties of such an approach is the parametrization of the ecosystem transformation processes, characterized by a large amount of coefficients, which are often poorly conditioned.

The enumerated causes necessitate the transition to the prognostic conception, based on the usage of discrete Markov processes.

Implementation of this conception is possible only in the bounds of the system modelling with the usage of principles of system adaptation and training for recognition of regularities of concrete ecosystem functioning in space and time.

System models are considered as purposeful computer technologies of monitoring and prognosis which are alienated from the author for multiple using in research work and practical applications.

The report considers adaptive-learning system (ALAPS) for monitoring and forecasting sauries' state in the South-Kuril Region of the Pacific Ocean. ALAPS is the universal system and it can be applied practically for any marine biological object.

As the example shown are results of forecasting the redistribution of shrimps assemblages in the Bering Sea with a month in advance.

2AM1993-POC05

OBSERVATION OF THE SEASONAL AND INTERANNUAL VARIABILITY OF THE BERING SEA INTERMEDIATE WATERS IN 1990-1992

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The CTD and chemical data of four quasi synoptic cruises held with the participation of the Russian Federal Institute of Fisheries and Oceanography in different seasons of 1990-1992 in the Bering Sea showed major variations in water properties near the continental slope in the subsurface layers even between spring and fall in contradiction to the widely accepted assumption that main property changes occurred here only during the cold period. In the center of deep basins range of these variations were less by an order than at the continental slope. Further more, somewhere near the continental slope the depth of the significant changes in properties reached 500-800 m, while in the center of the basins they have never been observed deeper than the lower boundary of the cold intermediate layer.

Spatial cores of the deepest and strongest variations of water properties coincided with the centers of the bathymetrically trapped anticyclonic mesoscale eddies, that have been considered to be principal of the enhanced vertical property transport there. Frontal double-diffusion is assumed to be responsible for the observed distribution of the properties off the slope along the surfaces of the enhanced vertical stability.

We consider revealed knowledge that has had confirmation in direct current measurements and diagnostic circulation estimations to contribute to more realistic understanding of the Bering Sea intermediate layer formation, and high bioproductivity zone functioning along the continental slope of the sea.

2AM1993-SB15 INVITED

ON THE DOMESTIC GROUNDFISH OBSERVER PROGRAM RUN BY THE ALASKA FISHERIES SCIENCE CENTER

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Since 1989, the Alaska Fisheries Science Center has made over 2,000 deployments of observers in the domestic groundfish fisheries off the coasts of Alaska, Washington, Oregon, and California. Currently, these observers are placed aboard the vessels under the authority of amendments to the fishery management plans implementing the Magnuson Act. The primary objectives of the observers are to: record fishing effort and obtain daily catch rates; determine species composition; monitor for the incidental take of marine mammals; gather data on fish species, size, and age compositions; determine incidence of Pacific halibut, salmon, king crab and Tanner crab in the landings; and report on possible violations of U.S. fishing regulations.

2AM1993-MEQ06

NUMERICAL SIMULATION OF DILUTION AND DIFFUSION OF SOLUBLE POLLUTANTS IN JINZHOU BAY

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The tidal current and pollutant dispersion in Jinzhou Bay are calculated by means of a two-dimensional model. Shallow water long-wave equations and convective-diffusion equations are used to calculate respectively the tidal current and the pollutant dispersion in the bay. Satisfactory results are obtained using the Alternating Direction Implicit (ADI) difference scheme and the tidal-level/current-velocity alternately controlled method for the open boundary. On the basis of the results of the tidal currant calculation, the chemical oxygen demand (COD), as one of the organic pollutant indicators, is modelled for the pollutant dispersion in the bay. The calculated results are in general agreement with observations. The pollution in Jingzhou Bay is assessed, and the changes in water quality in the bay, given an increased pollutant load, are also predicted.

2AM1993-POC24 POSTER

NUMERICAL SIMULATION OF STORM SURGE IN THE NORTH PART OF THE LIAODONG BAY

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The two-dimensional finite-difference scheme proposed by Leendertse, J.J. (1976), is employed to simulate the storm surge in the north part of the Liaodong Bay. Two runs of the model are performed: in the first, the computation is for the tides only; in the second, the tides and the meteorological effects are computed together. The storm surge residuals are obtained by subtracting the results of the first run from those of the second. The model-produced storm surge heights are in good agreement with the observed ones. In this way surge-tide interaction, an extremely important process for surge propagation in shallow water, is accounted for. Indicating the forecast surge residuals most likely to be of consequence for coastal flooding and navigation, respectively. These residuals are then added to the harmonically predicted astronomical tide to provide estimates of total levels. If these levels approach or exceed predetermined danger levels at a port, warning procedures are instigated.

