# PICES

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# abstracts

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3AM1994-MEQ01 Invited

## THE ROLE OF BIOCHEMICAL INDICATORS IN ASSESSING THE IMPACT OF MARINE POLLUTION

Richard F. Addison, *Institute of Ocean Sciences, P.O. Box 6000, Sidney, BC, Canada. V8L 4B2*

During the past decade, several practical workshops have been organized by intergovernmental agencies to compare and assess methods to measure the impact of marine pollution. The biochemical indices of pollution stress which have been evaluated include hepatic mono-oxygenase and metallothionein induction, inhibition of cholinesterase and of ATPase, and changes "phase II" (conjugating enzymes), all in vertebrates; and in invertebrates, changes in lipid composition and measurements of immunocompetence. Of this suite of approaches, mono-oxygeate induction measurements via enzyme catalytic activity, immunochemical determination of cytochrome p-450 1A1 (CYP 1A1). of the mRNA that codes for CYP 1A1 have consistently been well correlated with analytical chemical data. Some examples of these studies will be presented, and the relationship between biochemical measurements and those made at higher levels of biological complexity (e.g., the whole organism, population or community) will be discussed.

3AM1994-FIS01 Poster

## THE EVIDENCE OF BIOLOGICAL ORIGIN OF THE SUBARCTIC WATERS DISSOLVED OXYGEN MINIMUM IN THE NORTHWESTERN NORTH PACIFIC

A.I. Agatova and A.V. Verkhunov, *VNIRO, 17A V. Krasnoselskaya Street, Moscow, 107140, Russia*

The problem of the dissolved oxygen minimum origin in the Pacific subarctic waters has still remained unsolved. Thus during XXI and XXIV summer cruises of the R/V "Academic Alexander Nesmeyanov" in 1992 and 1993 in the western Bering Sea and Northwestern North Pacific Kuril Islands area exclusive attention have been devoted to the evaluation of the dissolved oxygen demand rates in the upper thousand meter layer.

The rates of dissolved oxygen demand were estimated using the activity of enzymes electron transfer system (ETS) in the samples of the particulate matter, collected by the glass-fiber filters GF/F, showing microheterotrophic organisms respiration activity. Intense dissolved oxygen demand by microheterotrophs has revealed to take place in the layer of maximum gradient of the dissolved oxygen in the intermediate Bering Sea/Pacific waters. The ETS activity appeared to increase in this layer from 2 to 10 times. From place to place the observed effect occurred both due to the raise in the microplankton biomass, and to the specific ETS activity.

The time of reaching observed dissolved oxygen minimum was estimated by the rates of its demand and concentrations. The estimated values appeared to show significant variations depending on intermediate waters origination and their transformation degree. The time has been ranged from 20 to 700 days, and its values on the specific stations formed groups consented with the oceanographic water mass partition revealed after T-S and isopycnal analysis.

3AM1994-BIO38

## ORGANIC MATTER: BIOCHEMICAL COMPOSITION AND RATES OF TRANSFORMATION AT THE KURIL ARCHIPELAGO

A.I. Agatova, N.M. Lapina and N.I. Torgunova, *Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17a V.Krasnoselskaya, Moscow 107140, Russia*

Organic matter (OM) content at the Kuril Archipelago show no prominent difference between the Pacific and the Okhotsk waters: both hold "low" concentrations of organic carbon (2 - 3 mg/l) as well as "high" ones (3 - 5 mg/l). It is also difficult to reveal any

deviations in the vertical distribution of $C_{org}$, which is rather patchy in the 0 - 1000 m column.

The main component of dissolved organic matter (DOM) is carbohydrates (50%). The photic DOM is characterized by a great volume of lipids: which equal and even dominate carbohydrates. Lipids maximum is 2.9 mg/l, and the minimum makes 0.1 mg/l. Dissolved protein concentrations range from 0.021 - 0.279 mg/l. Dissolved nucleic acids (NA) generally account for a rather large volume of DOM (about 20%).

The main component of particulate organic matter (POM) are carbohydrates and protein, meanwhile these waters are characterized by a fairly large amount of lipids. Waters of high concentrations of NA and lipids in dissolved and particulate matter are known as areas of intensive spawning.

OM transformation rates were estimated by the activity of enzymes of alcaline phosphatase and oxidation and reduction enzymes of the ETS.

Phosphatase activity increases at concentrations of mineral phosphorus limiting the primary production. Photic phosphatase activity ranges from 0.008 - 0.021 μmoles P/h/l. The vertical distribution of phosphatase activity is in reverse dependence on distribution of mineral phosphorus; the total values decrease generally 5 - 10 times with depth.

Rates of oxygen consumption in the photic layer of the Sea of Okhotsk were generally 2 - 3 times higher than those in the Pacific (mean rates were 4.5 and 1.3 μl $O_2$/l/h in the Sea of Okhotsk and in the Pacific, respectively). The vertical distribution of total and specific activity of the ETS is rather patchy. The majority of stations reported the two maxima: at the depth of 20 - 50 m and at 500 - 800 m, in the layer of maximal gradients of oxygen. Both microplankton and zooplankton held low values of energy activation ($E_a$) of the both reactions (3 - 6 kcal/mole).

Variability of OM concentrations and biochemical composition depends more on changes of the rates of production and destruction processes than on deviations in the hydrological regime in the area.

3AM1994-BIO01

## ESTIMATION OF PRIMARY PRODUCTION IN THE ECOSYSTEM OF WESTERN BERING SEA

N.V. Arzhanova, V.L. Zubarevitch and V.V. Sapozhnikov, *Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), V. Krasnoselskaya 17, Moscow 107140, Russia*

Based on seasonal changes of nutrient content in euphotic layer, the Bering Sea phytoplankton production was estimated for the "beginning of growing season - spring", "beginning of growing season - summer" periods, and over the whole growing season. It was found that the earliest and the most intense (more than 10 $gC/m^2$/day) phytoplankton development occurs near the melting ice edge in the Karagin-Olyutor region where the spring phytoplankton production varies from 20 to 40 $gC/m^2$. With the ice melting and the water warming up, the highly productive zone spreads southwards to the Kamchatka strait, along the shelf to the eastern part of the sea, and, partly, to the deep-sea region. By June it occupies an extensive area characterized by the production of 75-130 $gC/m^2$ (1-4.9 $gC/m^2$/day). The total annual production of phytoplankton comprises 30-890 $gC/m^2$. Its highest values exceeding 400 $gC/m^2$ tend to occur in the continental slope regions. It was observed that the intensity of productional processes remains at relatively low level in open sea area during the whole growing period. A considerable part of annual phytoplankton production (no less than 70% in vast majority of cases) was found to be accounted for by "new' production.

3AM1994-FIS03 Poster

## FEEDING ECOLOGY OF JUVENILE MASU SALMON, *Oncorhynchus masou*, IN THE COASTAL MARINE ENVIRONMENTS OF HOKKAIDO WITH SPECIAL REFERENCE TO STOMACH CONTENTS

Hiroki **Asami** and Hirofumi Hayano, *Hokkaido Fish Hatchery, Eniwa, Hokkaido 061-14, Japan*

Feeding ecology of juvenile masu salmon, *Oncorhynchus masu*, collected by set nets, was studied in the coastal marine environments of Hokkaido between 1991 and 1993. Stomach fullness indices varied among sampling dates and two areas samples. The composition of stomach contents along the coasts of personatus the northern Japan Sea was very simple. Juveniles grazed sand lance (*Ammodytes*), which were 1/4 - 1/2 of body lengths of juvenile salmon. On the other hand, stomach contents of the juveniles collected along the coast of the Pacific Ocean included various organisms, and size ratios of preys to juveniles were lower than those in the northern Japan Sea. From the comparisons of juveniles stomach contents between the Japan Sea and Pacific Ocean of Hokkaido, juvenile masu salmon have different ecological niche among two areas. Production of juveniles in the northern Japan Sea may depend on the abundance of sand lance.

3AM1994-FIS04 Invited

## "SUB-EL NINO FREGUENCY" CLIMATIC VARIABILITY AND SIMULTANEOUS "REGIME-SCALE" CLUPEOID FISH POPULATION SHIFTS IN DISTANT PARTS OF THE WORLD OCEAN

Andrew **Bakun**, *Food and Agriculture Organization of the United Nations, Rome, Italy*

Impressive interdecadal "regime shifts" in populations of clupeoid fishes have recently occurred simultaneously in widely-separated marine ecosystems distributed around the world. Variations in recruitment in certain populations of demersal fishes, notably the Alaskan pollock and some other major groundfish stocks of the Subarctic North Pacific, appear to have followed a similar pattern. A scenario is developed in which the dynamical systems in various regions experience intensification via climatic teleconnections in response to a relaxation of the system in the equatorial region of the Pacific Ocean during a decadal-scale period of enhanced "El Nino characteristics". It is argued that such intensification would result in increased supply of nutrients through upwelling and mixing processes, leading to increased primary organic production as well as to enhancement of various mechanisms that may act to concentrate food organisms and thereby to support efficient feeding activity. These considerations may serve to account for various aspects of the recent "regime shift" experiences.

3AM1994-FIS05 Invited

## A 1700 YEAR PERSPECTIVE ON RECRUITMENT VARIABILITY OF SARDINES AND ANCHOVIES IN THE CALIFORNIA CURRENT

Tim **Baumgartner**[1,2], Vicente Ferreira[1] and Andy Soutar[2]
[1]*Centro de Investigacion Cientifica y Educacion Superior de Ensenada, Ensenada, Baja California, Mexico*
[2]*Scripps Institution of Oceanography, University of California, San Diego, La Jolla, U.S.A.*

Variability in the sizes of the sardine and anchovy stocks of the California Current, with population centers in the southern California Bight, can be estimated from the rates of deposition of the scales of these fish to the annually layered sediments of the Santa Barbara Basin. We have reconstructed time series of 10 year averages of scale-deposition-rates from AD 300 to 1970 which we analyze by separating the variability into a low frequency component of centennial scale fluctuations (periods > 150 years) and interdecadal variability which is concentrated around periods of 50 to 75 years for both sardines and anchovies. The interdecadal variability exhibits patterns which are important to the understanding of long-term changes in growth and collapse of clupeoid stocks on time scales relevant to fisheries management.

Interdecadal variability in fish scale deposition indicates a generally consistent alternation of abundance between the two species. This occurs as a progressive change in the relationships between the estimated biomasses where one species tends to maintain numerical dominance for approximately 30-35 years. After taking into account the effects of fishing, the variation in the sizes of sardine and anchovy populations observed during the twentieth century appear to be consistent with changes in fish scale deposition over the past 1700 years. Combining our analysis of the fish scale record with the observed changes in populations and their relationship to large-scale climate, we propose that successive expansion and contraction of the sardine and anchovies is modulated by interdecadal variability in the coupling between the ocean and atmosphere of the North Pacific. Simulation of these processes by population models indicate that direct competition for resources plays a negligible role in the replacement of one species by another. We are now developing a hypotheses which relates the inderdecadal change in North Pacific climate to a regular alternation in habitat suitability which leads to the alternation in success of the reproductive and feeding strategies at different life stages of the two species.

3AM1994-MEQ02

## RESPONSES OF COASTAL MARINE ECOSYSTEMS TO ANTHROPOGENIC STRESSORS

T.A. Belan and A.V. Tkalin, *Far Eastern Regional Hydrometeorological Research Institute (FERHRI), Vladivostok, Russia.*

In this paper the results of ecological studies conducted by FERHRI specialists in some coastal areas of the Sea of Japan are presented. During the last decade investigations had been carried out in severely impacted areas as well as in background ones. These studies have shown the extremely high contents of trace metals (TM) and petroleum hydrocarbons (PHC) in bottom sediments of Vladivostok and Nakhodka harbours and at dredged material dumping sites. Marine bottom biocenoses in these areas were characterized by very low benthos biomass and anomalously high density of tolerant Polychaeta species. In some places the "dead areas" were observed.

During 1992-1993 some background sites and areas remote from industrial centers have been investigated too (Vostok Bay Strelok Bay). Ecological study in Vostok Bay have shown the background pollutant contents in bottom sediments but also the sharp decrease of benthos biomass as well as changes in benthos species composition. The main cause of these changes is connected with the disturbance of habitat areas due to trawling.

In some areas of Strelok Bay (near the NAVY ship bases) high concentrations of PHC and TM in bottom sediments were detected. As a result, negative changes in bottom communities were recorded: low benthos biomass and diversity indices, elimination of Bivalvia and Echinodermata species, dominating of tolerant Polychaeta species.

So, investigations conducted in the last few years allowed evaluation of the impacts of different anthropogenic stressors on the structure of coastal ecosystems.

3AM1994-BIO02 Poster

## PECULIARITIES OF THE COCCOLITHOPHORE DISTRIBUTION AND QUANTITY IN THE KUROSHIO INFLUENCE AREA AND ADJACENT WATER MASS

Mariya G. Biryulina, *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, Russia*

Calcareous nannoplankton studied in deep sea sediments of the Philippine Sea and North West Pacific (28-32 N lat.) showed that unstable hydrodynamic situation directly influences the composition of coccolithophore assemblages and creates peculiarities of their distribution and sedimentation.

In the area of the warm Kuroshio Current's influence tropical and boreal species extend to the North while the species ratio determining biogeographical aspect of assemblages changes gradually. Within these latitudes in the North Philippine Sea the ratio of subtropical and boreal species is approximately the same, in the Shatsky Rise region boreal species prevail. Quantitative analysis of some nannoplankton species in the surface sediments showed that the sediments exposed to the current influence were increasingly impoverished in microflora. This fact suggests the transport of microplankton to a quitter water mass.

3AM1994-POC01 Poster

## A COMPARISON OF SEA SURFACE TEMPERATURE FIELDS IN THE BERING SEA DURING SPRING-SUMMER SEASONS OF 1992 AND 1993

M.A. Bogdanov, *Russian Federal Research Institute Of Fisheries and Oceanography (VNIRO), 17a, V.Krasnoselskaya, Moscow 107140, Russia*

The variability of oceanologic conditions is an important factor of bioproductivity formation, affecting in large extent the life cycle of hydrobionts. That is why the study of variability is very important for understanding the ecology of the main commercial fish species.

Now the maps of sea surface temperature (SST) fields based on data obtained from satellites are the main source of information allowing to assess the spatial and temporal variability of thermal regime in the surface layers over the vast aquatories of the ocean.

The analysis of a set of weekly maps of the SST fields in the Bering Sea for spring and summer months of 1992 and 1993 allowed to identify and compare the main features of the consecutive changes in thermal conditions in these years. Compared with maps with longer periods of averaging the used maps have a number of advantages and first of all for study of intraseasonal SST variations.

The characteristics which allowed to assess and compare the development of SST fields in the sea during the above years were the following:

- sea surface temperature averaged over a period from 15 June to 15 July;
- date of stable transition of SST through 5° C (after this date the temperature usually increases);
- date of SST transition through 8° C (this value is almost maximal for the most part of the Bering Sea);
- difference of temperatures between 15 June and 15 July (period of maximal SST increase);
- number of days when sea surface temperature changes from 5° C to 8°C.

The last two characteristics may be considered as a rate of seasonal warming. The maps of the above characteristics allowed to analyze the main features of formation of SST field in the warm seasons of 1992 and 1993.

3AM1994-MEQ03 Poster

## CONTENT OF ARTIFICIAL RADIOACTIVE ISOTOPES IN HYDROBIONTS OF JAPAN SEA

G.S. Borisenko, *Laboratory of Applied Ecology and Toxicology, Pacific Research Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, Vladivostok, 690600, Russia*

Multiple research, conducted in natural conditions in Japan Sea, allowed to reveal regularity in distribution of the most important (in radiological aspect), products of fission- the long living isotopes Sr-90 and Cs-137. The object of research were commercial ichthyo-fauna (Pacific herring, flounder, saffron cod, greenlings, pollock, smelts), high water vegetation

(*Laminaria j'aponica*, *Ahnfeltia tobuchiensis*, non-fish objects of fishing (Japanese bay scallop, mussel of Grev, trepang, squid, sea-cucumber) and also the living area of hydrobionts (marine water and soil).

The content of Sr-90 in bony tissue of fish is 1,9-3,3 Bk/kg, the content of Cs-137 in muscular tissue of fishes is approximately from 1,5 till 3,5 Bk/kg of raw mass. In the same limits there is the content of radio-caesium in edible part of non-fish commercial objects. Slightly higher is the content of Sr in brown alga, in *Laminaria Japonica*- about 5.0 Bk/kg of air-dry mass and it depends on hydrobiont's age.

*Ahnfeltia tobuchiensis*, which is classified as red alga is not active concentrator of this isotope. The content of Sr-90 in it directly depends on encrusting organisms. And as we can see from received the data, the levels of radioactive pollution of hydrobionts (Japan Sea) is not high and this is because of low concentration of radioactive substances in their living area.

Concentration of Sr-90 and Cs-137 in sea-water is correspondingly 2,5 -0,5 and 5,1 - 0,8 Bk/m (in average).

The research of radioactive pollution of the sea directed to decision of urgent problem- the ensuring of human being's health and the protection of environment.

3AM1994-FIS06 Poster

## SUMMER DISTRIBUTION AND ASSOCIATIONS OF EARLY LIFE STAGES OF THE DOMINANT MARINE FISHES IN THE WESTERN GULF OF ALASKA

Richard D. **Brodeur**, Morgan S. Bushy and Matthew T. Wilson, *National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115 USA*

A midwater trawl survey was conducted during July of 1991 to examine the large-scale distribution patterns of late larval and early juvenile walleye pollock (*Theragra chalcogramma*) and associated fish taxa in the western Gulf of Alaska. Gear comparisons were conducted to evaluate which sampling trawl was most efficient at capturing the size range of *T. chalcogramma* present during this time of the year. Both the anchovy and Methot trawls caught similar length distributions through the dominant size-class of individuals caught, but the Methot trawl caught significantly more *T chalcogramma* in the smallest (mostly larval) size classes available and had generally higher standardized catches. Based on these results, a grid of 60 stations was sampled using only the Methot trawl.