2AM1993-POC12 INVITED

DISTRIBUTIONS OF THE ANTHROPOGENIC CHLOROFLUOROCARBONS F-11 AND F-12 IN THE NORTH PACIFIC OCEAN: 1985-89

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During the past decade the use of the dissolved chlorofluorocarbons F-11 and F-12 as tracers of ventilation and circulation of the ocean on decadal time-scales has resulted in a great deal of new information on these processes. We have combined the measurements made during 1985 to 1989 by the CFC analytical laboratories at Scripps Institution of Oceanography and at the NOAA Pacific Marine Environmental Laboratory to study the ventilation of the North Pacific Ocean. The vertical sections of the CFCs show a subsurface concentration maximum in both the subarctic and subtropical gyres with concentrations decreasing monotonically below this feature. The subsurface CFC maximum in the subarctic gyre is associated with the temperature minimum at depths near 100 meters. In the subtropical gyre, the CFC maximum lies at depths near 200 to 300 meters and is characteristic of Subtropical Mode Water in the western part of the gyre. The depths at which the CFCs drop below the detection level varies greatly over the basin. However, on potential density surfaces higher concentration are generally found to the north and to the west. The CFC distributions along isopycnal surfaces reveal details of the intergyre exchange, as well as permit us to study the ventilation of the various water masses such as North Pacific Intermediate Water. By combining the CFC-derived ages with apparent oxygen utilization, we can calculate oxygen consumption rates at several density levels.

2AM1993-MEQ04

NUTRIENT ENRICHMENT AND DYNAMIC RESPONSE OF ELEMENT CYCLE IN THE MARINE ECOSYSTEM

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Increase in the discharge of nutrients into the coastal sea ultimately change element matter cycle and therefore it is required to evaluate the effect of nutrient enrichment element on the marine ecosystem. The marine enclosure (18 m deep and 5 m in diameter) was used to understand the effect of nutrient enrichment. Top rim of the enclosure was fixed to flotation module and the weighted bottom rim of the enclosure was positioned in the sediment. Systematic vertical circulation in the surface layer was provided in order to suspend non-mobile phytoplankton, such as diatoms.

Transformation of DIC and DOC into higher trophic levels such as bacteria, microzooplankton and zooplankton, was analyzed by using carbon isotope tracer technique. In parallel the profiles of photosynthetic pigments, dominant phytoplankton, zooplankton, nutrients and oceanic physical parameters were also measured. After nutrient enrichment, phytoplankton

succeeded from the mixture of diatoms and dinoflagellates to dinoflagellats dominancy due to Si limitation. Zooplankton shifted from copepods to Dolioletta and grazing pressure increased. At the surface water the transformation rate of DOC into the higher trophic levels (<100 μm size fraction) was 0.02 - 0.1 μgC/1/4h and 30 - 50 times as small as that of DIC. At the depth of 10 m the transformation rate of DOC into higher trophic levels (<100 μm size fraction) was 0.005 - 0.05 μgC /1/4h and comparable to that of DIC. The details of marine enclosure experiment will be presented.

2AM1993-FIS09

OCEANOGRAPHIC CONTROLS ON THE DISTRIBUTION OF PACIFIC SALMON IN THE SUB-ARCTIC NORTH PACIFIC, AND THE POTENTIAL IMPACT OF 2xCO_2 CLIMATE CHANGE SCENARIOS

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Seven Japanese and two Canadian cooperative research cruises were run in 1992 to examine the factors limiting the distribution of salmon in the sub-arctic North Pacific Ocean. We use a series of non-parametric (Generalized Additive Models) and parametric (Maximum Likelihood) techniques to examine the relationship between the southern edge of the distribution and physical and biological oceanographic factors. The southern edge is nearly a step-function. The primary control on the location of the edge is temperature, mediated by season (food availability). The net result is a unique reverse migration, with salmon moving south in summer into warmer waters, and north in winter into colder waters.

For much of the year salmon only occupy a small fraction of the sub-arctic North Pacific, an area that they have traditionally been assumed to occupy almost completely. Satellite-based AVHRR measurements of SST indicate that the distribution of salmon relative to these thermal boundaries (and thus the amount of habitat available) in the North-east Pacific ocean must have fluctuated widely between years since 1981, and seems to be associated with changes in the marine growth rates of salmon. Simulation results from the Canadian Climate Centre atmospheric general circulation model coupled to a simple mixed-layer ocean model were also used to assess the effects of global greenhouse warming. Under a 2xCO_2 climate, almost none of the eastern North Pacific would still lie within the thermal limits identified within our field program. Our findings suggest that the productivity of Pacific salmon populations could therefore be substantially altered by predicted changes in the climate of the North Pacific Ocean.

2AM1993-BIO12

INTER-ANNUAL TROPHIC PHASING IN THE CENTRAL NORTH PACIFIC OCEAN: EVOLUTIONARY EVIDENCE FOR HIGH SEAS COMPETITION IN PACIFIC SALMON (*ONCORHYNCHUS*)

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Stable isotope measurements ($\delta^{15}N$ and $\delta^{13}C$) and stomach content analysis indicates that the trophic level of chum salmon shifted by one level between 1991 and 1992. When pink salmon were abundant in 1991, chum stomach contents were dominated by an amorphous white material, probably composed largely of gelatinous zooplankton. Although the identity of this material is unclear, it is common in the stomachs of chum salmon, and rare or absent from other salmon species. $\delta^{15}N$ values indicated that the trophic position of chum salmon in 1991 was nearly identical to that of chinook salmon, the most piscivorous salmon species, and one tropic level higher than that of pink salmon. In 1992, when pink salmon were rare, the diet of chum salmon showed a marked shift, towards a diet nearly identical to that of pink salmon (chiefly small bodied

zooplankton). Concurrent with the observed shift in diet, measured stable isotope levels indicate that the trophic position of chum salmon shifted down one level.

Competitive displacement appears to occur because chum modify their feeding behaviour to exploit a branch of the food chain not used by other salmon species in years of high salmon abundance. Because this trophic shift is a consequence of differences in feeding behaviour between years, it must be under evolutionary control. If true, high seas trophic competition by salmonids must have been important on evolutionary time scales. As salmon abundances have now reached levels seen prior to the start of commercial exploitation, the carrying capacity of the North Pacific Ocean for salmonids may have an upper limit that is now of practical significance. Our observations also suggest that chum salmon may be behaviourally programmed to minimize trophic competition, and that increases in the population size of pink salmon are more likely to negatively affect the marine productivity of other salmon species.

2AM1993-SB08

THREE DIMENSIONAL CDT-DATA VISUALIZATION ON A GRAPHICS WORKSTATION

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We have developed a graphics software tool to visualize CDT-data sets in three dimensions which provides a concise view of the spatial features of the data. One of the three variables temperature, salinity, or density can be rendered at a time as a three dimensional isosurface or a contour plot in two or three dimensions. The program allows to view the data at a specified depth (a depth interpolation is performed on the data), or in a specified domain within the sampling area. The package is designed on the IRIS Explorer which runs on Silicon Graphics IRIS graphics workstations. The current version of the program requires the data to be in Plot 3D format, a format in which the coordinate information and the physical information of the data set is stored in two separate files. The program can, however, be easily amended by the user depending on the application.

2AM1993-SB05

DISTRIBUTION OF NITRATE IN THE SUBARCTIC PACIFIC OCEAN: RESULTS FROM TRANS-PACIFIC SHIPS-OF-OPPORTUNITY AND STATION P TIME-SERIES MONITORING

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The Centre for Ocean Climate Chemistry at the Institute of Ocean Sciences has been monitoring nitrate in the Pacific Ocean using ships-of-opportunity between Japan and Vancouver and between Australia and Vancouver, and also at ocean station P (50°N, 145°W). The spatial and time-varying distribution are discussed and oceanic processes affecting the distributions are assessed as to their significance to the ocean productivity in the subarctic waters, now found to be as productive as the equatorial waters based on improved techniques for ^{14}C productivity measurements.

2AM1993-POC19

PROCESSES IN THE SUBARCTIC PACIFIC OCEAN AFFECTING THE UPTAKE AND TRANSPORT OF CO_2

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The processes affecting the uptake and transport of CO_2 in the subarctic waters are: (1) air-sea CO_2 exchange, (2) circulation, including the intermediate water, Ekman transport, vertical and horizontal diffusion and (3) the biological pump. These processes are reviewed in the context of the capacity of the subarctic Pacific Ocean to absorb CO_2 from the atmosphere. The buffering capacity of the upper ocean has been changing due to uptake of fossil-fuel CO_2 and CO_2 from wood burning, as shown by the invasion of "excess CO_2" from the upper ocean into the interior of the ocean, as illustrated by recent measurements on the INPOC cruises to the N.W. Pacific as joint effort between IOS and the Pacific Oceanological Institute in Vladivostok. CO_2 penetration has

reached 1,200 m depth in the western Pacific and 600 m in the eastern Pacific. The penetration rate is estimated to be about 30 m yr^{-1} based on $^{13}C/^{12}C$ changes in the ocean and freons time-series at Ocean Station P. CO_2 is being removed in an episodic way by the biological pump into the deep ocean, enhanced by climatic events such as El Nino, as illustrated by time-series measurements of C-flux at Ocean Station P. The CO_2 processes in the deeper waters of the subarctic Pacific are not clearly understood. The deep waters will return to the upper ocean, as the final stage of the "Broecker conveyor belt of CO_2" originated in the Atlantic high latitude waters. The time-scale for the deep Pacific waters to reach the surface is about 100 years, while the CO_2 penetration from upper ocean will reach the bottom layer in the same time scale. The implication for oceanic CO_2 disposal directly into various depths is discussed.