Although 64 taxa of fishes were collected overall, the majority (84%) of the larval catch consisted of just five taxa (flathead sole (*Hippoglossoides elassodon*), walleye pollock (*T. chalcogramma*), arrowtooth flounder (*Atheresthes stomias*), Pacific cod (*Gadus macrocephalus*), and unidentified sculpins (*Icelinus spp.*)). *Theragra chalcogramma* and *G. macrocephalus* were the dominant (> 99%) juveniles collected in the survey. The highest catches of larval (13-25 mm SL) and juvenile (26-52 mm SL) *T chalcogramma* were found inshore along the Alaska Peninsula and near offshore island groups. Recurrent Group Analysis and Two-way Indicator Species Analysis both showed that T. chalcogramma tended to be frequently associated with a large heterogeneous grouping of taxa including *G. macrocephalus*, several pleuronectids and other winter-spring spawning species. The rankings of the dominant taxa in the Methot survey exhibited a greater coherence to the Tankings of adult fishes from trawl surveys in the previous year than those of a ichthyoplankton survey that used bongo nets a few months earlier than the Methot survey.

3AM1994-PG01

## USING PREHISTORIC SKELETAL REMAINS OF FISHES AND MARINE MAMMALS TO INVESTIGATE THE BIOLOGICAL HISTORY OF EXTANT POPULATIONS

Susan Crockford, *Pacific IDentifications, 6011 Oldfield Rd., R.R.3, Victoria, BC V8X 3X1, Canada*

Skeletal remains recovered from archaeological sites all over the Pacific Rim present unique opportunities for investigations into the biological histories of a number of extant vertebrate species. The remains of many ecologically and commercially important species of fish and marine mammals have been recovered from coastal shell middens, the "kitchen" refuse heaps left by prehistoric fishers and hunters. A few of these date back about 10,000 years but many exist for the period 3,000 to 500 years ago, a period well before dramatic ecosystem changes. These archaeological sites typically contain bones in an excellent state of preservation. Techniques currently in use on modern fish samples, such as determination of age and growth rates from vertebrae, fin rays, otoliths and scales, are directly applicable to archaeological material. Zoogeographic changes over time in distribution of both fish species (e.g. bluefin tuna *Thunrius thynnus orientalis*) and marine mammals (e.g. northern fur seal *Callorhinus ursinus*) are also possible to investigate using archaeological material. New technological advances in molecular DNA analysis promise to add investigations of genetic history to the list of possible analyses. Determining an historic perspective on all biological processes which may have changed over time within populations are now seen as critically important to present and future management strategies. Archaeological skeletal remains of extinct populations are one of the few sources of historical information on the biology of extant marine species. The time has come to forge collaborative interdisciplinary research projects which include these valuable samples.

3AM1994-POC02 Poster

## ANNUAL VARIABILITY VERTICAL VORTEX SPEEDS IN THE KUROSHIO REGION IN SUMMER (AUGUST)

V.B. Darnitsky[1], E.I. Meeshuneena[2] and A.D. Nelezeen[3]
[1]*Pacific Research Institute of Fisheries and Oceanography(TINRO), Shevchenko Alley 4, Vladivostok 690600, Russia*
[2]*Far Eastern State University(DVGU), Octyabrskay 27, Vladivostok, 690600, Russia*
[3]*Far Eastern Regional Hydrometeorological Research Institute, (DVNIGMI), Dzerzinskogo 24, Vladivostok 690600, Russia*

As known the region of Kuroshio mean very important role in weather forming and fishing grounds in area near Japan. Subtropical and subpolar waters produce many gyres in subarctic front and near him because of its interaction, baroclinic instability, big gradients of bottom relief and influence of atmospheric cyclones and typhoons. Subposition of gyres is changes with time to time, seasons and annual.

We are calculating of potential vorticity - vertical speeds on the results of oceanographic program "SECTIONS" (August 1981-1989 years), made DVNIGMI in past decade. All calculating made to 1000m level. In results of this investigations one may saying about four quasistationary regions of anticyclonic vortisity, three of them are caused by bottom relief (seamounts near Japan). Vertical speeds change from $-4x10^{-7}$ to $9x10^{-6}$ 1/ó.

Annual changebility in the Kuroshio region have a different intensity with four year periodicity. Maximum vertical vorticity in region of South Kuroshio meander have been in 1984 and 1988 years. Minimum vertical vorticity have been in 1982 and 1985 years.

Analysis of this calculations is revealed changes in periods of intensities and weakening of vertical vorticitys caused by baroclinic instability.

3AM1994-FIS07 Poster

## ANCHOVY AND SARDINE SPAWNING IN THE GREAT PETER BAY (JAPAN SEA)

Svetlana V. Davydova, *Pacific Research Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

Anchovy migrates from the south Japan sea to the Great Peter Bay, along the coast of Korea. The first shoals of anchovy penetrate to Bay at surface water temperature of 9-10°C in late May or the first ten-day period of June. From Posiet Bay anchovy moves along the island ridge to Amurskiy, Ussuriyskiy bays and then to waters of the north Primorie. The number of eggs in the Great Peter Bay reaches 500 ind/$m^2$ at the period of intensive anchovy spawning. During the period from 1957 to 1992 maximum egg catches of this species were marked along the north-western coast at the 1000-1600 m the shore line.

Sardine migrates to the Great Peter Bay only in the definite period of year. Part of feeding population being ready to spawning runs to the waters of Primorie and occupies bays as well as anchovy. Isolated eggs of sardine are observed in late April. As a rule, maximum catches (4 ind/$m^2$) of eggs, are marked in the third ten-day period of June. Extent of spawning sardine and anchovy penetration of bay are limited by distribution of the front of mixing sea and river waters. The most high egg mortality of this species (99%) was observed in upper areas of bays with low salinity. Fry of anchovy occur in coastal areas of the Great Peter Bay till autumn and may be caught in waters of the north Priomorie as well. Larvae of sardine mark in ichthyoplankton net only in Amurskiy Bay.

In conclusion we may say, that anchovy abundance increase in 90-th. In the near future this species is expected to be private target of fishing in the north-western part of Japan sea. On the contrary sardine abundance is in depressive state.

3AM1994-POC03 Invited

## BUOYANCY FORCING OF THE PYCNOCLINE IN A WIND-DRIVEN OCEAN CIRCULATION MODEL

Roland A. de Szoeke, *College of Oceanic and Atmospheric Sciences, Oregon State University, Ocean Administration Bldg 104, Corvallis, Oregon 97331-5503, U.S.A.*

A model of steady ocean circulation driven by wind stress and surface buoyancy flux is presented. The model consists of a system of outcropping constant-density layers. Where layers outcrop they are directly forced by surface wind and buoyancy flux; where submerged the potential vorticity-pressure relations imposed by the wind in the layers' outcropping zones are approximately conserved. Buoyancy flux across the ocean surface must be balanced by turbulent diffusion across the layer interfaces, which is equivalent to diapycnal mass exchange among the layers. Turbulent diffusion is controlled by the diapycnal diffusivity parameter K_D. The relative mean positions of the outcrops and the magnitude of the pycnocline are determined by the buoyancy balance requirement. Model calculations have been performed in a rectangular ocean basin (6000 km X 5000 km), with idealized wind forcing that gives a subtropical-subarctic gyre pair, and negative buoyancy forcing (equivalent to heating) in the subtropics, positive buoyancy forcing (cooling) in the subarctic. With integrated buoyancy forcing over the subtropics equivalent to 0.5 PW, diapycnal diffusivity K_D ~ O(1 cm**2 s**-1), model pycnocline magnitudes at least ten times larger than observed in nature are obtained. It follows that the buoyancy throughput in the real ocean short-circuits the main pycnocline, most likely by means of vigorous mixing processes in the upper ocean. The implications of this conclusion to ocean general circulation modeling, especially the representation of thermohaline processes, is examined.

3AM1994-POC04 Invited

## SIMULATIONS OF THE SUBARCTIC PACIFIC PLANKTONIC FOODWEB WITH A SIMPLE ONE-DIMENSIONAL COUPLED PHYSICAL - BIOLOGICAL MODEL

Kenneth L. Denman, *Department of Fisheries and Oceans, Institute of Ocean Sciences P.O. Box 6000, Sidney, B.C., Canada V8L 4B2*

A simple coupled mixed layer/planktonic foodweb model of the euphotic layer has been developed that is forced by annual and daily cycles of solar heating and an annual cycle of surface heat losses. The model can simulate annual cycles with or without a spring bloom (characteristic of the subarctic Pacific or the North Atlantic) depending on either the initial slope of the curve specifying the dependence of primary production on light or on the maximum depth of winter mixing. Simulation of a High Nutrient-Low Chlorophyll region such as the subarctic Pacific, with 50% of the losses recycled within the euphotic zone and 50% lost from the system indicates the importance of physical supply of nutrients to these regions regardless of the possibility of iron limitation. In the subarctic Pacific, a primary supply of nutrients to the euphotic layer is upward transport (of 10 to 30 m/yr) from below required by Ekman divergence in the surface waters. Finally, attempts are made to simulate observed long term freshening, warming and shallowing of the surface mixed layer at Ocean Station Papa and the possible ecosystem response.

3AM1994-POC05

## ON MULTIPLE EQUILIBRIA TO A LOW - SPECTRIUM MODEL OF OCEANIC CURRENT DRIVEN BY THE BOUNDARY FORCE - THE BIMODALITY OF KUROSHIO SOUTH OF JAPAN

Chang-Ming Dong and Qing-Hua Zhang, *First Institute of Oceanography, SOA Qingdao, P. R. China*

A vast amount of measured data and numerically simulated results have showed that two kinds of stable paths exist in the southern oceanic region of Japan. In the present paper, the multiple solutions to the nonlinear quasi - geographical oceanic current equation with diffusion under the influence of the boundary force are studied with a low - spectrum model. The results show that within certain ranges of Rossby Number and Reynolds Number, the three solutions exist, the first stable one of which corresponds to the straight path of Kuroshio, the second stable one with large amplitude to the meander path, and the third unstable one to the transition process between the two kinds of paths. In addition, the dependence of multiple solutions on Rossby Number and Reynolds number was studied in detail, which meets well with the numerically simulated results presented in our previous papers

3AM1994-FIS08

## MATHEMATICAL MODELING OF PROCESSES IN MARICULTURE WITH REGARD FOR NATURAL REPRODUCTION AND CATCH

V. Dulepov and M. Ermolitskaya, *Institute of Marine Technology Problems, Far Eastern Branch Russian Academy of Sciences, 5-a Sukhanov Street, Vladivostok, 690600, Russia*

In present work mathematical models of salmon fish reproduction (keta, gorbusha) by example of the sakhaline region with regard for natural reproduction and catch . In connection with reduction of salmon resources, the questions of network expansion of fish breeding farms are raised, and that's why it is very important to evaluate the efficiency of their work and find optimum correlation between natural and artificial reproduction concerning habitat capacity. Evidently such correlation of natural and artificial reproduction will be considered optimum when artificial reproduction does not undermine the conditions of existence of natural part of population, and in total the quantity of reproducted fish will aim at maximum, at minimum of fixed expenditures for artificial reproduction. The decision of this problem is possible only with the help of analysis of these processes on mathematical models.

For model coefficient calculation and generalization of economic indicators of fish-farms, the materials of 23 fish factories for the period of 1966-1990 were used. The system analysis of ecological-economical conditions of keta and gorbusha reproduction was carried out, and new methods of estimation of economic efficiency of salmon factory work were offered. On the grounds of average annual income calculations, absolute and relative efficiency, it was revealed, that in gorbusha reproduction more paying farms are those ones that are situated in the South-East of Sakhalin and South-Kuril islands; and in reproduction of keta - in the South-west of Sakhalin and in Aniva Bay.

One the grounds of available ecological and economic information imitation models of keta and gorbusha reproduction are built in different (regions) districts. Three variations of control were considered: the control of artificial reproduction, the control of natural reproduction, the mixed control.

The result of modeling allowed to value economic efficiency of separate farms both at present period and in future.

3AM1994-SB01 Invited

## PROCESSES REGULATING PLANKTON PRODUCTION AND ITS INTERANNUAL VARIABILITY IN THE OPEN SUBARCTIC PACIFIC OCEAN

Bruce W. Frost, *School of Oceanography, WB-10, University of Washington, Seattle, Washington 98195, USA*

In the oceanic phase of their life cycles, species of Pacific salmon depend on a pelagic food web whose production is dominated by "microbial loop" processes. Phytoplankton production, due primarily to pico - and nanophytoplankton (cells < 201$\mu$m), is consumed chiefly by nano-and microzooplankton (mostly protozoans < 200$\mu$m). Surface layer concentrations of macronutrients (e.g., nitrate, phosphate, silicate) remain high year-round because protozoan grazers prevent blooms of small (pico- and nano-) phytoplankton species, while availability of dissolved iron and perhaps other trace nutrients severely limits the growth of large-sized, microphytoplankton species that bloom in coastal waters. The zooplankton prey of oceanic salmon - mesozooplankton suspension-feeders such as copepods and euphausiids - appear to derive most of their nutrition from microzooplankton and small mesozooplankton. Thus, the production of mesozooplankton must be a small fraction of phytoplankton production. Interannual variation in the standing stock of mesozooplankton in the eastern subarctic Pacific has been attributed to climate change over the North Pacific Ocean, but the specific causal mechanisms remain obscure. Interannual variations in intensity of vertical mixing, caused by changes in intensity of surface winds, would not appear to induce changes in the level biological production in a pelagic ecosystem not limited by the availability of macronutrients. However, interannual variations in atmospheric deposition of iron could have major impact on the production of the subarctic oceanic ecosystem. Enhanced iron deposition could stimulate the production of large phytoplankton cells, favoring increased growth of mesozooplankton and enhanced feeding and growth conditions for salmonids. As atmospheric iron input to the open subarctic Pacific is now being monitored, it would be appropriate to reinstitute long-term monitoring of plankton standing stock and production.

3AM1994-POC06

## REPEAT HYDROGRAPHY ALONG LINE P AND LONG TERM SAMPLING AT STATION P

John Garrett, Howard Freeland and Frank Whitney, *Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C., V8L 4B2 Canada*

The Line P (WOCE Line PR6), Station P (WOCE Station PRS1) program is one of the longest ocean time series in existence. Canada has had vessels visiting Station P for meteorological observations since 1950, and began oceanographic measurements in 1956. Over 4000 profiles of temperature and salinity have been taken at Station P to date.

The full time occupation of Station P with weatherships ended in June 1981, when satellites started providing reasonable means of weather forecasting, and the expense of maintaining 2 vessels could not be justified. Since that time, 2 to 6 cruises yearly along Line P have provided information on seasonal and inter-annual variability off the Canadian west coast.

The Line P time series has produced important data sets that permit us to understand the impact of global perturbations such as El Nino/La Nina oscillations and the response of the ocean to anthropogenic climate change.

This talk will describe the history of sampling at Station Papa and along Line P. Examples of the use of this long data series will include a description of the effects of recent El Nino events on the distribution of temperature and salinity along Line P and a description of long term trends in hydrographic, chemical and biological variables at Station Papa and in the N.E. Pacific. Observations indicate a long term warming and freshening trend at the surface. This leads to a strong and statistically significant trend in mixed layer depth at Station Papa. The implications of this change for nutrient concentrations and primary productivity will be discussed.

3AM1994-POC07 Poster

## FRONTS OBSERVED NEAR THE KURIL ISLANDS

S.V. Gladyshev, *Pacific Oceanological Institute, Far-Eastern Branch, Russian Academy of Sciences*

Description of the fronts observed in the Kuril Area in summer which are formed under the influence of different causes such as water exchange between the Pacific ocean and the Okhotsk Sea, atmosphere-ocean interaction, tidal mixing, river plume and mesoscale variability is given. Main features of these fronts are shown. Evolution of the Kuril Front dividing the Okhotsk Sea and the North Pacific water in the Bussol and Kruzenshtern Straits caused by tidal and constant currents as bottom topography is analyzed. The sharpness of this front during maximal tidal current velocity in the narrowest part of the Straits is revealed.

3AM1994-POC08 Poster

## ROLE OF THE WARM-CORE KUROSHIO EDDIES IN FORMATION OF THE NORTH PACIFIC INTERMEDIATE WATER (NPIW)

S.V. Gladyshev, *Pacific Oceanological Institute, Far-Eastern Branch, Russian Academy of Sciences*

Process of the NPIW renewal conditioned by the interaction of the warm-core Kuroshio eddies with surrounding waters in summer is researched. Its intensification occurs during frontal-eddy reciprocity as well as at formation of the meandering and eddies of the Kuroshio. Water sinking at the warm-core eddies periphery is one of the sources of the low salinity intermediate water supply. Some quantitative estimates of the renewal rate of the NPIW are given.

3AM1994-POC09 Poster

## PALEOCEANOGRAPHYCAL FEATURES OF THE NORTHWESTERN PACIFIC, BERING, OKHOTSK, JAPAN SEAS DURING LAST 25.000 YEARS

S.A. Gorbarenko, *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, 690041, Russia*

Data of foraminifera d18O, d13C, carbonate and organic carbon content, lithological and other analyses of sediments show that main paleoceanographical changes in the northwestern (NW) Pacific, Bering and Okhotsk seas (NW region) have some common features but strong differ from variation in the Japan sea.

Our and literature data allow to suggest that intermediate water formation increase to depth 2.500m during last glaciation in the NW region. There are two desalinity pulses in the surface water of the NW region as a results of two maxima of melt water pulses (1A, 1B) during transition time (12.6ky, 9.8ky respectively). These surface changes affect on reorganization of deep water ventilation and productivity. In most cores from the NW Pacific and Bering sea organic carbon content (OC) in glacial sediments exceeds ones in postglacial sediments. The reverse is true for the Okhotsk sea. There is an OC maximum in transition sediment of the NW region.

Peculiarities of the Japan sea paleoceanography are determined by mainly two factors: a) this marginal sea is connected with Pacific by shallow straits with depth of deeper ones - Tsushima and Tsugaru (130m) compatible with amplituda of falling of the sea level in past; b) warr water of Kuroshio current and cold water of Oyashio with different parameters inflow or may infow in the past into sea through these straits respectively.

3AM1994-BIO03 Invited

## MARINE BIRD COMMUNITIES IN THE TEMPERATE NORTH PACIFIC

Patrick J. Gould[1] and Peggy Ostrom[2]
[1]*National Biological Survey, Alaska Fish and Wildlife Research Center, 1011 E. Tudor Road, Anchorage, Alaska, U.S.A., 99503*
[2]*Department of Geological Sciences, Michigan State University, 206 Natural Science Building, East Lansing, Michigan, U.S.A., 48824-1115*

In the temperate North Pacific, three distinct avian communities exist within the subtropical, transitional, and subarctic zones. Overlying this basic pattern are east-west differences both in breeding and non-breeding species. We identify differences in marine bird distributions and food habits and discuss how they relate to both physical and biological variations in the temperate North Pacific environment. Major habitat changes from east to west include effects of ocean currents and water mixing, fresh water runoff from land, seamounts and continental shelves, and availability of suitable breeding areas, especially islands. Stable isotope ratios of birds are related to the origin and trophic position of the food consumed. Consequently, $\delta^{15}N$ values are used to infer breeding origins of at-sea bird populations and, in conjunction with stomach content analyses, describe resource partitioning as a function of inter-specific and spatial differences.

3AM1994-MEQ04 Invited

## THE ROLE OF BIOLOGICAL EFFECTS MONITORING IN MARINE ENVIRONMENTAL PROTECTION

John Stuart Gray, *University of Oslo*

In recent years through intercalibration workshops it has been shown that biological effects techniques are both reliable and sensitive. Thus rather than having to rely on chemical contamination we can now relate contaminate loads to biological effects. Examples of the use of biological effects techniques will be given ranging from biochemical through physiological to community. Emphasis will be given to the authors own work on application of multivariate statistical techniques to effects on benthic communities. It will be shown that oil exploration on the Norwegian continental shelf lead to far greater biological effects than predicted by the Environmental Impact Assessments. The Norwegian authorities have imposed legislation to control pollution following the publication of these results.

Finally the importance of good sampling design and quality assurance protocols will be stressed in relation to incorporation of biological effects techniques in routine monitoring programs.

3AM1994-STA06 Invited

## INTERANNUAL TO DECADAL SCALE VARIATIONS IN THE NORTH PACIFIC

Kimio Hanawa, *Department of Astronomy and Geophysics, Faculty of Science, Tohoku University, Sendai 980-77, Japan*

Interannual to decadal scale variations of the upper thermal condition in the North Pacific are described. An empirical orthogonal function (EOF) analysis for the sea surface temperature (SST) fields shows existence of two distinctive patterns: one is that with the El Nino/Southern Oscillation (ENSO) time scale (3-4 years) and the other is that with decadal (DC) time scale. The leading mode of DC time scale is a meridional dipole pattern: north-south oscillation of low latitude oceans (central North Pacific). Time coefficient of this mode showed abrupt change like a step function around 1976 and continued to late 1980s. Analysis for the upper thermal condition also shows DC time scale variation coherent with SST field.

So far, upper thermal condition of the mid latitude North Pacific has been monitored well, especially by XBT observations using many voluntary observing ships (VOS): TRANSPAC program. However, this program will be ended in the end of this year. This situation will cause severe damage for oceanographic community. It goes without saying that new monitoring program must be urgently established. The author believes that PICES can play an important role to establish new functional monitoring program in succession to TRANSPAC program.

3AM1994-STA01 Poster

## FERRY-BASED BIOGEOCHEMICAL MONITORING FROM THE MARGINAL SEAS TO THE SUBTROPICAL GYRE

A. Harashima[1], R.Tsuda[2], Y.Tanaka[2]*, T.Kimoto[3], H. Tatsuta[4] and T. Hagiwara[5]
[1] *National Institute for Environmental Studies*
[2] *Kinki University*
[3] *Research Institute of Oceanochemistry (Foundation)*
[4] *Japan Weather Association (Foundation)*
[5] *Global Environmental Forum (Foundation)*
* Presenter

We reported the system description and data outputs of biogeochemical monitoring of Japan-Korea Ferry (Kobe-Pusan, 1991 - ) in the 2nd PICES Meeting. This program showed several products, time series aspects of the phytoplankton blooming, the pH-Lows in the Inland Sea, and the variation of phytoplankton characteristics. This ferry line was stopped in 1993 and we initiated a succeeding monitoring program using two ferry routes ( Osaka - Seto Inland Sea - Beppu line, one cruise per day; Osaka - Okinawa line one round trip per week). The main purpose of the former is to succeed the time series of the Seto Inland Sea portion of Japan-Korea Ferry and the latter is to scan newly the environmental states across the zonation structure: semi-closed sea - thermohaline front - continental shelf slope - Kuroshio - Subtropical Gyre using identical sensors. Besides the regular monitoring, we carried out manned investigations targeting the characterization by laser equipment, taxonomy of plankton, and measurements of carbonate species. From these experiences, merits, demerits, and certain desirable integration of continuous ferry monitoring systems and other platforms - satellites, mooring and drifting buoys are discussed.

3AM1994-MEQ05 Invited

## A MARINE ECOSYSTEM MONITORING NETWORK FOR CANADA

Lee Harding, Steve Wetmore and Robert Wilson, *Environment Canada, Pacific Wildlife Research Centre, P.O. Box 340, Delta, B.C., V4K 3Y3 Canada*

A national marine status and trends monitoring network is being established in the coastal regions of Canada. The network is designed to measure key attributes of marine

ecosystems that can be used to diagnose ecosystem health, and to detect processes, such as biomagnification or eutrophication, that could lead to large scale changes in structure and function. Its purposes are to integrate the time series monitoring of several federal and provincial agencies, and to identify the need for selective enhancements to existing programs. The network is intended to achieve strategic, scientific and operational linkages between agencies. Strategic linkages are based on agreements among agencies to cooperate in this initiative, to develop common objectives, and to share resources needed to achieve these objectives. Scientific linkages may include shared sampling and analytical protocols, common metadata standards, and cooperative technical design of monitoring programs, including selection of stations and approaches to analysis and interpretation. Operational linkages involve sharing of physical resources, such as ship and computing facilities, and joint planning to identify opportunities for collaboration. In Phase I (1992-93) a hierarchical marine ecosystem classification system was developed for Canada's marine environments. Phase II (1993-94) was the collaborative design of the network, involving a series of workshops with federal marine scientists and science managers across Canada. Phase III (1993) was a field trial of the network concept, conducted in the Pacific region. This paper presents the results of the first year of integrated monitoring of ecosystems on Canada's Pacific coast.

3AM1994-SB02 Invited

## INTERDECADAL CLIMATE-DRIVEN VARIABILITY IN SALMON PRODUCTION: A DISCUSSION OF MECHANISMS

Steven R. Hare, *School of Fisheries, WH-10, University of Washington, Seattle, WA 98195*

Large-scale interdecadal variability has characterized Alaska salmon production during the 20th century. Utilizing the time series technique of intervention analysis, we have demonstrated that salmon production has alternated between high and low production regimes. Similarly, we have identified four climatic regimes in the 20th century North Pacific coupled atmospheric-oceanic system with breaks, or interventions, occurring in the mid 1920s, late 1940s and late 1970s. The pattern of salmon production has not only been consistent across large spatial scales and different species, but corresponds very closely to the climatic regimes. The link, or mechanism, between North Pacific climate change and salmon production has been the focus of much speculation. Three general aspects of the mechanism have been proposed in the recent literature: 1) The driving climatic force is the winter Aleutian Low pressure system, which in turn affects gyre-scale ocean circulation, 2) primary and secondary production in the Subarctic North Pacific is important, 3) salmon year class strength is established early in the first year of the marine life history. In this paper, the evidence supporting these assertions is first summarized. Several competing and complementary mechanisms are then outlined and tested with available observational evidence.

3AM1994-FIS09

## ANATOMY OF A STRONG YEAR CLASS: ANALYSIS OF THE 1977 YEAR CLASS OF PACIFIC HERRING IN BRITISH COLUMBIA

Douglas E. Hay and P.B. McCarter, *Pacific Biological Station, Department of Fisheries and Oceans, 3190 Hammond Bay Road, Nanaimo, BC, Canada, V9R 5K6*

An exceptionally strong year class of herring (*Clupea pallasi*) occurred in 1977 in British Columbia. This strong year class developed in different spawning populations that vary in spawning time and geographical distribution. It was strong throughout the British Columbia coast but exceptionally strong among northern populations close to Hecate Strait. The year class recruited to the commercial fishery in 1980 and dominated catches for more than 5 years. This paper comments on the temporal and spatial development of that year class. We compare year class strength among different herring populations whose spawning time varied by 3-4 weeks or more. We describe the geographical distributions of larvae and show that the strong 1977 cohort was derived from populations in which (I) larval distributions were separated in space and (ii) larval production and development varied in time. We also describe the fate of

the 1977 year class as it passed through the fishery and compare age-specific growth rates, for ages 3-10, of the 1977 year class, with other year classes. We discuss the implications of these observations for the formation of the 1977 year class and other year classes.

3AM1994-POC10 Poster

## REGIONAL ENVIRONMENTAL SATELLITE MONITORING FOR OKHOTSK AND JAPANESE SEAS INVESTIGATIONS

E.E. Herbeck, A.I. Alexanin, I.A. Gontcharenko, J.G. Proshjants, J.V. Naumkin and V.G. Federjakov, *Institute of Automation and Control Processes FEBRAS, Vladivostok, Russia*

The facilities of Regional Environmental Satellite Monitoring (RESM) as an oceanographical data source and information tools for marine investigations in Okhotsk and Japanese seas are discussed.

The RESM is based on daily real-time receiving and processing of NOAA AVHRR multichannel multisatellite IR imagery (HRPT/LAC format) from NOAA/9/10/11/12 satellites as well as on digitized geostationary GMS data. The main goals of RESM are: reconstruction of ocean and atmosphere geophysical fields (such as sea surface temperature fields, surface current and wind vector fields); selection and tracing of meso-scale natural objects (eddies, rings, sea currents and its meanders, frontal zones, ice fields, cyclones etc.); estimation of short-term variability of objects and fields mentioned above.

RESM can be provided both as a self-dependent instrument of oceanographical researches (e.g., investigations of natural objects, their origination and evolution) and as an environmental support of physical and non-physical (biological, ecological, chemical etc.) marine studies.

There are some regional peculiarities of satellite data processing, that are determined by specific observation conditions. First of them is hard necessity of cloudy filtration and atmosphere correction. For the goal, the hierarchical processing scheme is developed.

Experience and results of RESM observations of natural objects in Okhotsk and Japanese seas are described. Some ways of further development of RESM possibilities are discussed.

3AM1994-FIS10

## YEAR-CLASS STRENGTH AND GROWTH OF SARDINE IN THE SEA OF JAPAN AND ADJACENT WATERS

Yoshiaki Hiyama, Hiroshi Nishida and Tsuneo Goto, *Japan Sea National Fisheries Research Institute, Suido-cho, Niigata, Japan*

There was a 20-fold variation in year-class strength of the sardine *Sardinops melanostictus* in the Sea of Japan and adjacent waters during the period between 1978 and 1993. Stock size and year-class strength, measured by the number of individuals 0 years old in December, were calculated by multi-cohort analysis. The year-class strengths were low in 1978 and 1979, high between 1980 and 1984, extremely high between 1985 and 1987 and low between 1988 and 1990. There was an inverse correlation between year-class strength and water temperature in the winter except for 1984, when water temperature was exceptionally low. Stock size of spawning sardine and ;year-class strength showed a convex relationship in which year classes produced by both low and high levels of spawning stocks were poorer than those produced by middle levels. This means that the reproduction curve of the sardine in no a contest (Beverton-Holt) type but a scramble (Ricker) type. The body length at each age was determined by a scale reading method. The average lengths at 3 to 5 years old for year classes between 1980 and 1989 were markedly smaller than those of earlier year classes. The average

lengths of 3 and 4 year old fish have been increasing since 1991, and the change in stock size has corresponded to that in growth.

3AM1994-PG02 Poster

## DISTRIBUTION OF WALLEYE POLLOCK ON THE SHELF OFF SOUTHEASTERN HOKKAIDO BY ACOUSTIC SURVEY

Satoshi Honda, Makoto Kashiwai and Yasunori Koya, *Hokkaido National Fisheries Research Institute, Japan*

There are large quantities of Walleye pollock distributed on the shelf off southeastern Hokkaido. This species is a main target of the trawl fishing industry in this region. This paper reports the results of a research cruise in June 1994. A quantitative echo sounder (FQ-70) was used to investigate relationships between distribution of Walleye pollock and environmental factors.

Acoustic survey runs were made during daytime because the abundance of integrated, detected echoes in the daytime was 15 times greater than that taken during night.

The significant echoes of Walleye pollock appeared at the depth layer from 30 to 60m, where the bottom depth ranged from 40 to 600m. The water temperature of the layer where significant echoes were detected was 1 to 4 deg.C. These facts are almost coincident with those found in previous papers.

The occurrence of echoes tended to increase with the undulation of bottom topography on the shelf or with the shelf break. The depth of daytime swimming layer is almost constant compared with the change of bottom depth. It means daytime swimming depth of Walleye pollock is not bottom referred. However, the horizontal distribution appeared effected by bottom topography. Results of analysis to clarify the effects of bottom undulation upon the distribution of Walleye pollock will be presented.

3AM1994-MEQ06

## IMPOSEX IN JAPANESE GASTROPODS AND ITS DEVELOPMENT BY TRIBUTYLTIN AND TRIPHENYLTIN FROM ANTIFOULING PAINTS

Toshihiro Horiguchi[1], Hiroaki Shiraishi[1], Makoto Shimizu[2] and Masatoshi Morita[1]
[1]*National Institute for Environmental Studies*
[2]*University of Tokyo*

Imposex is the superimposition of male sex organs (penis and vas deferens) in female gastropods. Thirty species of Japanese gastropods (24 neogastropods and 6 mesogastropods) were found to be affected by imposex (as of October 1993). Occurrence rates of imposex in rock shells, *Thias clavigera* and *T. bronni*, were 100% at almost all stations surveyed (32 sites in Japan). Relative penis length (RPL) indexes (a ratio of mean penis length in females to that in males) were higher at sites near harbours and marinas and were positively correlated with the concentrations of tributyltin (TBT) and triphenyltin (TPT) in both species.

The results of the injection experiments on 6 kinds of organotins (TBT, DBT, MBT, TPT, DPT, and MPT) using *T. clavigera* showed that TPT as well as TBT had strong effects on the initiation and promotion of imposex in this species. Judging from the flow-through exposure experiments for 3 months, imposex is induced in adult females of *T. clavigera* at amount 1 ng of TBT per 1 of environmental water. The threshold body burden of TBT inducing imposex is also estimated to be about 20 ng/g wet weight (0.06 nmol/g wet weight) in this species.

Effects of organotin pollution on the population of *T. clavigera*, bioconcentration factors and biological half-lives for TBT and TPT in T. clavigera are also discussed.

3AM1994-BIO04 Invited

## SMALL AND LARGE SCALE DISTRIBUTION OF ZOOPLANKTON WITHIN THE SUBARCTIC FRONTAL ZONE

Steven Ignell, *National Marine Fisheries Laboratory, Auke Bay, Alaska*

An intensive oceanographic and zooplankton survey of a small portion of the North Pacific's subarctic frontal zone (SFZ) was conducted in the 1991 in conjunction with an international monitoring program of nekton caught by squid driftnet vessels operating in that region.

Abundance of most nekton species captured in the driftnets were generally not associated with plankton abundance; the power of these tests were very low, however, as the observed fishing operations occurred in only a small portion of our survey area.

Over 91% of the total displacement volume (DV) or biomass of the plankton samples consisted of salps, followed by copepods (2.1%), euphausiids (2.0%), chaetognaths (1.7%) and amphipods(1.0%). Salps also accounted for almost half (44.7%) of the total caloric value in the samples. Salp abundances were uncorrelated with abundances of the crustacean zooplankton groups in our study. Pair-wise correlations between chaetognath, copepod, amphipod, and euphausiid abundances were all significant, especially those of euphausiids and amphipods (r=0.71).

Concentrations of non-gelatinous zooplankton in our study were more than double those of ocean station "P", the Sargasso Sea, Norwegian Sea and the Central Equatorial Pacific, but less than those of the Bering Sea, British Columbian coastal waters, and the N.W. Pacific Ocean. Such relatively high concentration values in our study might be expected as our survey area lies within a prominent area of convergence across the North Pacific Ocean.

Generalized Additive Models were used to estimate the time-of-day adjusted abundance and distribution of plankton. Salps exhibited a crepuscular vertical migration pattern; other species exhibited diurnal patterns. Model residuals were plotted spatially and comparisons made among nekton species and to the physical oceanographic data. We also compare our results with data from plankton samples taken east of our survey area and discuss some of spatial scales of plankton abundance in the SFZ.

3AM1994-BIO05 Poster

## VISUALIZATION AND QUANTIFICATION OF MARINE ORGANISMS AND WATER FRONT USING HYDRO-ACOUSTICS

Kohji Iida, Tohru Mukai, Doo-Jin Hwang, Tomoko Hayakawa and Yukihiro Matsuyama, *Faculty of Fisheries, Hokkaido University, Hakodate, Hokkaido, Japan. 041*

The distribution and the behavior of spawning walleye pollock *Theragra Chalcogramma* in Funka Bay, Hokkaido Japan, were investigated during acoustic survey by R/V "Ushio Maru" in the late of 1993.