2AM1993-POC31
FRESH WATER BALANCE IN THE NORTHERN PACIFIC
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The evaporation and water vapor fluxes were calculation based on the meteorological data observed on the Chinese research vessel in East China sea and the Goddard Laboratory for Atmospheres (GLA) interactive-forecast-retrieval-analysis system. The comparison between the results obtained with these two methods was carried out. By using the GLA IFRA system the evaporation and precipitation in the Northern Pacific were estimated. The distributions and temporal variation of fresh water flux and water vapor transfer and their relationship with marine environmental parameters were discussed.

2AM1993-POC30
GLOBAL UPWELLING -- INTERANNUAL VARIABILITY AND CLIMATE CHANGE
Liu-sen **Xie** and William W. Hsieh, *Dept. of Oceanography, University of British Columbia, Vancouver, B.C., Canada. V6T IZ4*

Using the COADS monthly wind stress data (1950-1988) to calculate the global distribution of wind-induced upwelling/downwelling (vertical velocity at the bottom of the surface layer), we studied the interannual variability and long-term change of global upwelling. In the Pacific, EOF analysis showed that the first 3 modes were all related to various stages of the El Nino-Southern Oscillation (ENSO). ENSO induced upwelling/downwelling also occurred far away from the well known equatorial regions. By compositing ENSO events, the anomalous ENSO induced upwelling/downwelling over individual gyres were calculated and compared with the corresponding climatological upwelling/downwelling values. In particular, in the Pacific sub-Arctic domain, there was a significant increase in upwelling during El Nino. Besides ENSO, longer term decadal scale variations were found in global upwelling, the most notable of which was the meridional shifting of the equatorial upwelling band.

Strong climatic trends were found in the equatorial and coastal regions, with a maximum value of 3 cm/day/year, obtained near the equator at 120°W. The subpolar, the equatorial and the coastal regions west of continents tended to have increasing upwelling trends, whereas the subtropical regions and the southern hemisphere tended to have decreasing upwelling trends (or intensifying downwelling trends).

2AM1993-POC21
DISTRIBUTION AND FORMATION OF THE NORTH PACIFIC INTERMEDIATE WATER IN THE KUROSHIO-OYASHIO MIXED WATER REGION
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Multiship CTD and ADCP observations were performed in the Kuroshio-Oyashio mixed water region in the area 30 - 41°*N* and 140 - 180°*E* from May to June in 1992. Salinity and current fields along σ_θ = 26.7 - 26.8 layer indicate that NPIW is classified into four types: (*A*) High-salinity (*S* > 34.2 psu) waters transported by the north-eastward Kuroshio, (*B*) low-salinity (*S* < 33.8 psu)

waters transported along the coastal and off-shore southward Oyashio branches and then along the eastward Kuroshio Extension, (*C*) intermediate-salinity waters with $33.9 < S < 34$, distributed widely in the mixed water region and (*D*) second intermediate-salinity waters with $34 < S < 34.1$, distributed in the southern side of the Kuroshio Extension. Mixture of *A* and *B* waters along the Kuroshio Extension can produce *C* and *D* waters, suggesting that wide distribution of *C* and *D* in the subtropical gyre is formed near the Kuroshio Extension.

2AM1993-BIO05

MONITORING PLAN FOR LOWER TROPHIC LEVEL PRODUCTIVITY OF THE YELLOW SEA LARGE MARINE ECOSYSTEM

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Known as one of the most heavily exploited regions of the world, the Yellow Sea is now under the pressure of ever-increasing environmental deterioration from various human activities. At present, we are developing a monitoring project for the Yellow Sea marine ecosystem in cooperation with Chinese scientists.

In the Productivity Module, one of the three core monitoring modules, CPR/UOR surveys will be combined with ocean color remote sensing to provide a synoptic view on lower level productivity change. To this end, certain environmental characteristics have to be considered and in this respect, the Yellow Sea marine ecosystem is a unique environment. For example, primary and secondary productivity seem to be influenced by its high turbidity. The estimated annual primary productivity (circa 150 gC/yr) falls at the lowest end of the range among the world continental shelves. Zooplankton grazing efficiency also appears to be inhibited in highly turbid regions. Also, the heavy suspended sediment load and high CDOM concentration require a special regional algorithm for ocean color remote sensing.

Here, the environmental and ecological characteristics of the lower trophic biota in the Yellow Sea marine ecosystem will be reviewed with special references to CZCS imagery.