The three types of echo, namely pelagic echo patches, demersal echo patches and the sound scattering layer (SSL) in the middle layer were recorded on the echogram of dual frequency quantitative echo sounder.

The hydrographic data by CTD observation showed that the cold and less salty water mass below 5°C and 33.5‰ was laying down on the bottom of the shelf of Oshima Peninsula then they formed water front along the boundaries to surrounding warmer and saltier waters.

By comparing the both hydrographic and acoustic data, the sound scattering layer appeared along with the water front and the demersal echo patches were remarkably found in the cold water mass. Activity of fishing boats and the hydrographic conditions in this area

demonstrated that the demersal echo patches are the shoals of walleye pollock who are migrating for spawning and the sound scattering layer consisted of zooplankton aggregation to the water front.

The statistics of the echograms indicated that the height of fish shoals are 1 to 4 meters and the SV of the echo are about -65 to -60dB. The density of the shoals of walleye pollock along the transects were 5.8 shoals/NM in November to 8.1 shoals/NM in December respectively.

3AM1994-POC11
## OCEANIC STRUCTURE AROUND THE ALEUTIAN ISLANDS
Haruo Ishii and Takatoshi Takizawa, *Ocean Research Department, Japan Marine Science and Technology Center (JAMSTEC)*

In August 1992 and October 1993, we conducted physical oceanographic observations down to near the ocean bottom by R/V Alpha Helix, in the eastern Aleutian Basin and around the Aleutian Islands. Vertical profiles of geostrophic flow based on CTD measurements are similar to those obtained by XCP (expendable current profiler) from sea surface to 1500m at maximum. The XCP profiles also show surface Ekman currents and vertical fluctuation with wave length of a few hundred meters. Probably these fluctuation of current speed is attributable to the internal wave. Around the straits on the Aleutian Islands such as Amukta Pass, north-south component of current velocity measured by XCP shows that maximum current speed often exceeds 50 cm/sec. This fact suggests an intensive water exchange between the Bering Sea and the North Pacific.

In October 1993, observation lines along the Aleutian Islands were occupied. Vertical distributions of dissolved oxygen content on the southern(Pacific) side show that the minimum layer below 0.7ml/L locates at about 800m depth and the oxygen gradually increases to more than 3.0 ml/L at depths deeper than 3000m. These distributions are almost the same as the observation results along 47N by R/V T. Thompson in 1985. In the Bering Sea (northern side),on the other hand, the minimum layer (< 0.7ml/L) locates at about 1000m depth and the oxygen increase more gradually than in the Pacific side to below 3.0 ml/L at near the bottom. The temperature-oxygen diagram shows clearly difference of water mass between the Bering sea and the North Pacific, especially in the deep layer more than 1000m.

3AM1994-FIS11
## CALCULATION PROCESSES IN THE NORTH WESTERN PACIFIC OCEAN AND LONG PERIOD FLUCTUATIONS OF PACIFIC MACKEREL POPULATION
A.N. Ivanov, *Pacific Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, Russia.*

Data on climatic fluctuations and depending changes in intensity of circulation system in areas of reproduction and feeding migration have been used to investigate the long period changes of environment and abundance of mackerel population.

The natural fluctuations of such scale directly influence on the level of reproduction, dynamics of mackerel population abundance and biological water productivity.

The analysis of interaction process of subtropic and subarctic circulations and dynamics of mackerel population abundance in the Northwestern Pacific Ocean in 1981-1988 has been done on the regional base (area of Kuroshio and Oyashio interaction). The antiphase of above mentioned circulation development is determined. Non linear common relation between circulation development and mackerel abundant brood are noted. Abundant brood of mackerel are in low or lower middle level at low and high values of subtropic circulation development anomalies. The high abundant brood is in the period of minimum values of

subtropic and subarctic circulation development. It happens at different levels of population stock. Water productivity fluctuations in Kuroshio and Oyashio currents are under the influence of circulation system changes of the Northwestern Pacific Ocean. The similarity of above mentioned common trends of circulations with biological water productivity and dynamics of mackerel population abundance are noted.

3AM1994-FIS12 Invited

## STOCK-RECRUITMENT MODELS FOR PACIFIC SARDINE

Larry D. Jacobson and Alec D. MacCall, *Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, California, U.S.A., 94920*

We used generalized additive models to study recruitment of Pacific sardine (*Sardinops sagazx*) along western North America, and to compare effects of fishing and environmental factors on the stock. We found significant relationships between the logarithm of sardine reproductive success (recruits per unit of spawning biomass) and average sea surface temperature (SST), as well as between sardine recruitment, spawning biomass, and average SST. Correlation with log reproductive success was highest when average SST data included temperatures after the period of larval development, indicating that recruitment estimates were affected by environmentally driven changes in availability of older sardine to the fishery. Predicted equilibrium biomass and MSY for sardine are lower under environmental conditions that prevail when temperatures are colder. Long-term fluctuations in sardine productivity, and little or no sardine harvest may be sustainable during periods of adverse environmental conditions and cold temperatures.

3AM1994-FIS13 Poster

## CHANGING OF SPECIES COMPOSITION OF MESO-PELAGIC FISHES OF NORTH-PACIFIC PELAGIAL TO "WEST-EAST" DIRECTION

E.P. Karedin and B.N. Gagach, *Pacific Research Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

The upper level 200 meter of waters of North-Pacific drift is thickly inhabited by meso-pelagic species at night, when active migrants of nictoepipelagic complex are rigen /terminology of N.V. Parin (1968). The average catches increasing from west to east make about 100 kg on the whole zone of North Pacific drift at night and lower at day time. Irregularity of amount of catches is higher in western part of ocean.

There are 66 species, belonging to 49 genus of 27 families. Genus: Lampanyctus (7 species), Diaphus and Lampadena (in 3 species) are represented by the most number of species.

The list of species on the whole area of North-Pacific drift and in the Bering and Okhotsk seas as well have considerable similarity. In the western part of North Pacific there were 52 species, in central part there were 46 species and in the east part - 39 species.

Every where the dominant species (on abundance and biomass) are *Diaphus theta, Symbolophorus californiensis* and *Senobrachiuos leucopsarus. Diaphus perspicillatus* (western region), *Lampanyctus jordani* and *L. ritteri* (western and central), *Nansenia crassa* (central), *Tarletonbeania crenularis* (eastern part).

Changing of species composition and of ichthyocene structure (mesopelagic fishes) occurs more smoothly to the direction from west to east and much more sharply when the latitude borders of water masses are crossed.

The region of underwater Emperor mountains, probably, is to by made into a separate district of western part of drift with leading position in its ichthyocene of the species *Maurolicus muelleri.*

3AM1994-FIS14 Poster

## PACIFIC SAURY MIGRATION IN DIFFERENT THERMAL YEAR TYPE

E.P. Karedin, *Pacific Research Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

Seasonal fish migration is one of the most important element of its ecology. It allows the mass pelagic species (saury, sardine and etc.) to inhabit the food resources of areas with marked seasonal rhythm of productivity in outlying waters of areas. Keeping of these species abundance cannot be provided with food resources in area of their reproduction.

The fisheries of these species is carried out only in area of their concentrations, position of which is connected with their migrating runs.

The western part of saury vast area (inhabitation of its Asian population) includes the area of subarctic front and outlying waters of subarctic and subtropic structures, and it is under influence of two strong currents (Kuroshio and Oyashio).

It is established that spring, forage migrating ways of saury are formed in tops of front meanders, eddies and "branches" of Kuroshio current, but autumn spawning runs - in analogous formations of Oyashio.

Position of these structures relative to Japan and Kuril Islands, terms of their formation and area dimension with cold and warm waters can be defined as "thermal type of year".

The thermal year includes seasonal dynamics of area with positive anomalies of surface ocean temperature within area with migration cycle. In warm years 1-2 "branches" of Kuroshio are well developed and coastal "branches" of Oyashio are weak. In cold years the first "branch" of Kuroshio is weakly marked and the second one is moved to the east by strong current of Oyashio. In warm years the migration of the main saury concentrations is in the coastal area, and in cold ones - in offshore of Japan and Kuril Islands. In first case the fisheries starts in the region of Shikotan Island and Friz Strait, in second - in Bussol Strait. In intermediate thermal years the hydrological situation and position of migrating ways are less determined.

Classification and procedure of thermal year estimation, corresponding schemes of migrating ways and characteristics of fisheries efficiency have been worked out on the base of analysis of 25 year data on hydrological regime, distribution and efficiency of Russian and Japan saury fisheries.

3AM1994-BIO06 Poster

## VARIABILITY IN TIMING AND MAGNITUDE OF SPRING BLOOM IN THE WESTERN SUBARCTIC PACIFIC OFF HOKKAIDO, JAPAN

Hiromi Kasai, Hiroaki Saito and Satoru Taguchi, *Fisheries Oceanography Division, Hokkaido National Fisheries Research Institute, Katsurakoi 116, Kushiro, Hokkaido 085, Japan*

Seasonal change of nutrients and phytoplankton standing stock was studied during the period from 1990 to 1992 in the western subarctic Pacific off Hokkaido, Japan. Abundant nutrients in the surface layer in winter were exhausted by the end of June. Spring phytoplankton bloom was observed in the Oyashio water and adjacent waters in April and May every year. Spatial variability in timing and magnitude of the bloom was observed. This spatial variability was different annually. Vertical stability of water column may play the important role in the initiation of the bloom and nutrient supply may control the termination of the bloom. Other factors such as sedimentation and grazing loss will be discussed.

3AM1994-POC12

## ON THE CHANGE IN WATER MASS STRUCTURE AND CHARACTERISTICS AROUND THE KURIL ISLANDS AND THE KURIL BASIN FROM AUGUST TO NOVEMBER 1993

Yasuhiro Kawasaki and Tokihiro Kono, *Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, 085 Japan*

The Oyashio was defined as a southwestward flow of the western Subarctic circulation south of the Urup Island and its formation process seemed to be related to the mixing process of two Subarctic waters; the East Kamchatka Current water and the Okhotsk Sea water. To investigate the seasonal change in water characteristics and water distributions of Subarctic waters, three hydrographic observations (Aug.-Sept., Oct., Nov.) around the Kuril Basin and the Kuril Islands were made from the stratified summer season to the mixed early winter season in 1993.

In the upper layer lighter than 26.4 in sigma-theta, Soya Warm water was distributed more wider area southwest of the Kuril Basin in November than in August. The depth of mixed layer was increasing from 30m in August to 80m in November. Salinity in the density range of 26.65-27.07 in sigma-theta were slightly increasing from August to November 1993. It suggests the intermediate Pacific saline water intrudes and/or diffuse into the Okhotsk Sea through straits of the northern Kuril Islands, in spite of a general anticyclonic circulation pattern in the Kuril Basin.

We will discuss another possibilities about the modification of Subarctic waters during the mixing period in our presentation.

3AM1994-POC13 Poster

## ON THE SEASONAL AND INTER-ANNUAL CHANGE IN DYNAMIC STRUCTURE OF THE OYASHIO ALONG THE HYDROGRAPHIC LINE SOUTHEAST OF HOKKAIDO

Yasuhiro Kawasaki and Tokihiro Kono, *Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, 085 Japan*

The hydrographic observations along the Akkeshi line (A-line) southeast of Hokkaido was made in every two months from April 1987 to May 1994, in order to make clear the magnitude and variability of the western Subarctic circulation.

Currents across the A-line are as follows; southwestward Oyashio 1st Branch (Oy1), anticyclonic circulation induced by warm-core ring (WCR), southwestward Oyashio 2nd Branch, and northeastward Oyashio Front. Oy1 flows almost south-westward from the coast of Hokkaido to continental slope area. The volume transport of Oy1 referred to 2500-3100 dbar was fluctuated from ten several Sv to several Sv. In general, Oy1 showed maximum transport of ten several Sv during winter and spring seasons. Especially during the period of January 1993, intense southwestward geostrophic flow above 15cm/s was calculated at 1000-1500m water depth over the continental slope area. Anticyclonic circulation induced by WCR was fluctuated because of its magnitude and north-eastward passage route.

We will discuss the dynamic structure of the Oyashio using the data of hydrographic observation, coastal water level, moored current meter, and satellite altimeter in our presentation.

3AM1994-POC14 Poster

## THE MINIMUM OF GENERAL ENTROPY PRODUCTION TO STUDY THE OCEAN STRUCTURES

Talgat Kilmatov, *Pacific Oceanological Institute, 43 Baltiyskaya St., Vladivostok, Russia. 690041*

It is proposed a variational approach for studying stationary states in the ocean. General stationary equations of hydro- and thermodynamics are used in the Euler formalizm in the problem of founding of the functional extremum.

The physical essence consists in the following. The minimum of the general entropy production takes place in any stationary state in the ocean (the concept of local potential of Prigogine - Glansdorff).

The application of this method to study cross-structure of Kurosio Front (width of stream, field of 3d velocity) is available.

3AM1994-FIS15

## THE EFFECT OF SEASONAL ANOMALY OF SEA WATER TEMPERATURE AND SALINITY ON THE FLUCTUATION IN THE BIMONTHLY YIELDS OF YELLO CROCKER, *Pseudosciaena manchurica*, IN KOREAN WATERS

Suam Kim and Sukgeun Jung, *Polar Research Center, Korea Ocean Research & Development Institute, Ansan P.O. Box 29, Seoul 425-600 Korea*

To delineate the time-lagged effects of physical environmental factors on the production of *P. manchurica* in the southwest sea of Korea, the bimonthly data on sea water temperature, salinity, and catch statistics from Feb. 1970 to Dec. 1988 were examined by time series and regression analysis. The mean and standard deviation of sea water temperature and salinity were used as parameters of physical environmental conditions. Autocorrelation, cross correlation and regression analysis with autoregression (AREG) by maximum likelihood were tried, using the unbiased and deseasonalized residuals of the parameters which were derived from weighted least square regression with month, average water depth, latitude and longitude. The residuals of the logarithmically converted catches from the weighted least square regression with year and month were calculated to remove seasonality and long term trends of fish landings. The landings illustrated a tendency of decrease with conspicuous seasonal cycles. The residuals of bimonthly catches showed a strong positive autocorrelation. AREG revealed that seasonal anomalies of temperature, i.e., the monthly decrease or increase relative to the corresponding months of other years, influenced the seasonal anomalies of the yield of *P. manchurica* with time lags of approximately one or two years. The bimonthly predicted catches from 1989 to 1990 by this model explained 70% of the observed landings and the mean percent error was 6.4% at the logarithmic scale.

3AM1994-POC15 Invited

## ECOSYSTEM MODEL FOR NORTHERN PACIFIC

Michio J. Kishi, *Ocean Research Institute, University of Tokyo, Minamidai 1-15-1, Nakano-ku, Tokyo,164 Japan*

On the processes to investigate a proper models for understanding the processes that govern the ocean biochemical cycle, an ecosystem model with seven compartments was made and coupled it with a one dimensional mixed layer model for calculating diffusion coefficient which appears in the governing equations and applied it to Station papa.

According to the calculated results, the model could reproduce characteristic features at Station papa such as the ammonium maximum, dissolved oxygen maximum and total yearly production. This ecosystem model was also run together with OGCM developed by CCSR, University of Tokyo.

3AM1994-FIS16

## CURRENT RESEARCH PROBLEMS WITH THE KING CRABS IN NEMURO WATERS

Jiro Kittaka, *Research Institute for Marine Biological Sciences, Institute for Science and Technology, The Science University of Tokyo and Nemuro City Fisheries Research Institute, 74 Onnemoto, Nemuro-shi, Hokkaido 087-01 Japan*

The Hanasaki king crab *Paralithodes brevipes* occurs mainly in Nemuro waters while the king crab *P. camtschaticus* is widespread in the Okhotsk Sea. Research has been carried out by the late Kurata et al. to clarify early life history, and the Akkeshi Branch of Japan Sea Farming Association has cultured the larvae for stock enhancement. Larvae hatch out as zoea and after about 30 days metamorphose into the glaucothoe stage; glaucothoe moult into juveniles about 20 days later. Culture experiments suggest that the glaucothoe stage does not feed and so in this respect is similar to the puerulus stage of spiny lobsters. The ecology of settlement, however, is quite different between the two crustaceans: glaucothoe presumable settle near where they metamorphose and then molt with intervals which are influenced by water temperature. On the other hand, pueruli metamorphose offshore and migrate inshore to settle; their survival appears to depend on nutrients stored during the zoea stage. The pigmented body of the glaucothoe is an adaptation to the settlement substrata while the recently-metamorphosed puerulus is transparent to avoid predation in the water column. There was often heavy mortality during the culture of the glaucothoe, probably due to poor nutrition during the zoeal stage. Juvenile *P.brevipes* are found under stones in the intertidal zone. Juveniles cultured at 15-20°C fed more actively than those cultured at 15-20°C. *P. brevipes* tolerate warm temperatures better than do *P. camtshaticus*. Both field sampling and laboratory culture experiment will help determine larval recruitment processes for these species.

3AM1994-FIS17 Invited

## LONG-TERM FLUCTUATION OF HERRING POPULATIONS DISTRIBUTED AROUND NORTHERN JAPAN AND THE DISCUSSION ON THE RELATIONSHIP TO MARINE ENVIRONMENT

Tokimasa Kobayashi, *National Research Institute of Fisheries Science, Fisheries Agency of Japan, 2-12-4, Fukuura, Kanazawa-ku, Yokohama, Kanagawa 236, Japan*

It has been known that the landings of Hokkaido-Sakhalin herring oceanic type population, fluctuated both between years and localities from the historical records. The amount of catch of Hokkaido-Sakhalin herring reached almost one million metric ton in 1897, however, the population size had gradually declined since at that time. Hokkaido-Sakhalin population's decline from 1950s closely correlated with generally warmer sea water temperature during the season from winter to spring. It has also observed that the dominant diatom species shifted from *Chaetoceros decipiens*, cold-neritic species, to *Coscinodiscus gigas* warm-nonhen species, in the waters off north western coast of Hokkaido. Drastic changes in marine environment which occurred around 1955 would have accelerated the decrease of stock size. Therefore spawning run has not been observed along the west and north-east coast of Hokkaido since 1959. But after about thirty years disappearance the 1983 year-class reappeared without premonitary symptom in 1985. It is an interesting phenomenon that spawning Atlantic herring reappeared on Georges Bank synchronously with the Rokkaido-Sakhalin heiring in 1983. What particular change has occurred globally in marine environment in 1983? Stock abundance of Pacific herring depend on the year class strength, and recruitment also depends on the survival rate in the period of early life stage. Marine environmental factors may play an important rôle to cause the variability of recruitment. Therefore result of analyses of environmental factors such as sea and air temperature, wind, atmospheric pressure, composition of plankton will be discussed.

3AM1994-POC16

## SEASONAL AND INTER-ANNUAL VARIATION OF THE OYASHIO CURRENT VELOCITY OBSERVED BY MOORED CURRENT-METERS

Tokihiro Kono and Yasuhiro Kawasaki, *Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, Hokkaido, 085 Japan*

We have been observing current velocity since May 1991 at the two sites on the continental slope south east of Hokkaido, in which the western boundary current of the subarctic circulation in the North Pacific flows. We analyze current records which were obtained at 1114m depth in stn. A3 on the northern continental slope with water depth of 1164m, at about 250, 1260, 3240m depth in stn. A5 on the southern continental slope with water depth of 3730m. Observed current at stn. A3 almost always flowed west-southwestward with average velocity of 3cm/s which is parallel to the bottom topography. Since surface current velocity observed by ADCP is 30 - 50cm/s in the same direction, barotropic component is concluded to have the ratio of 6 - 10% and 12 - 20% to the absolute geostrophic velocity and volume transport. In stn. A5, the west-southwestward current is not always dominant at all layers and the along-shore component was directed northeastward in autumn to early winter. The along-shore component seasonally changes only for at 1260m depth with maxima peaks in January to March, although maximum always occurred in winter to spring in stn. A3 and 250m depth layer in stn. A5. The passage of a Kuroshio warm core ring and/or the change in width and path of the Oyashio may have influenced the current velocity in stn. A5.

3AM1994-FIS18

## THE INFLUENCE OF REGIONAL CLIMATIC CHANGES ON MARINE FISHERY IN THE FAR EAST SEAS

Boris N. Kotenev, *Russian Federal Research Institute of Fisheries & Oceanography (VINRO), 17, V.Krasnoselskaya, Moscow, 107140, Russia*

Waters of the Russian exclusive economic zone in the Far East seas (the Seas of Japan and Okhotsk, the Bering Sea) are characterized by high bio and fish productivity. Thus, the total biomass of the commercially valuable species was estimated to be 50 mln. tons at the annual production of 26 mln tons in the 1980s (Shuntov et al., 1990).

The exploitation of the resources was marked by a tremendous growth of catches, especially in the post war period. The dynamics of catches of individual species, though, changed closely depending on deviations in the regional climatic conditions.

The analysis of their relationship permits firstly, to determine resources which have been poorly exploited at the growth of the biomass of the commercially valuable species population, and to discuss methods which shall permit to avoid underestimation of possible catches; secondly, to discuss prospects of fishery in the nearest future in connection with the coming epoch of cooling in the north west Pacific.

3AM1994-BIO07

## SEASONAL VARIATIONS IN THE ABUNDANCE AND COMPOSITION OF CHAETOGNATHA IN THE EPIPELAGIC LAYER OFF EASTERN HOKKAIDO, APRIL 1992 TO FEBRUARY 1993

Moriyuki Kotori, *Hokkaido Central Fisheries Experimental Station, Yoichi, Hokkaido 046, Japan*

Chaetognaths collected by 0 to 150m vertical hauls with a North Pacific standard net (0.33mm mesh openings) at 5 stations (Stns P1, P13, P15, P16 and P17) off eastern Hokkaido in the northwestern North Pacific Ocean were observed bimonthly from April 1992 to February 1993 to elucidate the seasonal cycle of this animals in the epipelagic layer. The following 6 species were found: *Parasagitta elegans, Eukrohnia hamata, Zonosagitta nagae,*

*Mesosagitta minima*, *Pseudosagitta* sp. and *Aidanosagitta* sp. Among them *E. hamata* was most abundant in the daytime on 21 May 1992 (17-24 individuals $m^{-3}$), although they disappeared in the epipelagic layer at night on 15 and 19 February 1993. *P. elegans* occurred all over the periods in this study, and they were most abundant in the daytime on 28 July 1992 (5-8 individuals $m^{-3}$). *Z. nagae* was appeared in summer (28 July 1992) and autumn (5-6 October 1992), being most abundant (3.5 individuals $m^{-3}$) at night on 6 October 1992 at Stn P11, the nearest station to the shore. *M. minima* occurred only in autumn (5-6 October, 30 November, and 1 December 1992), and *Pseudosagitta* sp. did through the periods from summer (28 July 1992) to late autumn (1 December 1992). The former was most abundant at night on 6 October 1992 at Stn P11, and the latter was numerous (2 individuals $m^{-3}$) at night on 28 July 1992 at Stn P17, the most seaward station, where the thermocline was pronounced, being covered by the warm water higher than 17°C in the upper about 10 m. *Aidanosagitta* sp. was only at Stn P17 in the morning of 1 December 1992. The body-size composition was observed to estimate the breeding season of *Parasagitta elegans*.

3AM1994-POC17

## PROGRESSION OF THE SEA SURFACE TEMPERATURE ANOMALIES IN THE NORTH PACIFIC

A.S. Krovnin, *Russian Federal Research Institute Of Fisheries And Oceanography (VNIRO), 17a, V.Krasnoselskaya Moscow 107140 Russia*

The spatial structure of the long-term fluctuations in the mean winter sea surface temperature anomalies (SSTA) in the North Pacific at grid points of 5° latitude by 5° longitude (from 55 to 20°N) for the 1957-1992 period has been studied. Five large-scale regions with the coherent character of SSTA variations were identified on the basis of clustering procedure: the eastern region (1P), the central region (2P), the northwestern region including the Sea of Okhotsk (3P), the southwestern region (4P), and the southern one (5P). The statistically significant simultaneous negative correlations in SSTA fluctuations exist between eastern and central parts of the North Pacific (regions 1P and 2P) and between its northwestern and southwestern parts (regions 3P and 4P). These correlations, in turn, may be associated with teleconnection patterns in the middle troposphere: the Pacific/North American and Western Pacific patterns, respectively. The relationships between index the Southern Oscillation and SSTA variations are also considered.

The correlation coefficients between time series of SSTA averaged over each region defined and time series of anomalies in every grid point in the North Pacific have been calculated with time lags from 1 to 9 years. This has allowed to analyze a progression of sea surface temperature anomalies in the North Pacific. It has been obtained that SSTA of the certain sign (for example, positive) gradually moved from the western coasts of North America (region 1P) to the west and reached the area off the Japanese Islands (region 4P) after 5 years and the central region (2P) after 6-7 years. The anomaly of the opposite sign initially arises at t=1 year off the Eastern Kamchatka and spreads to the east along 50-55 deg.N. At t=5-6 years the SSTA pattern in the region 1P is completely opposite to the initial pattern. Thus, the whole period of variations in SSTA (for example, from positive to positive anomaly in region 1P) is about 10-12 years. The correspondent changes in atmospheric circulation patterns at different time lags are also analyzed. The possible qualitative scheme of the atmosphere-ocean interaction during the SSTA progression is proposed.

3AM1994-FIS18 Invited

## ON THE MAIN CAUSE OF THE COLLAPSE OF THE JAPANESE SARDINE

Kazunori Kuroda, *Tohoku National Fisheries Research Institute*

The Japanese sardine (*Sardinops melanostictus* S.) began to increase dramatically in the early 1970's, attained to a peak in the late 1980's, then clearly decreased after 1988. Kawasaki

and Omori (1988) reported that the Japanese sardine stock fluctuated with the same cycle as the California and the South American sardines. But, it is difficult to elucidate the causes of fluctuations in the three sardine species.

The year-class strength of the Japanese sardine may depend upon its recruitment success. In other words, there are some main causes of stock fluctuations in the recruitment process of the Japanese sardine. In the present paper, the author tries to analyze the relationship among temporal and spatial distribution and developmental stages of the fish which would affect the recruitment success of the stock using the field data obtained so far.

The I -year-class strength of the Japanese sardine would be largely determined, not at the first feeding stage, but at the postlarval-juvenile stage, especially the postlarval stage of 10mm to 55mm in body length (namely, the Shirasu stage). The Shirasu stage larvae are distributed in the inner and outer parts along the main stream of the Kuroshio south of Japan and the Kuroshio Extension cast of Japan from March to May. The main cause of mortality for the Shirasu stage fish in the main stream and the outer part of the Kuroshio and the Kuroshio Extension may be considered to be predation by myctophiid fishes.

3AM1994-BIO08 Poster

## DISTRIBUTION OF BUCCINUM WHELKS (*Gastropoda: Buccinidae*) IN KITAMI-YAMATO-TAI BANK AND ADJACENT WATERS, NORTHEASTERN HOKKAIDO

Ren **Kuwabara**, Takahiro Kinoshita, Osamu Ichihashi and Takashi Mitsuzuka, *Tokyo University of Agriculture, Faculty of Bio-Industry, Department of Bioproduction, Laboratory of Aquatic Resources, Yasaka 196, Abashiri, Hokkaido, Japan. 099-24*

A large molluscan family Buccinidae is utilized in Japanese fisheries and food industry especially as such as raw sashimi dishes or traditional Kaiseki style cooking. Its need and commercial value have been accelerating in recent years. The gastropods of this family composed of a major group distributed in cold water regions in the world, and the records of bio-geography and depth in each species have been adopted to many Japanese monographs and illustrated handbooks. Nevertheless, fine data and ecological perspectives on this group are still few because of less information.

Comprehensive research on Kitami-Yamato-Tai bank and the surrounding area was made during 1991 and 1993. Test fishings were carried out with an exclusive dredger and set nets for catches of mollusks and crustaceans as a part of the research in 1993. The results include semi-quantitative data on species abundance and fresh informations of distribution ecology in Buccinidae.

Thirty-two species of the family were obtained from 29 stations in depth 44-1,497m. Genus *Neptunca* including 8 spp. and *Buccinum* with 12 spp. were major groups of the total species. Depth range of each species was renewed from referred monographs in the greater part. Distributions of species having high value of its mean shell-length were concentrated in depth range 500-800m which is allied to field of commercial fishing. In shallower and deeper zones, species has a tendency to provide smaller or light shell. Abundance of individuals was also seen in the above mentioned depth range.

3AM1994-BIO09

## DISTRIBUTION PATTERN OF MACROBENTHOS IN CIRCALITTORAL ZONE AND THE BORDERING AREA OF KITAMI-YAMATO-TAI BANK, NORTHEASTERN HOKKAIDO

Ren Kuwabara, Takahiro Kinoshita and Osamu Ichihashi, *Tokyo University of Agriculture, Faculty of Bio-Industry, Department of Bioproduction, Laboratory of Aquatic Resources, Yasaka 196, Abashiri, Hokkaido, Japan. 099-24*

Succeeding to the last presentation on distribution of macrobenthos in Kitami-Yamato-Tai Bank and neighbouring waters by the authors, a result of new survey which was carried out in summer of one year after and different season will be explained with additional and more detailed informations of benthic assemblage in this area; in which samples obtained with the regular Smith-McIntyre grab was analyzed because of showing a fine data as against those of a variety of tried sampling gears. The data was limited to a closed area of the bank of circalittoral depth and not beyond to deeper zones as the last survey.

Structure of the benthic assemblage and the distribution pattern were analyzed using species diversity by Shannon-Weaver's index and species similarity by Pianka (1973) in relation to depth, sediment and species habitats. As a consequence of the analysis, four groups of the benthic assemblage were demonstrated, i.e. Group I locates in the western slope of the bank at about 200m depth, Group II is on the southern part of flat plateau of the bank, Group III occupies a shallower area between the southern end of the plateau and the coast near Cape Notoro where is much abundant in benthic assemblage as same as the result of the last survey, and Group IV is a part of the northern end of the plateau of the bank.

3AM1994-POC18 Invited

## NORTH PACIFIC CIRCULATION MODELING WITH TELESCOPIZATION

Victor I. Kuzin, *Computing Center, Siberian Divisions, Russian Academy of Science, Novosibirsk*

Numerical modeling of the North Pacific circulation with the detailization for some western zones is based on the concept of the telescopization. This means that a set of models, one being included into another with respect to the scales is created. These models describe the circulation in the following basins: the North Pacific (1°x2°res.), the Kuroshio region (0.25°res.), the Okhotsk sea (0.25°res.). The numerical basis of these models is the combination of the finite element method and the splitting technique.

The North Pacific circulation model is developed for the domain including the tropical part up to 30°S. The model is intended for the description of the main features of the hydrophysical fields and as a control system for the regional models. With the use of this model the diagnostic and adaptive calculations in 2 and 3D versions were carried out. For the barotropic version the annual cycle of the circulation was calculated and the analysis of the seasonal variation of the main gyres was made. 3D diagnostic calculations were carried out by the wind stress and T-S climatic fields for the seasons. The results show the formation of the main gyres with the weaker analogs of the western boundary currents (Kuroshio, Oyashio) than in nature. The equatorial zone is characterized by the high level of 'noise', manifesting the unbalance between the T-S wind stress fields and the bottom relief. This inadequacy was smoothed by the additional adaptative calculations.

Some results of the preliminary 3D diagnostic calculations for the Okhotsk sea as well as a brief analysis of the Kuroshio current simulation are also presented in the talk.

3AM1994-BIO10 Poster

## INTERANNUAL AND SEASONAL DYNAMICS OF EPIPELAGIC ICHTHYOCEN OF OKHOTSK SEA

V.V. Lapko

In the last 1980s - early 1990s total fish biomass of Okhotsk epipelagic varied from 13 to 15 mln. t and a part of the most common species - walleye pollock was about 80%. The considerable part of epipelagical ichthyocen composed herring (3 - 10% of total fish biomass) and less - capelin (< 1%) in coastal waters and mesopelagic fishes, mainly northern smoothtongue were the most abundant (10 - 17%) under the deep basins. Pacific salmons were also significant - about 1% of total fish biomass.

In 80s the seasonal biomass dynamics of epipelagic ichthyocen was mainly related with the redistribution of ichthyomass between epipelagic (0 - 200 m) and mesopelagic (200 - 500 m) by means of walleye pollock descend to mesopelagic and decreasing of daily vertical migration of northern smoothtongue. There were also some numerous subtropical migrants such as sardines in the Okhotsk Sea before 1991.

In the early 90s changes in the ichthyocen structure were conditioned by the decreasing of walleye pollock biomass, discontinuance of sardine migrations and interannual fluctuations of pacific salmons abundance mainly pink salmon.

There is a tendency towards some increasing of the herring biomass in the coastal waters and northern smoothtongue in the upper layers under the deep basins at the last time. It's supposed that long term changes in the epipelagic ichthyocen of Okhotsk Sea were related with the essential climate - oceanological reconstructions in the north Pacific.

3AM1994-BIO11 Poster

## TROPHIC RELATIONS IN EPIPELAGIC ICHTHYOCEN OF OKHOTSK SEA

V.V. Lapko

Composition and trophic structure of epipelagic ichthyocen of Okhotsk Sea was examined basing on data collected in 1989-91.

In last of 80s total ichthymass in epipelagic (0-200m) of Okhotsk Sea was 13-15 mln.t (9.6 t/sq.km) in summer and about 5 mln. t (3.5 t/sq.km) in winter. The most abundant fishes - walleye pollock, pacific herring, northern smoothtongue, pacific salmons and capelin composed 98% of total fish biomass in both seasons. Such considerable difference between summer and winter ichthyomasses is explained by seasonal redistribution of the most abundant fish - walleye pollock between epipelagic and mesopelagic (200-500m) layers and by decreasing of daily vertical migrations of northern smoothtongue.

All fish daily diet was about 0.57 mln. t (378 kg/sq.km) I summer and 0.13 mln. t (100 kg/sq.km) in winter. The seasonal proportions of fishes - consumers in total diets were similar. Total diet composition was conditioned mainly by distribution of fish biomass in sea square.

The walleye pollock and herring were the main potential competitors in coastal waters and walleye pollock and northern smoothtongue in high sea. Diet overlap between walleye-pollock and herring was 19-23% and between walleye pollock and smoothtongue 50-56%. Biomass of preys included to the rations of both competitors were more than daily diets at hundreds times in summer and at thousands times in winter. Competition was low level because of high food supply.

3AM1994-SB03

## MODELING THE BIOPHYSICAL CONTROLS OF PACIFIC SALMON MIGRATION AND PRODUCTION

Paul H. LeBlond[2], Michael C. Healey[1], Carl J. Walters[1], Keith A. Thomson[1] and James Scandol[1]

[1]*Fisheries Centre, University of British Columbia, Vancouver, British Columbia, Canada, V6T 1Z4*
[2]*Department of Oceanography, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z4*

Pacific salmon migrate to the ocean as smolts, foraging heavily and growing rapidly before migrating back to their natal streams to spawn. This life history strategy has evolved to maximize survival and growth, and requires migrations of thousands of miles for salmon to reach their ocean foraging areas and return. These migrations and the distribution of salmon at sea are effected with rather precise direction-finding mechanisms and responses to ocean variables which are not fully understood.