2AM1993-POC28 POSTER

CHARACTERISTICS AND FRONTOGENESIS OF THE SUBARCTIC FRONT IN THE NORTH PACIFIC

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The subarctic front, a major front across the North Pacific, separates two distinct water masses: colder, fresher water to the north and warmer, saltier water to the south. In the mixed layer, the subarctic front is usually a sharp salinity front and a weaker temperature front without a density front. 69 CTD/STD sections across the subarctic front are used to summarize the characteristics of the front. The northern boundary of the subarctic frontal zone is defined by a high horizontal salinity gradient in which the 33.0‰ isohaline is embedded while the southern boundary is defined by the outcropping of the 33.8‰ isohaline. Averaged maxima of temperature and salinity gradients within the frontal zone are $0.47°C/10km$ and $0.083‰/10km$, respectively. Density ratio ($\alpha\Delta T/\beta\Delta S$) indicates the density compensated nature of the frontal zone. Brunt-Vaisala frequency is calculated along the sections to show the vertical stability both north and south of the subarctic frontal zone. All those characteristics of the front are compared between the eastern and western North Pacific. Onset of the North Pacific Intermediate Water is north of the northern boundary of the subarctic frontal zone in the eastern North Pacific and south of it west of 175°W. The shallow salinity minima start within the subarctic frontal zone in the eastern North Pacific. Three repeated sections along 170 E, 175E and 180 from 1978 to 1989 show interannual variation of the front's characteristics.

Daily surface wind stress data at 2x2 grid from 1977 to 1987 in the North Pacific is analyzed for its temporal and spatial variation. In the subarctic front area, only the seasonal cycle has a significant peak in the wind stress power spectrum. The direct link between the wind stress curl and the subarctic frontogenesis is investigated.

2AM1993-POC11
ANOMALOUS FEATURES OF SUBARCTIC FRONT STRUCTURE
G.I. **Yurasov** and I.D. Rostov

Long time observations in the area to the east of Honsu Island between 145.00E and 155.00E shows that northern (39.00N - 42.00N) and southern (35.00N - 37.00N) subarctic fronts can be allocated. The zone of 400 - 700 km between two main fronts is very important because of its complicated dynamic regime. This zone forms warm and cold rings, secondary fronts, processes of water mixing.

The evolution of anomalous anticyclonic meander of southern front between 147.00E and 151.00E could be followed using 3 - 4 days' faximile temperature maps in March - May of 1988. The CTD vertical section was made along 149.00E to detail the information. Map analysis showed both fronts well recognized. Isolines of 5.0 °C and 15.0 °C were located on 41.00N - 42.00N and 35.00N - 36.00N. From the beginning of March to the middle of April the meander top moved to the point of 38.00N - 149.00E. After the 15th of April there was high increase of meander developing speed to 0.9 m/s, so isoline of 15.0 °C drifted to 40.50N and both fronts linked on the surface. The size of meander was (550 - 650)/(100 - 300) km. During further evolution the top of meander became separated and formed a new ring with center in the point of 40.00N - 149.00 E.

The water structure was transformed during meander development. Warm and salt subtropical waters of 250 meters layer were moved to 40.00N - 41.00N and connected with subarctic structure waters. Horizontal gradients of surface temperature and salinity were 0.5 - 0.6 degC/km and 0.06 - 0.07 ‰/km between 41 00'.00N and 41 20'.00N. It is interesting to take notice of isolines drop near Kuril-Kamchatka trench. It can be identified as anticyclonic ring which was followed by satellite observations during a long time. The influence of this ring can be noticeable during 1500 meters layer.

2AM1993-POC35 POSTER
TRANS-PACIFIC SECTION AT 50°N: PROPERTIES DISTRIBUTION AND WATER MASS FINE STRUCTURE
I.A. **Zhabin**, G.I. Yurasov, V.P. Tapinov, *Pacific Oceanological Institute, Far Eastern Branch of Russian Academy of Sciences*

The R/V PRILIV cruise 57 (April-May, 1992) provided the opportunity to sample the large scale distribution of properties at trans-Pacific section at 50°N and to investigate relationship of fine structure and basin-scale general circulation. The CTD-data are used to calculate the fine structure-temperature Cox number. The vertical distribution of the Cox number indicates that mixing is more intensive in mesothermal layer. Spatial distribution of temperature fine structure shows that this part of the Subarctic Pacific have high level of the fine structure activity associated with intrusions. The largest values of the Cox number occur in the vicinity of the East Kamchatka Current anticyclonic eddy, over Obruchev Rise and near the fronts associated with Subarctic Gyre currents.