Studies of sockeye salmon energy budgets, from the freshwater stage of juveniles to the oceanic return migration stage, have estimated the metabolic component as 40 to 50% of the total energy budget. Most of this metabolic cost is due to volitional swimming associated with avoidance of predators, foraging for prey, and active migration to specific goals or optimum habitats; the relative physiological costs of these activities varies with life history stage. Different direction-finding mechanisms (e.g. piloting, compass orientation, bicoordinate navigation) and responses to ocean variables (e.g. rheotaxis, temperature preferences) have different metabolic costs and different effects on salmon distribution, which would alter available food supply and abundance of predators (i.e. growth and survival). The return migration behavior of adult sockeye salmon and the dynamic environment in the northeast Pacific Ocean influences coastal migration route and return timing; understanding and predicting these effects are important to fisheries managers attempting to meet stock-specific escapement and allocation goals.

This paper will discuss our use of dynamic programming and individual-based migration models for examining the effects of the ocean environment on the distribution and migration of Fraser River sockeye salmon, including: optimum migration behaviours, and effects of mesoscale eddies and between year variations of the large-scale surface temperature and current structure in the northeast Pacific Ocean.

3AM1994-POC19

## AN EFFECT OF FRESHWATER INPUT AT THE SEA SURFACE

Jae Hak Lee, *Physical Oceanography Division, Korea Ocean Research and Development Institute (KORDI), Ansan P.O. Box 29, Seoul, Korea. 425-600*

In a thin water layer in which a vertical salinity gradient is maintained with the lighter freshwater on the top and the heavier salty water at the bottom, the thermal expansion is insufficient to disturb the stability provided by the salinity gradient and convection is suppressed. Such an insulating effect causes reduced moisture and heat flux to the atmosphere when low-salinity waters cover the sea surface.

An oceanic phenomena affected by the insulating effect may be found in the Yellow Sea where waters at depths of the thermocline are strongly stratified in summer. During the rainy season, a large amount of rain and runoff dilutes surface waters and provides the insulation. Consequently, heat is more effectively stored in the upper mixed layer than without freshwater caps. This may partly support the strong summer stratification observed usually.

A more pertinent application of the insulating effect may be a climate change problem in relation to high-latitude ocean melt-water input caused by the expected greenhouse effect.

It is necessary to attempt a modeling study to understand climate response to ocean freshwater discharge.

3AM1994-FIS42 Invited

## ON THE SOURCES OF RECRUITMENT VARIABILITY IN SMALL PELAGICS

Daniel Lluch-Belda, *National Oceanic & Atmospheric Administration, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA, 98115-0070, U.S.A.*

Small pelagic fishes are well known for one of their population's most striking features, the ability to grow to very considerable biomasses and collapse to extremely low numbers in very short time periods. Although for a time it was assumed that these large fluctuations were caused by the fishery (particularly the collapsing), it has been more and more evident that environmental changed play a major role in driving the abundance of these populations.

Sinchronous population abundance variations in widely separated coastal areas show that environmental changes have a predominant influence on this changes. This, the Regime Problem, has been increasingly recognized. The effect of environment on the abundance of these populations has been long postulated. The analysis of scale deposition in the varied sediments has strengthened this belief.

The recognition of this fact led to a number of hypothesis searching for the specific mechanisms through which environment acts to produce variability in the population size. Interspecific competition, effect of temperature or productivity, genetic diversity, etc. have all been mentioned in this context. However, it has been the Recruitment Problem, the differential survival from the egg to larvae, the hypothesis that has received more attention. Several authors have addressed this problem and, although they had different approaches, all depended on Hjort's idea that it is lack of food what determines larval survival and, as a consequence, recruitment magnitude.

However, there are other stages in which the size of the recruiting generation could be determined. In the present paper we will try to show some evidence that points in the direction of the magnitude of spawning determining the strength of recruitment.

Three pieces of evidence are shown and discussed:

a. the rather constant rate of larvae to eggs in three different locations, with distinct sardine populations,

b. The high variability in the spawning process of sardine populations, and

c. The bias introduced in the estimation of sardine populations abundance when using exclusively egg and larvae surveys.

3AM1994-FIS19 Poster

## VARIATION OF LIFE STAGE DURATION AND SURVIVAL PARAMETERS AS RELATED TO RECRUITMENT VARIABILITY OF COASTAL PELAGIC FISHES

Nancy C. H. Lo, Paul E. Smith and John L. Butler, *Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA, 92038, USA*

A stage-specific population matrix, the Lefkovitch matrix, was used to identify stages in the life history of the Pacific sardine, *Sardinops sagax* and the northern anchovy *Engraulis mordax* which allows the least costly detection of recruitment failure. For short-lived fishes like anchovy and sardine, the population change is directly related to the variability of recruitment. In the population model, both the mean the variability of duration within stage is incorporated. This study shows that for the percentage change of mortality in yolk-sac larvae, fecundity of two year old fish and duration in late larvae (10-35mm). For the sardine, the

recruitment success is most sensitive to the percentage change of mortality in life stages of egg and yolk-sac larvae, fecundity of five year old fish and duration in the early larvae (4-10mm). A population with variable stage growth is less sensitive to the change of stage specific vital rate yet grows faster than a population with fixed duration.

3AM1994-POC Invited

## STATISTICAL STUDY OF THE KURIL EDDIES AND THEIR ROLE IN REGIONAL HYDROGRAPHY

Vyacheslav Lobanov, *Pacific Oceanological Institute, 43 Baltiyskaya St., Vladivostok 690041 Russia*

Satellite infrared images for the period 1973-1992 were analyzed to determine the presence, location, number, size, life-time and movement of the Kuril eddies. The eddies appear at IR imagery in August-November period when SST contrasts are sufficient for their manifestation at sea surface. From 2 to 5 anticyclonic eddies were found to present east of Kuril Islands each year having dominant diameters of 120-140 km. It was difficult to determine the eddy center position exactly due to its irregular and rapidly evolving shape. So the eddy appearance in 1 degree squares were calculated and mapped. Maximum value of the existing frequency function stretches along the axis of Kuril-Kamchatka bottom trench forming three local areas of the eddy extreme prevalence. Significant cloud cover of the region prevented from the observation of the eddies movement in details. It was found a general north-eastward drift. Lacks of satellite data from late autumn till early summer do not allow to determine the eddies life-time and to state with confidence a succession among the structures observed in different years. However hydrographic data suppose their long time existence. In the discussion an average effect of the eddies on an offshore advection of the shelf water is analyzed in comparison with volume transport through the Kuril straits and of the Oyashio branches.

3AM1994-FIS20 Poster

## WINTER MIGRATION AND FORAGING ECOLOGY OF ADULT MALE NORTHERN FUR SEALS IN THE SUBARCTIC PACIFIC OCEAN AND BERING SEA

T.R. Loughlin[1], G.A. Antonelis[1], B.W. Robson[1] and [2]M. Kiyota
[1]*National Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, U.S.A. 98115*
[2]*National Research Institute of Far Seas Fisheries, Fisheries Agency, Shimizu, Japan*

We studied the foraging ecology and movements of northern fur seals (*Callorhinus ursinus*) during winter to characterize pelagic areas of importance. Data on location at sea and dive characteristics were collected by satellite-linked time-depth-recorders (SLTDR) glued to the backs of 14 male fur seals during October to November 1991 and 1992. Once at sea, male fur seals utilized oceanic areas as well as the outer domain of the continental shelf of the Bering Sea from about St. Matthew Island south and from about the 100 m isobath on the continental shelf west of Shirshov Ridge in the western Bering Sea. They left the Bering Sea usually by January and fed either in the eastern Pacific Ocean and Gulf of Alaska or to the west off the Kuril Islands and Japan. The mean duration in the Bering Sea after SLTDR attachment was 30.3 days. Most dives (83%) were between 4 and 100 m and the remaining 17% were between 101 and 350 m. No dives were >350 m. Sixty eight percent of all dives were between 4 and 50 m and 14% were between 51 and 100 m. Only 22.5% of the dives were >250 m. Dive duration was <6 minutes (90%), with 43% being 1 minute or less and <1% over 11 minutes. Information collected during this study on male fur seals, and in earlier studies on females and pups, suggests that most fur seals of all ages and both sexes leave the Bering Sea during winter (February to March) and forage in subarctic Pacific and Gulf of Alaska.

3AM1994-FIS21
## RECRUITMENT PATTERNS OF SARDINES, ANCHOVIES AND MACKEREL OFF CALIFORNIA, AND COMPARISON WITH JAPANESE STOCKS

Alec D. MacCall, *NMFS, SWFSC, Tiburon Laboratory, Tiburon, California, USA*
Kenichi Tatsukawa, *Ocean Research Institute, University of Tokyo, Tokyo, Japan*

A 2000 yr paleosedimentary record from southern California shows low frequency periodic fluctuations in both sardines and anchovies (period about 57 yrs). There is a general term coincidence of sardine population size in California and Japan, but with time lags of up to a decade. The stock-recruitment relationship of California's sardine is strongly association with temperature, which serves as a proxy variable for a variety of poorly understood oceanic influences. Long term fluctuations in southern California ocean temperatures appear to be associated with the Southern Oscillation (as measured by the Southern Oscillation Index--the difference in barometric pressures between Tahiti and Darwin, Australia), and also with the strength and position of the Aleutian Low, suggesting driving climatic mechanisms of global scale.

The fluctuations of the California anchovy stock may be influenced by the same long term climatic and oceanic patterns. There is better evidence of independent population responses to mutually experienced environmental conditions than to direct interaction between sardine and anchovy stocks.

In California, mackerel (*Scomber japonicus*) have shown a strong six to seven year cycle in recruitment success, but the long term peaks of abundance have been nearly in phase with those of the sardine. This pattern contrasts with Japan, where there may be a different phase relationship between mackerel and sardines. While we are gaining a better understanding of long term fluctuations of pelagic fish recruitment, the mechanisms that determine pelagic fish recruitment on the local scale remain unclear.

3AM1994-POC Poster
## NUMERICAL MODELING OF THE ANNUAL CIRCULATION VARIABILITY IN THE OKHOTSK SEA: PART 1. BAROTROPIC EXPERIMENT

Andrey Martynov, *Computing Center, Siberian Division of the Russian Academy of Sciences, Lavrentieva av.,6, Novosibirsk, 630090, Russia*

Air circulation above the Okhotsk Sea has the monsoon character: strong northerly/westnortherly geostrophic winds dominate during the winter time driven by a low-pressure center (the Aleutian Low) east of Kamchatka and a high pressure center over Siberia (the Siberian High). Weak winds of opposite direction are typical for summer time and some reorganization of the wind fields takes place during intermediate autumn and spring months according to the pressure center position changes.

A barotropic numerical model is used to investigate the wind-driven circulation in the Okhotsk sea. 3-D ocean general circulation model of Kuzin and Golubeva (1986) based on the primitive hydrodynamical equations is adapted for the Okhotsk Sea. The model has a horizontal resolution of 0.5 x 0.5 degree in latitude and longitude.

The governing equations of the model are transformed by separations of the external and internal modes. Equations for external mode are reduced by the rotor operation to the vorticity equation.

This equation in terms of stream function $\Psi$ is solved numerically on a sphere in the spherical coordinates as separate model in the present study. And it can serve as part of 3-D model in future.

$$(\partial/\partial t + R)m\Delta_H\psi \cdot rot\,((\zeta + f/H)\,\Delta\psi) = \mu(\Delta H\zeta + 2n^2H\zeta) + F,$$

in which $F_x$ is the wind stress source.

The numerical realization of the model is based on the combination of splitting and finite element methods.

The wind stress is interpolated to the model grid from the monthly averaged data of Hellerman and Rosenstein (1983). To simulate the ice cover during the period from December to May the wind forcing is supposed to be zero above the ice covered regions according to the mean position of ice edge (Pacific Ocean: Atlas of oceans, 1974).

Numerical experiments are carried out with flat bottom (with a depth of 1,000 m) and with real bottom topography using annual-mean wind stress, wind stress for all seasons /WINTER, SPRING, SUMMER and AUTUMN/ and for 12 months separately.

A clear cyclonic general circulation (Leonov, 1960) is not saved in the annual cycle. The presence of two or more cyclonic and anti-cyclonic circulations above the shallow regions and Kurila Basin is more typical. The position and intensity of these formations has some changes both from month to month and from one season to another.

The anti-cyclonic circulation is appeared in the northern Kuril Basin as in some Runs of Sekine's study (1990), but this formation also is not persists during all year.

It is necessary to include in the model the density stratification to represent more accurately both the general circulation of the Okhotsk Sea and some features of the current system. It is also very important to use more fine resolution for better representation of inflow/outflow processes at the open boundaries especially in the region of Kuril Islands.

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3AM1994-BIO12 Invited

## DISTRIBUTION AND ZOOGEOGRAPHY OF EPIPELAGIC NEKTON OF THE NORTH PACIFIC TRANSITION ZONE


Skip McKinnell[1] and Akihiko Yatsu[2]

[1] *Pacific Biological Station, Nanaimo, B.C. Canada*

[2] *National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan*


During 1990 and 1991, scientific observer programs studied the large scale pelagic driftnet fisheries of the North Pacific Ocean. These programs produced one of the most extensive databases ever collected on epipelagic macronekton in the North Pacific Ocean. In the Japanese squid driftnet fishery, daily observations of catch, bycatch, and environmental conditions were recorded across approximately 3600 km of the North Pacific Transition Zone from 170°E to 145°W. Approximately 10,000 sea surface temperature measurements were made in each of 2 years. Because the fishing occurred in a narrow band (÷200 km wide), this data set is ideally suited to east/west comparative studies. Over 5,000 daily fishing operations were monitored during these two years. Our zoogeographic study uses multivariate analytical techniques to explore community diversity, species abundance, and geographic structure in the North Pacific Transition Zone. Clustering, principal coordinate analyses, and principal

component analyses are used to examine the data for evidence of zoogeographic structure with special focus on the effects of longitude.

3AM1994-FIS22 Poster

## ESTIMATION OF BIOPRODUCTIVITY IN THE WESTERN BERING SEA BASED ON THE SEASONAL INVESTIGATIONS OF PHYTOPIGMENTS

M.P. Metreveli and N.V. Mordasova, *Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17a, V.Krasnoselskaya, Moscow 107140, Russia*

During expeditions in the Bering Sea conducted by VNIRO in 1990-1993 the distribution of phytopigments during the different seasons was studied with use of submercible fluorimeter which allowed to register continuously changes in intensity of chlorophyll a fluorescence with depth. Simultaneously the water samples were taken for determination of chlorophyll a, b, c and pheophetin a by spectrophotometric method.

The spring blooming of phytoplankton started under active insolation near the ice edge in the coastal waters characterizing with negative temperature and high stability (>1000 ref. units) associated with ice melting and formation of the upper freshened layer. In April 1990 during the blooming of diatoms (*Thalassiosira* spp.) the high concentrations of chlorophyll a (1.1-36.5 mg $m^3$) were observed off the Karaginsky Island, in the Olutorsky Bay and in the zone adjacent to the eastern Bering Sea shelf (total content in the photic layer- up to 680 mg $m^2$). The content of pheophetin a product of chlorophyll a decay did not exceed 10-15% of their total content.

In April-May the hydrological conditions in the open sea were characterized by winter situation. Photosynthesis was weak in waters with weak stratification, and concentration of chlorophyll on the average was 0.4 mg $m^3$ (total content in the photic layer up to 25 mg $m^2$); content of pheophetin 35-70%.

In summer phytoplankton developed actively in the deep sea and over the continental slope due to formation of the upper quasi-homogenious layer; the concentration of chlorophyll a reached 3-4 mg $m^3$. In the zones of constant advection of nutrients (for example, in the Dezhnev Bay) the content of chlorophyll was comparable with that observed during the phytoplankton blooming in the early spring up to 30 mg m-3 and higher.

Judging from concentrations of chlorophyll a in the waters of the western Bering Sea (in the shelf zone and bays) during spring-summer season, they may be considered as the most productive regions of the world's oceans such as upwelling regions. Bioproductivity of the deep part of the sea in spring and autumn is close to mesotrophic waters, and in summer when the upper quasihomogenious layer forms to eutrophic waters.

3AM1994-MEQ07

## CHANGES IN STABLE CARBON AND NITROGEN ISOTOPE RATIOS IN SOOTY (*Puffinus griseus*) AND SHORT-TAILED (*P. tenuirostris*) SHEARWATERS DURING THEIR NORTHWARD MIGRATION IN THE NORTH PACIFIC

Hiroshi Minami[1], Masao Minagawa[2] and Haruo Ogi[1]
[1] *Research Institute of North Pacific Fisheries, Hokkaido University*
[2] *Laboratory of Biogeochemistry and Sociogeochemistry, Mitsubishi Kasei Institute of Life Science*

Stable isotope analysis of consumer and prey tissues represents a valuable method to assess trophic levels in marine and terrestrial ecosystems. In this study, stable carbon (δ13C) and nitrogen (δ15N) isotope ratios were measured in muscle tissues of 18 sooty and 44 short-tailed shearwaters sampled in the northwestern Pacific ocean from April to June in 1986, 1989, and 1990. The shearwaters showed δ13C and δ15N values of -24.5 - -17.6 per mil and

7.3 - 13.0 per mil, respectively. This result agrees well with previous studies analyzing stomach contents, in which shearwaters fed mainly on zooplankton and pelagic fish. In the coastal area of northern Japan, sooty shearwater showed somewhat higher δ13C value than short-tailed shearwater, while no interspecific difference was found in the oceanic area of North Pacific. The interspecific difference in the coastal area reflects their dietary difference. Shearwaters also showed areal differences in stable isotope ratios: the shearwaters from oceanic area during June had significantly higher δ13C and δ15N values than those from coastal area during April and May. The low stable isotope ratios in the birds from coastal area suggest the preservation of isotope ratios of prey in their breeding area in the southern hemisphere. Our results indicate that the stable isotope ratios of migratory seabirds differ not only by their trophic position but by their inhabiting water mass.

3AM1994-FIS23

## ESTIMATION OF CONSUMPTION OF WALLEYE POLLOCK BY FLATFISH IN THE EASTERN BERING SEA DURING 1970 TO 1985

Kei-ichi Mito, Akira Nishimura, and Takashi Yanagimoto, *North Pacific Groundfish Section, National Research Institute of Far Seas Fisheries, 7-1, Orido 5 chome, Shimizu, 424 Japan*

Walleye pollock is one of the key species in the Bering Sea ecosystem. It is important of analyzing of pollock population and ecosystem dynamics to estimate consumption by groundfish. The North Pacific Groundfish Section analyzed the stomach contents of groundfish sampled in the Bering Sea during 1970 to1985. These data are used for calculating of pollock by itself and Pacific cod was already estimated using the daily ration and the population number of predator. We will estimate here the consumption by flatfish in number.

Greenland turbot, arrowtooth flounder and Pacific halibut mainly ate pollock and flathead sole took a little, but yellowfin sole and Alaska plaice ate it very little. The biomass of predatory flatfish estimated by Japan-U.S. cooperative groundfish surveys was smaller than that of Pacific cod. Therefore, the consumption of pollock by flatfish will be fewer than that by Pacific cod. The biomass of many groundfishes in the eastern Bering Sea changed largely between surveys in 1979 and 1982, that is, adult pollock and Pacific cod increased but Greenland turbot decreased. The consumption number by groundfish before 1980 will be compared with that after 1980. We will discuss the role of predation in determining the year-class strength of pollock.

3AM1994-FIS24

## BODY SIZE AND DISTRIBUTION OF 0-AGE WALLEYE POLLOCK ALONG THE PACIFIC COASTAL AREA OF SOUTH-EASTERN HOKKAIDO IN AUTUMN, 1987-1993

Hiroya Miyake, *Hokkaido Wakkanai Fisheries Experimental Station, Hourai, Wakkanai, Hokkaido, 097, Japan*

The indices of the year-strength of walleye pollock were estimated based on the results of Nahira trawl surveys along the Pacific coast of south-eastern Hokkaido in previous paper. In this paper I compare the body sizes by months (September to October), by the years (1987-1993) and by the depths. Using the changes of the body sizes, I discuss the relationship between the year-class strength estimates and the body sizes.

3AM1994-MEQ08 Poster

## ANTHROPOGENIC INFLUENCE ON ECOSYSTEMS OF SAKHALIN SHELF WHILE DEVELOPMENT OF GAS AND OIL-FIELD DEPOSITS

G.V. Moiseychenko, *Laboratory of Applied Ecology and Toxicology, Pacific Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, Russia*

Augmentation pollution anthropogenic stress while development of gas and oil-field deposits in Far North Environment is highly dangerous for highly productive marine ecosystems of the Far East Seas. Pollution by petroleum and other chemical compounds of marine environment is possible during research and development drilling, during repair and development of borehole. Our toxological researches showed water soluble and aromatic oil products to be most dangerous for ecosystem species. Oil hydrocarbons appeared to be especially high toxic for early stages of echinoderms, fish and mollusk development. Chemical reagent and drilling solutions examinations showed their toxicity for a number of species of zooplankton, young fish and echinoderms larvae. GKZ, disolvan, sulfanol from the series of chemical reagents applied are most dangerous for such marine biota. Experimental research with heavy chemical - bentonite didn't result marine brota mortality, but even traces of it interfered with spawning in mussels. Multi factor experimental influence of drilling solutions on young salmon and it's nutrition base in Sakhalin Shelf let us make a conclusion about more high toxicity of drilling solution comparing it's separate components.

Measures to decrease toxicity of pollution on marine ecosystems during development of gas and oil fields, based on experimental researches, are suggested.

3AM1994-BIO13 Poster

## DISTRIBUTION OF JUVENILES OF THE JAPANESE COMMON SQUID *TODARODES PACIFICUS* IN THE NORTHWEST PACIFIC OFF JAPAN.

Ken Mori and Yoshikazu Nakamura, *Hokkaido National Fisheries Research Institute, 116 Katurakoi, Kushiro, Japan*

This paper examines the distribution pattern of juveniles of *Todarodes pacificus* in the northwest Pacific off Japan. The juveniles were collected in April 1993 and 1994. Three types of sampling gears were used: the 10-ft Isaacs-kidd midwater trawl (5mm mesh), 1.3m ring net (5mm mesh), and 2m ring net (3mm mesh). Isaacs-Kidd midwater trawl and 2m ring net were towed obliquely from the surface to 100m. Both the ring nets were towed horizontally at the surface for 15min. A total of 95 juveniles of *T. pacificus* were captured. Appearance rates of the juveniles were 22.7% of total sampling stations in 1993 and 38.9% in 1994, respectively. The distribution pattern of juveniles is discussed with oceanographical conditions.

3AM1994-POC22 Poster

## AN ESTIMATE OF STRATIFICATION BACKGROUND CONDITIONS OF SEA-WATER STABILITY IN THE NORTH PACIFIC

L.F. Muratov and I.A. Zhabin, *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, Russia. 690041*

The formulation of criterion which would enable to identify the development of convective instability processes on the basis of background stratification conditions is one of the important problems in the study of fine structure generation processes.

The structural zones and layers with favourable stratification conditions for development of double-diffusive convection in the North Pacific were distinguished on the basis of long-term mean temperature and salinity data (Rostov, Zhabin, 1987). It is shown that distribution of their parameters is determined by location of subsurface and intermediate water masses and fronts. Due to the fact that the definition for density ratio $R_\rho$ do not include

obviously some dynamic factors such as vertical variability of velocity fields, non-stationary pertrubations caused by the internal waves we attempt to formulate another criterion for estimation background conditions of fine structure generation processes. From this point of view the hydrographical data received on the board of R/V "Academik M.A. Lavrentyev" (1990) in the various amphidromic systems were used. The indirect criterion for the fine structure generation conditions which can be used as the estimation intensity of temperature field variability was formulated. The estimations of this criterion on periphery of three amphidromic systems in the North Pacific were obtained. The comparison of these estimates with ones computed for other ocean areas indicated that stratification on the periphery of amphidromic systems is more favourable for development instability then in the central area. The stability conditions are varied significantly during tidal period on the periphery of amhpidromic systems.

3AM1994-SB04

## PATTERNS IN THE SPATIAL DISTRIBUTION OF SALMON (*Oncorhynchus* spp.) CAPTURED IN THE PACIFIC DRIFTNET FISHERY FOR FLYING SQUID (*Ommastrephes bartram*)

James Murphy, *Prince William Sound Science Center, 300 Breakwater Ave., Cordova, AK, 99574*

In an attempt to understand the factors which lead to the bycatch of salmon within the driftnet fishery for flying squid, *Ommastrephes bartrami*, I model the spatial distribution of salmon (*Oncorhynchus* spp.) bycatch at large and meso-scales and use a bioenergetic hypothesis to explain the observed spatial distribution of salmon. The bioenergetic hypothesis assumes that salmon are distributed in a manner which maximizes growth and that growth is dependent on both sea surface temperature (SST) and available forage. I identify two spatial patterns in forage which influence the spatial distribution of salmon in addition to SST. 1) Changes in the biological productivity associated with water mass types produce large-scale spatial pattern in the encounter probability of salmon by the fishing fleet. 2) Mesoscale enhancement in biological productivity over the Northern Emperor Seamount Chain results in dense clusters of salmon above the seamounts. I speculate that these spatial patterns in forage account for the differences in salmon abundance which can not be explained by SST.

3AM1994-POC23 Invited

## TEMPORAL AND SPATIAL VARIABILITY OF THE TEMPERATURE AND SALINITY CHARACTERISTICS ALONG 50°N

David L. Musgrave[1], Vladimir V. Plotnikov[2] and Nicolai S. Vanin
[1]*University of Alaska Fairbanks, Fairbanks, Alaska*
[2]*Pacific Rim Research Center, Vladivostok, Russia*

The International North Pacific Ocean Climate (INPOC) Program is a collaboration of scientists from Russia (Pacific Oceanological Institute, Far Eastern Region Hydrometeorological Institute, and the Pacific Rim Research Center, Vladivostok), Canada (Institute of Ocean Sciences, British Columbia), and the United States (University of Alaska Fairbanks, Alaska, and Scripps Institution of Oceanography, San Diego) to study the physical and chemical oceanography of the North Pacific. As part of this program, four CTD surveys of the North Pacific were conducted in the fall 1991, spring 1992, fall 1992, and spring 1993. Each survey had over 300 stations in the upper 2000m and covered the region north of 35°N. We present an analysis of the temporal and spatial variability of the temperature and salinity characteristics of a section along 50°N, which was occupied in each of the four cruises.

3AM1994-POC24 Poster

## SEASONAL VARIATION OF THE TSUGARU CURRENT AND FORMATION OF DENSE WATER ALONG THE SANRIKU COAST

Y. Nagata[1], S. Takasugi[2], K. Ishida[2] and M. Mizutani[3]
[1]*Mie University, 1515 Kamihamacho, Tsu, Mie, Japan. 514*
[2]*Iwate Fisheries Technology Center, 3-75-3 Heita, Kamaishi, Iwate, Japan. 026*
[3]*Shin-Nipponn Meteorological and Oceanographic Co., 3-14-5 Tamagawa, Setagaya, Tokyo, Japan. 158*

The Tsugarau Current which flows out from Tsugaru Strait has high salinity as it originates from the Tsushima Current in the Japan Sea. The Tsugaru Current Water can get high density just off the Sanriku Coast by surface cooling in winter season, and its density becomes comparative to or heavier than the North Pacific Intermediate Water. The formation of the dense water is closely related to the seasonal and inter-annual variations of the Tsugaru Water. The Tsugaru Current there is weak from February to June, and the Tsugaru water off Sanriku coast is usually replaced by the Oyashio Water in February. Thus the formation seems to occur rather in January than in the coldest February.

3AM1994-BIO14

## DAILY VERTICAL MOVEMENT OF NEON FLYING SQUID *Ommostrephes bartramii* IN THE CENTRAL NORTH PACIFIC

Yoshikazu Nakamura, *Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, Japan.*

Vertical movement of *Ommostrephes bartramii* was studied by ultrasonic telemetry in the central North Pacific. Ten females were tagged with ultrasonic transmitters which provided information on depth, and tracked for 6.5 to 48 hours in July-August 1991 and August-September 1992. Clear daily vertical movement was observed in four of the ten trackings. The daily vertical movement of *O. bartramii* in the central North Pacific was shown to have the following pattern: female *O. bartramii* swims above 40 m depth during the night and descends around sunrise and swims at 150 to 300 m in the daytime and then ascends around sunset.

The swimming layer of *O. bartramii* during the night corresponded essentially to a thermocline observed at depths of 20 to 40 m in the tracking area. The depth of *O. bartramii* during the night thus appears related to the depth of thermocline. Daily changes in depth of several light intensities in the sea were calculated from light intensities measured on board during trackings. Daily vertical movement of *O. bartramii* was generally consistent with the daily changes in light intensity. The vertical movement of *O. bartramii* would thus appear due primarily to change in light intensity in the sea.

3AM1994-FIS24

## TROPHIC LINKAGES AND INTERANNUAL VARIABILITY IN THE ALASKA COASTAL CURRENT: LARVAL POLLOCK (*THERAGRA CHALCOGRAMMA*) AND THE ZOOPLANKTON THAT AFFECT THEIR SURVIVAL

J.M. Napp[1], D.L.W. Siefert[1], L.S. Incze[2], L. Britt[1], P. J. Stabeno[3] and S. Syrjala[1]
[1]*NOAA/Alaska Fisheries Science Center, Seattle, WA U.S.A*
[2] *Bigelow Institute for Ocean Sciences, West Booth Bay Harbor, ME U.S.A*
[3] *NOAA/Pacific Marine Environmental Laboratory, Seattle, WA U.S.A*

The major pollock spawning stock of the northern Gulf of Alaska occurs in Shelikof Strait between Kodiak Island and the Alaska Peninsula near the end of the Alaskan Coastal Current. This coastal current, in combination with the shelf-break Alaskan Stream, delivers a rather homogeneous assemblage of zooplankton along > 2,000 km of coastline from northern British Columbia to Unimak Pass, Alaska. Pollock larvae are "injected" into a faunal

assemblage which began its development many kilometers "upstream," the distance of which depends on transport and temperature for that particular year. Annual transport can be weak (1990, 1994) or strong (1991) influencing the ratio of autochthonous to allochthonous production in the Strait.

In Shelikof Strait, the plankton assemblage which provides larval and early juvenile pollock with food, differs from other regions (e.g. North Atlantic oceanic or neritic regions) where the dominant prey producers have either strong or weak linkages to the spring phytoplankton bloom (*sensu* Runge, 1988). In Shelikof, the major prey producers represent both types, but the majority of the zooplankton biomass occurs in a genus that is unavailable to pollock as food until the late larval/early juvenile stage. Thus a large fraction of the primary production supports biomass unavailable to the larvae during the "critical first-feeding stage." Interannual variations (1985 - 1991) in the composition of prey, prey producers, and predators are evident in our data. Interannual variation in larval pollock survival has been demonstrated and is consistent with fluctuations in food supply. However, larval pollock survival was not synonymous with successful recruitment (Bailey *et al.*, submitted).

3AM1994-BIO15

## INTERRELATIONS OF EDDIES, FINE STRUCTURE AND ZOOPLANKTON IN THE SUBARCTIC FRONT ZONE

Vladimir V. Navrotsky and T.A. Zadonskaya, *Pacific Oceanological Institute FEBRAS, Vladivostok, Russia*

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-August 1987 in the region of the Pacific Subarctic Front (the program "Megapolygon").

The main attention is given to relations between characteristics of the temperature field and distribution of zooplankton concentration.

Detailed analysis of the data led to several conclusions:
1) The full energy of the temperature fine-structure fluctuations 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) The position of the maximum zooplankton biomass coincides with the position of adjoined to fronts cyclonic eddies and maximum intensity of vertical fine-structure.
3) Spectra of temperature vertical fine-structure are rather uniform in horizontal direction in the range of vertical scales 20-30 m, but in larger and smaller vertical scales they form a sequence of closed maxima and minima.
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.

3AM1994-POC25 Poster

## INTERANNUAL DYNAMICS OF MERIDIONAL HEAT TRANSPORT IN OCEAN: INVESTIGATIVE TECHNIQUES AND TENTATIVE ESTIMATES

Leonid V. Nechvolodov, *State Oceanographic Institute, Marine Dynamics Division, Kropotkinsky per.6, 119838 Moscow, Russia*

The generalized hydrodynamic approach to the computation of meridional heat transport (MHT) in an ocean is developed. The balanced hydrodynamic model is created that provides a way of estimating the seasonal and interannual variability of the oceanic MHT on

the base of only such available data as sea-surface temperature and meteorological observations. The advective heat fluxes in sub-surface layer are determined using one-dimensional upper ocean model by means of indirect techniques. The integral MHT is computed with the use self-similar hypothesis on the vertical distribution of advective fluxes in ocean baroclinic layer. The existence of self-similar solutions for unsteady heat transport equation is justified theoretically. The results of the model testing on the MHT calculation are compared with those obtained previously by other authors. The tentative estimates of the MHT interannual variability are presented. The climate effects of the oceanic MHT anomalies are discussed. The most expressive result is that close correlation between Southern Oscillation (El-Nino) in Pacific and the MHT anomalies in Atlantic is found.

3AM1994-BIO16 Poster

## COMPOSITION AND DISTRIBUTION OF MICRONECTON COLLECTED BY THE MID-WATER TRAWL NET DURING SUMMER IN THE BERING SEA

Akira Nishimura, Taku Yoshimura and Kei-ichi Mito, *National Research Institute of Far Seas Fisheries 7-1, Orido 5 chome, Shimizu, 424 Japan*

Midwater trawl sampling were conducted in the Bering Sea to examine the distribution of juvenile walleye pollock and other micronocton in the summer of 1989-1991. A netliner of 4mm mesh size was attached inside the cod-end, and sampling was carried out within a few hours after sunset by trawling in the subsurface layer at depths of 20-40 m. A total of 59 samples were collected on the eastern Bering Sea shelf and slope, and 60 samples were collected in the Aleutian Basin. The total collections of 303,012 fish comprised 35 species of 22 families. Juvenile walleye pollock was the most dominant species on the shelf, that was found more than 90% of the total catch on the shelf area. It was suggested that juvenile walleye pollock is an important organism on the shelf area. In the Aleutian Basin, Lanternfishs was the dominant species in 1989 (93%) and 1990 (74%), and Northern smoothtongue was the dominant in 1991 (56%). These two species contribute more than 95% of the catch in the basin in 1989 and 1991, and 86% in 1990. Squids were also found frequently in the basin area. Results suggest that Lanternfishs, Northern smoothtongue and squids are playing an important part in the ecosystem of the Aleutian Basin.

3AM1994-FIS25

## HABITAT MODELS FOR JUVENILE PLEURONECTIDS AROUND KODIAK ISLAND, ALASKA, USA

Brenda L. Norcross, Franz-Josef Müter and Brenda A. Holladay, *Institute of Marine Science, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, Alaska 99775-7220*

Juveniles of four species of Pleuronectid flatfishes were abundant in bays and near shore areas around Kodiak Island, Alaska during August 1991 and August 1992. Linear discriminant analyses were used to identify physical characteristics important in determining presence or absence of juveniles for each species in 1991 and resulting discriminant functions were tested on 1992 data.

Discriminant functions predicted presence more accurately than absence in 1991 for rock sole (*Pleuronectes bilineatus*), yellowfin sole (*Pleuronectes asper*), and Pacific halibut (*Hippoglossus stenolepis*). In 1992, absence was predicted more accurately than presence for these three species. The result was opposite for flathead sole (*Hippoglossoides elassodon*) in 1991 with absence being more accurately predicted, while in 1992 presence and absence were predicted equally well.