2AM1993-FIS22
CHANGES IN FISH ABUNDANCE AND SPECIES DOMINANCE IN THE YELLOW SEA
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Korean annual catches from the Yellow Sea have been gradually increased until the mid 1980s, showing about 130,000 metric tons (mt) in the 1960s, 300,000 mt in the 1970s, and 450,000 mt in the 1980s. Three major fisheries, that is, the two-boat large bottom trawl fishery, the large staw net fishery and the medium-sized bottom trawl fishery, accounted for about 70% of the total catch from the sea. During the three decades the catch per unit of effort (CPUE) in terms of horse powers declined substantially, indicating that the relative abundance of the 1960s was reduced by about one tenth of that of the 1980s for all of the three fisheries, due possibly to overexploitations of the fish stocks. In addition species compositions in the catch revealed a remarkable change in species dominance for the same period. Nine species, which are anchovy, hairtail, small yellow croaker, filefish, mackerel, Jack mackerel, Spanish mackerel, skaterays and pomfret, were consistently dominant in the catches as well as considered to be commercially important. Among

the demersal and semi-demersal species, small yellow croaker was the most dominant species in the 1960s, followed by hairtail, skaterays, pomfret, corvenias, sharptoothed eel and so on. However, hairtail occupied the position of the most dominant species in the 1970s, and this position was replaced by filefish in the 1980s. In general, there were some shifts in species composition from large, high-valued fishes to small, low-valued fishes. For the pelagic species, the major dominant species were anchovy, Jack mackerel, Spanish mackerel and mackerel, and the species compositions had more or less stable during the last three decades.

2AM1993-MEQ10

BIOGEOCHEMISTRY OF LARGE CHINESE ESTUARIES

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Trace metals levels in Chinese rivers are quite similar to those from large and less disturbed world aquatic systems, whereas nutrient element concentrations are much higher. This is attributed to serious weathering and erosion, extensive agricultural activities and domestic waste drainages related to dense population. In the estuary particulate elements show somewhat stable distributions in the mixing zone especially when absolute values were normalized to A1 and/or Sc. However dissolved trace and nutrient elements may have either conservative and/or non-conservative distributions or both in Chinese estuaries. Wherever non-conservative distributions were observed, elements may be remobilized and/or scavenged from dissolved phase depending upon river discharge, sedimentary dynamics and elements from individual estuaries.

2AM1993-BIO08

STUDY ON THE HETEROGENEITY OF SPATIOTEMPORAL PATTERNS OF NEKTON COMMUNITY STRUCTURE IN THE COASTAL WATERS OF YELLOW SEA AND BOHAI SEA

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The interrelationship between community structure of nekton and its spatiotemporal patterns of heterogeneity was examined by exploiting the data aggregated from a series of encyclopedic ecological investigation along Liaodong Bay (Liaoning) to the estuary of Changjiang (Yangtze River) within 20 isobath from 1980 to 1985. It was inscribed that there were 185 nekton in the community, including 177 fishes and 8 cephalopoda, assembling 52.23% of total species impregnated in the whole Yellow Sea and Bohai Sea, which associated concurrently with three faunistic components, warm water (WW), warm temperate (WT) and cold temperate (CT), with diversified ecological components, such as occasionals, seasonals and regulars, dominated by 31 regulars of the WT in the rate of NED (Ecological Density in Number) and BED (Ecological Density in Biomass) with 68.86% and 65.59%, respectively. Meanwhile, 34 occasionals of the WW were accounted for 0.10% and 0.19% of the community composition.

Systematic clustering for time-series around the year was adopted to depict the temporal variability of the dominant assemblage, which revealed two distinctive groups, one is the warm-seasoned group, mainly resulted from the data of the BED in the period from May to September, the other based on the data of the NED between October and April, each was characterized by a significant relationship of alternate utilization of coastal waters as breeding or nursery grounds by different faunistic components, and spatially heterogeneous changes in the oceanographic factors such as circulation and warm or cold mass. In accordance with the comprehensive analysis of the spatiotemporal structure of the nekton community in the coastal regimes, it appeared remarkable that there was a tendency of miniaturization of structuring the community, dominated by low-quality and small-sized clupeid, such as anchovies, *Setipinna taty* (C. et V.), japanese anchovy, *Engraulis japonicus* Schlegel, and gizzard-shad, *Clupanodon punctatus* (Schlegel), scaled sardine, *Sardinella zunasi* Bleeker, and red-nosed anchovy, *Thrissa kammalensis* (Bleeker), totally taken up 50.45% and 34.41 of the NED and BED, respectively. Contrary to the increase of ecological components of the smaller fishes in the community, traditional commercial fisheries resources, such as little yellow croaker, *Pseudosciaena polyactis* Bleeker, large yellow croaker, *Pseudosciaena crocea* (Richardson), chinese herring, *Ilisha elongata* (Bennett) and hairtail, *Trichiurus japonicus* T. et S., were made up 24.43% of the catch quota in the whole Yellow Sea and Hohai Sea in 50's. At

present, the catch of these four species was dramatically declined to 6.20% in 80's, which is concordant with this analysis of the community structure at the ratio of 2.65% and 3.18% of the hairtail and little yellow croaker in the NED and BED, respectively. The reason leading to shifting ecological niche is substantially attributed to expanding in fishing effort over the target species in the breeding and nursery grounds, which resulted in the decrease of both parent stocks and juveniles of nekton. Judged by the requirement of conservaiton of marine biodiversity, it is urgent to implement a systematic program on conduction of long term monitoring of ecosystem in the coastal waters.

2AM1993-FIS28 POSTER

INTERANNUAL VARIABILITY IN SUBSURFACE AND BOTTOM WATER STRATA IN THE NORTHERN JAPAN SEA AND FISH POPULATIONS

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There are three main water masses in the northern part of the Japan Sea: Surface, Deep (or Japan Sea Proper Water) and Bottom.

The Deep Water does not have any significant year-to-year variability in the layer between 250-2500 m, but its upper layer adjoining to a seasonal thermocline (50-200 m) changes the temperature and salinity in dependence on the intensity of turbulent exchange through the thermocline. Usually the temperature in this layer is more or less higher than on deeper horizons. It displayed positive or negative long-term trends with the shorter-term 8-11-year fluctuations during the period of surveys after World War II. The summer modal water temperatures of subsurface layer were averaged within 8-11-year cycles are following (Zuenko, 1992):

	1948-54	1955-62	1963-73	1974-81	1982-91
(°C)	0.74	0.86	0.81	0.78	0.76

Thus, the negative trend is observed since middle fifties to nowadays. But we suppose an upward trend in the nearest future.

Bottom Water year-to-year variability seems to be relatively significant following a few precise measurements of its temperature, salinity and dissolved oxygen content (Gamo et.al., 1986). This water is consider to be without active renovation between 1969-1984 very likely in dependence on the intensity of dense water formation by ice-freezing on the shelf of Primorye (NW coast of the Sea). Our investigation of very cold (below -1°) shelf water spreading since 1960 displays the periods of extreme generation of this dense water in the winters of 1965-66 and 1984-86 and the long period of its small spreading between 1969-1976.

The variations of Deep (on subsurface horizons) and Bottom water masses are not coherent. Which of them is the stock of the main commercial fishes of this region as pollack (*Theragra chalcogramma*) and herring (*Clupea pallasi pallasi*) influenced by? We conclude that the subsurface temperature influences upon pollack reproduction, and that is why its population is in depression now in spite of very limited fishery. The herring stock or its spawn survival do not depend obviously on both processes, but they are able to influence as parts of a complex of oceanographic and atmospheric factors.

LATE SUBMISSIONS TO THE FISHERY SCIENCE COMMITTEE:
PACIFIC SALMON PRODUCTION TRENDS IN RELATION TO CLIMATE

Richard J. **Beamish** and Daniel R. Bouillon, *Department of Fisheries and Oceans, Biological Sciences Branch, Pacific Biological Station, Nanaimo, B.C., Canada. V9R 5K6*

Pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), and sockeye salmon (*O. nerka*) represent approximately 90% of the commercial catch of Pacific salmon taken each year by Canada, Japan, the United States, and Russia. Annual all-nation catches of the three species and of each species, from 1925 to 1989, exhibited long-term parallel trends. National catches, in most cases, exhibited similar but weaker trends. The strong similarity of the pattern of the all-nation pink, chum, and sockeye salmon catches suggests that common events over a vast area affect the production of salmon in the North Pacific Ocean. The climate over the northern North Pacific Ocean is dominated in the winter and spring by the Aleutian Low pressure system. The long-term pattern of the Aleutian Low pressure system corresponded to the trends in salmon catch, to copepod production, and to other climate indices, indicating that climate and the marine environment may play an important role in salmon production.

GROUNDFISH STOCK ASSESSMENTS FOR THE WEST COAST OF CANADA IN 1992 AND RECOMMENDED YIELD OPTIONS FOR 1993

B.M. **Leaman** and M. Stocker (Eds.)

Groundfish stock assessments for the west coast of Canada, for 1992, and yield recommendations for 1993 are presented. Assessments have been conducted for the following species: lingcod, Pacific cod, petrale sole, Dover sole, rock sole, English sole, arrowtooth flounder, sablefish, Pacific hake, spiny dogfish, walleye pollock, Pacific ocean perch, yellowmouth rockfish, rougheye rockfish, redstripe rockfish, widow rockfish, silvergray rockfish, yellowtail rockfish, canary rockfish, quillback rockfish, copper rockfish, yelloweye rockfish, hagfish, and Pacific halibut. A number of analytical methods have been employed in these assessments, e.g., surplus production analysis, virtual population analysis, several variants of sequential age-structured analyses, dynamic pool models, and depletion estimators. Biological objectives are the only considerations of these assessments and yield options. Yield options and recommendations on catch limitations and other management measures to achieve biological objectives are made to the fishery managers of Offshore Division of Fisheries Branch (Pacific Region). Alternative options allow managers to consider high risk and low risk yields in relation to a stock's potential productivity.

CLIMATIC INFLUENCE LINKING COPEPOD PRODUCTION WITH STRONG YEAR-CLASSES IN SABLEFISH, *ANOPLOPOMA FIMBRIA*

G.A. **McFarlane** and R.J. Beamish, *Department of Fisheries and Oceans, Biological Sciences Branch, Pacific Biological Station, Nanaimo, B.C., Canada. V9R 5K6*

Stomach contents from first-feeding larval sablefish (Anoplopoma fimbria) comprised mainly calanoid copepods. Along the west coast of Vancouver Island, these copepods were the dominant zooplankton at the depth that sablefish larvae developed. We propose that strong year-classes in sablefish populations occur when there is exceptional production of copepods. The periods of exceptional copepod production appear to be correlated with climate and ocean conditions.

STATISTICAL MODELS FOR ESTIMATING CPUE FROM CATCH AND EFFORT DATA

Laura J. **Richards** and Jon T. Schnute, *Department of Fisheries and Oceans, Biological Sciences Branch, Pacific Biological Station, Nanaimo, B.C., Canada. V9R 5K6*

Catch-per-unit-effort (CPUE) provides one of the most commonly used abundance indices in fishery research. The literature, however, offers no unique method of estimating CPUE and its variance from catch and effort data. In this paper we develop two models (univariate and bivariate) that generalize previous approaches and remain valid under management restrictions on catch and effort distributions. The models involve normalizing transformation parameters that, along with other parameters, are estimated by maximum likelihood. We illustrate the models using data from Pacific ocean perch (*Sebastes alutus*). For the four data sets examined, the univariate and bivariate

models result in similar estimates of CPUE. However, other commonly used CPUE measures lead to inconsistent results, in particular for data sets in which catch was restricted by low trip limits. We recommend the bivariate model, since it accounts for the bivariate structure of catch and effort data. Furthermore, it can easily be adapted to accommodate alternative indices, for example, the effort required to attain a specified catch.

STATISTICAL MODELS FOR THE ANALYSIS OF AGEING ERROR

Laura J. **Richards**, Jon T. Schnute, A.R. Kronlund, and Richard J. Beamish, *Department of Fisheries and Oceans, Biological Sciences Branch, Pacific Biological Station, Nanaimo, B.C., Canada. V9R 5K6*

We present statistical models for estimating the true age distribution of a population, based on multiple readings from individual fish. There are two steps to this process. The first involves estimating a classification matrix that defines the probability of assigning an age *a* to a fish when its true age is *b*. Since true age is unknown, we require an assumption related to ageing error bias; we assume that the true age is the most probable value for the observed age. True age proportions, or alternatively, true ages of fish in the sample are then estimated in the second step. Our methods allow us either to conduct both steps simultaneously or to estimate true age proportions from a previously estimated classification matrix. We illustrate our methods with data on walleye pollock (*Theragra chalcogramma*). We recommend that multiple independent readings be obtained for a subset of structures in future ageing studies and that ageing error be considered in subsequent analyses. Sample sizes must be increased with increasing ageing error to achieve a specified precision in estimates of true age proportions.

STOCK ASSESSMENT FOR BRITISH COLUMBIA HERRING IN 1992 AND FORECASTS OF THE POTENTIAL CATCH IN 1993.

J.F. **Schweigert**, V. Haist and C. Fort

Herring stock abundance in British Columbia waters was assessed for 1992 and forecasts were made for 1993 using two analytical methods: (1) escapement model; and (2) age-structured model. Coastwide, the estimated spawning stock biomass for all assessment regions is 220,000 tonnes, a 45% increase from 1991 abundance levels. This is the result of a strong 1989 year class recruiting in the Strait of Georgia, Central Coast and Prince Rupert District.

Forecasts of the pre-fishery spawning stock biomass in 1992 are obtained by weighting the estimates from the two models. Stock forecasts for the northern stock assessment regions are 154,250 and 128,550 tonnes for the southern regions assuming average recruitment to all areas.

The recommended 1993 catch (20% of the 1993 forecast herring run) is 56,560 tonnes for the entire B.C. coast. Although stock levels in the Queen Charlotte Islands and west coast of Vancouver Island have declined recently there is no evidence that these stocks should not be harvested in 1993.

SHELLFISH STOCK ASSESSMENTS FOR THE WEST COAST OF CANADA IN 1991 AS REVIEWED BY THE PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE (PSARC).

G. **Thomas** (ed.)

This manuscript contains shellfish management advice for the Pacific Region of Canada in 1991, provided by the Shellfish Subcommittee of the Pacific Stock Assessment Review Committee. There are two categories of documents included: Working Papers contain recommendations to management and were subject to scientific review; and Fishery Updates review progress in shellfish fisheries. In 1991, Working Papers were provided for geoduck (*Panope abrupta*), intertidal clams, mussel (*Mytilus edulis*), abalone (*Haliotus kamtschatkana*), shrimp (*Panadalus* sp.), prawn (*Pandalus platycerus*), and sea cucumber (*Parastichopus californicus*). Fishery Updates were provided for ten major and seven minor shellfish fisheries.