The distributions of the flatfishes captured in 1992 were examined with respect to the following conceptual habitat models which had been produced from the mathematical models based on 1991 data.

MODEL #1: Age-0 rock sole are found predominantly in water depths less than 70 m on sand or mixed sand substrate within 10 km of bay mouths.
MODEL #2: Age-0 flathead sole are found predominantly in water depths greater than 70 m on mud or mixed mud substrate throughout bays.
MODEL #3: Age-0 Pacific halibut are found predominantly in water depths less than 70 m on mixed sand substrate near or outside mouths of bays.
MODEL #4: Age-1 yellowfin sole are found predominantly in water depths less than 40 m on mixed substrate at upper reaches of bays.

3AM1994-POC26
## INTERANNUAL VARIATIONS OF PHYSICAL PROPERTIES IN THE WESTERN NORTH PACIFIC

H. Onishi, M. Shonai, H. Miyake and M. Onishi, *Faculty of Fisheries, Hokkaido University, Minato-cho 3-1-1, Hakodate, Japan. 041*

Data were collected by both Nansen casts and CTD casts along 5 meridional transections (144°E, 155°E, 170°E, 175°30'E and 180°) using the T/S Oshoro Maru, the T/S Hokusei Maru (both belong to Hokkaido University) and the R/V Kofu Maru (belong to Hakodate Marine Observatory). Each section consists of 11-24 stations and The observations were carried out from 1978 to 1993 in summer.

From the data, the mean temperature, salinity and density fields in each section were calculated, and interannual variations will be discussed.

3AM1994-FIS26 Poster
## COMPOSITION AND STRUCTURE OF FISH COMMUNITIES ON THE PACIFIC SLOPE OF THE NORTH KURILS

Alexei M. Orlov, *Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17a, Verkhnyaya Krasnoselskaya, Moscow, 107140 Russia*

Despite the permanent development of fishery, the main volume of commercial species is obtained in the shelf areas and pelagial in the upper 200m layer. The fishery resources of the continental slope are used very weakly in the most regions of the world's oceans. This situation is characteristic for the Pacific slope of the North Kurils. The main reason is a lack of a reliable information about distribution of fish concentrations, their abundance and biomass in this region. Moreover, there is no scientific publications about species composition and structure of benthic and benthopelagic fish communities.

During 1992-1994 a number of research expeditions was carried out on the Pacific slope of the North Kurils which allowed to obtain data on the above topics.

Taxonomic structure of ichthyofauna of the region under consideration includes 25 families, 97 genera and 185 fish species. The most abundant fish species are families which origin is associated with the North Pacific. They are Zoarcidae (32 species), Liparidae (31), Cottidae (26), Pleuronectidae (15), Rajidae (13), Agonidae (11). These 6 families include 128 species that consist 69.2% of the total quantity of fish species. The rest 19 families are present mainly by from 1 to 3 species which as a rule are newcomers from the warm southern waters.

According to occurrence and bathymetric distribution in the community structure the following groups of fishes may be distinguished: subintertidal (2.7% of the total number of species), intertidal (25.4%), upper bathyal (49.7 lower bathyal (18.4%) and abyssal (3.8%) species.

Several zoogeographic fish groups may be identified regarding their geographic distribution. They are arctic-boreal (5.4% of the total number of species), north-boreal (6.5%), temperate-boreal (67.0%), south-boreal (16.7%), south-boreal-subtropical (2.2%), tropical and subtropical (2.2%) species.

According to feeding type the following trophic groups are notabled: plankton-eating, bentophage, vultures fishes and fishes with mixed feeding.

According to reproduction character may be distinguished three fish groups: egg-laying species with external fertilization, egg-laying species with internal fertilization and viviparous species.

Besides, regarding to some other abiotic (bottom relief, circulation, water temperature, oxygen, etc.) and biotic factors in the composition of ichthyophauna of the region may be identified the different fish groups.

3AM1994POC27 Poster

## VARIATIONAL ANALYSIS OF MOORINGS DATA IN THE NORTH WESTERN PACIFIC

G.G. Panteleev, *Institute Oceanology Russian Academy Science*

Simple 2D and 3D variational algorithms "weak constraints" (according to Prof. Sashays classification) were used for analysis of data set of current measurements at "Megapolygon" experiment in Summer-Fall, 1987 within 500 x 500 km area centered at 40°N, 155°E. These "weak constraints" suggested that velocity field must meet the data of experiment and 2D continuity equation or full-transport equation with a rigid lid condition in 3D-cases.

It is shown that variational algorithms give more realistic velocities field in comparison with a method of optimal interpolation (Gandin, 1970). It was proved both for the real data set and for simulated current velocity field.

The analysis of mean and synoptic structures in "Megapolygon" area applied to the set of current fields generated by 2D and 3D variational algorithms allows to make the following conclusions on the circulation features in this region of the Pacific:

a) mean current has two-layer structure (first layer - from 0 to 1000m, second layer - from 1000 to 5000 m).
b) intensive synoptic structures are quasi-stationary.
c) the North Pacific Subarctic Front and Kuroshio Extension are the regions of intensive generation and absorption of the synoptic eddies.
d) strong current velocity causes strong non-linearity of current field within main thermocline.

3AM1994-PG03 Invited

## ESTIMATES OF TROPHIC EFFICIENCY, BASED ON THE SIZE DISTRIBUTION OF PHYTOPLANKTON AND FISH IN DIFFERENT ENVIRONMENTS

Timothy R. Parsons[1,2] and Yuh-Ling Lee Chen[1]
[1]*Department of Marine Resources, National Sun Yat-sen University, Kaohsiung, Taiwan*
[2]*Department of Oceanography, University of British Columbia, Vancouver, Canada*

The trophic efficiencies of four fisheries were calculated on the basis of the size spectrum and productivity of both the phytoplankton and the fish. Results showed that for the Gulf of Alaska salmon fishery and the Strait of Georgia Pacific whiting fishery, the average ecological efficiency was 14.3 % and 13.2 %, respectively, for each step in the food chain. The offshore Kaohsiung fishery had the highest ecological efficiency of 16.2 %. These results were in contrast to the near shore Kaohsiung fishery, which had an average ecological efficiency of only 7.4 %. This result could be explained in terms of eutrophication of the near

shore environment which is known to lower trophic efficiency in aquatic habitats, or it could be due to overfishing in this area.

The importance of calculating the trophic efficiency exponent lies both in being able to detect the overall effect of environmental or anthropogenic stress on a fishery, as well as the alternative of being able to use the exponent to calculate the total production of a particular fishery, from the size spectrum and productivity of the primary producers.

3AM1994-SB03 Invited

## ASSEMBLAGES OF EPIPELAGIC FISHES FROM THE SUBARCTIC PACIFIC OCEAN

William G. Pearcy and Joseph P. Fisher, *College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA*

Gillnet catches of epipelagic fishes and squids by the OSHORO MARU and HOKUSEI MARU in the North Pacific during the summers of 1978-1989 were divided into assemblages using multivariate classification and ordination techniques. Four major species-groups were identified among the 43 common species: a northern group comprised mainly salmonids, two intermediate groups, each comprised of three wide-ranging or migratory species (e.g., Pacific saury, Pacific pomfret), and a fourth subtropical group, mainly tunas and flying squid, inhabiting waters near the Subarctic Boundary. Four station or sample groups were also identified. These formed a ontinuum closely related to latitude. Two groups were found mainly in Central Subarctic Domain, the third in the Transitional Domain, and the fourth near the Subarctic Boundary. Northward shifts of station groups were pronounced between June and July. Detrended correspondence analysis showed a strong gradient in station scores near the Subarctic Boundary. However, when the six ubiquitious species were deleted, a stronger gradient occurred between 440 and 460N, clearly dividing the two northern from the two southern station groups. Features of temperature and salinity were all closely correlated (r>0.8) with this latitudinal gradient. Subsurface temperature, which changed rapidly across 44@-46,)N, was most highly correlated with the strong gradient in station ordination scores.

3AM1994-SB05 Poster

## INTERACTIONS BETWEEN CONTINENTAL SHELF AND HIGH SEAS ECOSYSTEMS IN THE NORTHEAST SUBARCTIC PACIFIC

R. Ian. Perry[1], Gordon A. McFarlane[1], Peter Thompson[2] and Mike Foreman[2]
[1]*Dept. of Fisheries & Oceans, 3190 Hammond Bay Road, Nanaimo, B.C., V9R 5K6 Canada*
[2]*Dept. of Fisheries & Oceans, P.O. Box 6000, Sidney, B.C., V8L 4B2 Canada*

The margins of the NE Subarctic Pacific form a continuous gradient of physical and biological properties from near-shore to high-seas ecosystems. Transitions between ecosystems can be gradual with indistinct boundaries, or rapid with clear boundaries. The question arises, therefore, as to how effective such boundaries may be at enhancing or reducing the exchange of physical and biological properties among these ecosystems.

In this presentation we consider the ecosystems of the continental shelf and adjacent deep ocean in the NE Subarctic Pacific, and explore the degree to which they interact and exchange materials, with particular reference to larval fishes. Persistent patterns in the distributions of larval fishes and plankton off southwest B.C. in spring suggest relatively little exchange between the continental shelf and the deep ocean. Distinct trophic linkages and stable isotope signatures occur from phytoplankton to larval fishes in these two regions, also suggesting relatively little exchange of materials. General physical processes that might enhance or inhibit the cross-shelf exchange of larvae are explored using a finite-element circulation model, and we discuss other, intermediate-scale, features which may contribute to sporadic exchanges. The degree of exchange of biological materials and ecosystem interactions

between the continental shelf and the high-seas in the NE Subarctic Pacific should be an important consideration in developing research plans for such programs as PICES-GLOBEC.

3AM1994-BIO17 Invited

## IMPACT OF 1977-88 CLIMATE EVENT ON MIXED LAYER DEPTH AND LINKS TO ECOSYSTEM PRODUCTIVITY IN THE CENTRAL AND NORTH PACIFIC OCEAN

Jeff Polovina, *Southwest Fisheries Science Center, NMFS Honolulu Laboratory, 2570 Dole Street, Honolulu,Hawaii, U.S.A., 968-2396*

The intensification of the Aleutian Low during 1977-88 resulted in winter mixed layer depths which were deeper in the northern subtropic gyre and western transition zone and shallower in the Gulf of Alaska. A physical-biological model simulates the change in phytoplankton and zooplankton productivity due to the mixed layer depth changes. In the western transition zone, a deeper mixed layer depth delays the onset of the zooplanktonbloom while a shallower mixed layer depth in the Gulf of Alaska triggers an earlier zooplankton bloom. Together these changes lead to a change in zooplankton gradient across the subarctic domain and between east and west regions of the transition zone. These changes can alter both abundance and migration of higher trophic level fishery resources. Recent observed changes in higher trophic levels will be discussed in the context of these physical-biological changes.

3AM1994-BIO18 Poster

## DYNAMICS OF NEKTON TROPHIC LINKAGES IN RELATION WITH THE REFORMATION OF COMMUNITIES IN THE BERING SEA EPIPELAGIAL

V.I. Radchenko, *Pacific Research Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, Vladivostok, 690600, Russia*

Nekton species dwelling in the Bering Sea epipelagial constantly are very plastic in their feeding habits. They are characterized with wide specialization in the prey choice, wide distribution and large-scale migrations within the feeding area limits. Many species consume nekton organisms as well as plankton ones. Average nekton portion in the pollock diet makes 10%, in herring diet 4%, in pink salmon diet 30%, in chum one 10%, in sockeye one 49,5%, in chinook (age 1) one 83-90%.

Annual consumption of zooplankton by fishes and squids in the second part of the 1980s has been assessed as 265 mln. t (Radchenko et at., 1991; Shuntov et al., 1993). In the beginning of the 1990s it decreased to 138 mln. t in relation with the pollock biomass decline. Portions of zooplankton taxocenes in the total nekton ration during these periods were following: euphausiids 36,6 and 33,2%, copepods 48 and 43%, amphipods 6,6 and 9% , pteropods 1,2 and 2,2%, jelly-fishes 2,3 and 4,3% sagittas 2,2 and 3,1%, appendicularians 1,3 and 1,2%, comb jellies, pelagic polychaete worms, meroplankton, miscellaneous 1,8 and 3,8%. In the beginning of the 1990s the predatory plankton portion increased, that partly related with the increase of herring abundance in the western and northern Bering Sea.

Walleye pollock and Pacific herring are dominant species in the nektonic communities of the Bering Sea epipelagial which exist in conditions of changed and periodically modified environment. Accordingly, these species are characterized by the significant fluctuations of abundance, which coincide with phases of environment changes. The dynamics of state and features of food supply and fluctuations of nekton species abundance are based on the same global climate-oceanological processes.

3AM1994-POC28
## COASTAL OYASHIO CURRENT AS DRIVEN BY THE SEA SURFACE COOLING IN THE COLD SEASON

Kunio Rikiishi and Takahiko Nakashima, *Department of Earth Sciences, Hirosaki University, Hirosaki 036, Japan*

Coastal Oyashio Current, flowing southward along the coasts of northern Japan, is an integral part of the subpolar circulation in the North Pacific. It shows clear seasonal variation in current speed with the maximum in early spring and the minimum in early fall. The Coastal Oyashio Current extended abnormally southward in the years when the northwesterly monsoons were extraordinary strong to cause heavy snowfalls in northern Japan. Sekine(1988) suggested that the abnormally southward extension of the Oyashio could be caused by southward shift of the latitude where the wind stress curl shows zero-value. According to his theory, the southward extension is expected to be seen over the entire subpolar circulation. However, examination of the sea temperatures at surface and 100 m depth shows that the southward extension is limited only in the coastal area.

In order to solve this problem, the dataset of occupational area of Oyashio water (by Yoshida, 1992 ) has been analyzed together with time series of sea level, air temperature, and sea surface temperature at coastal stations. It has been found that variation in Oyashio area is highly correlated with that in sea level difference in the down-stream direction both for the monthly mean value and anomaly. Variation in the sea level difference, in turn, has been shown to be correlated with those in air temperature and sea temperature at coastal stations. Finally it has been concluded that the observed sea level difference is caused by the cooling of the sea surface layer in the cold season: the sea level falls less in the northern area than the southern because the sea water density is less dependent on the temperature at lower temperatures than higher ones.

This conclusion implies that the Coastal Oyashio Current is drived thermally or drived by the sea surface cooling in the cold season. It is likely that there are some other thermally driven currents in the sub-polar circulation.

3AM1994-STA04 Invited
## SPACE AND TIME SCALES OF VARIABILITY IN THE SUBARCTIC NORTH PACIFIC: IMPLICATIONS TO MONITORING THE SYSTEM

Stephen C. Riser, *School of Oceanography, University of Washington, Seattle, Washington 98195 USA*

It is possible to obtain a gross estimate of the space-time variability of the subarctic North Pacific by examining the frequency-wavenumber spectrum of the density and motion fields at various depths. However, in general this spectrum is not known for very much of the world ocean. In general, however, it is possible that we can crudely estimate the relative size of the mean circulation, eddies, and higher frequency waves in frequency-wavenumber space with some degree of success. It is impossible at the present time, however, to estimate the space-time variability due to the so-called "regime shifts" that have been observed regionally over the North Pacific over the past two decades; the space-time variability due to these shifts may be sizable and may be as large as any other single effect in the frequency-wavenumber spectrum. Additional complications may arise due to variations of inputs of mass, heat, and chemical tracers at the boundaries of the ocean that have not to date been adequately quantified. Finally, the space-time variability in the deepest part of the ocean is nearly completely unknown, although such deep variability may have serious implications to the flow fields in the upper ocean. It is proposed that a modest monitoring effort coordinated with improved models of the subarctic North Pacific could together greatly improve our knowledge of the space-time variability.

3AM1994-POC29 Invited

## THE FLOW-FIELD IN THE INTERMEDIATE LAYER OF THE NORTHWEST PACIFIC AS REVEALED FROM ACOUSTICALLY-TRACKED FLOATS

Stephen C. Riser[1] and Nobuyuki Shikama[2]
[1]*School of Oceanography, University of Washington, Seattle, Washington 98195, USA*
[2]*Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, Ibaragi 305, Japan*

We examine the character of the flow field at depths of 400-1100 m in the Northwest Pacific from the trajectories of 30 acoustically-tracked RAFOS floats. The floats were tracked over intervals between 1 and 2 years, with positions determined every 1 or 2 days. The resulting trajectories reveal an extremely strong mesoscale eddy field at mid-depth in the Northwest Pacific, with eddy kinetic energies apparently higher than analogous values from the western Atlantic. The float trajectories show considerable exchange between the subtropical and subpolar gyres in the Northwest Pacific, especially in the far west Pacific off Hokkaido, where it appears that Kuroshio warm rings are able to transport water from the sub-tropical gyre north along the Kurile Islands as far as southern Kamchatka. There is also evidence that a strong counterflow exists below the Kuroshio Extension at least as far east as the Emperor Seamounts, that may transport a large quantity of water at depths near 1000 m to the west.

3AM1994-BIO19 Invited

## SUBARCTIC-SUBTROPICAL TRANSITION ZONE IN THE WESTERN, CENTRAL AND EASTERN PACIFIC: PHYSICAL PROCESSES AND BIOLOGICAL IMPLICATIONS

Gunnar I. Roden, *School of Oceanography WB-10, University of Washington, Seattle, Washington, 98195*

An overview is given of the oceanic environment, physical processes and biological consequences occurring in the subarctic-subtropical transition zone across the North Pacific. In the western Pacific, the transition zone is narrow and is maintained by geostrophic confluence between the subarctic and subtropic gyres. It is characterized by strong meandering boundary currents, which border the zone and a vigorous mesoscale eddy field in between. Thermohaline and nutrient fronts and frontal eddies are sharp and extended deep.

In the central Pacific, geostrophic gyre confluence weakens and the transition zone is maintained mainly by the spatial structure of the planetary wind field. Boundary current extensions tend to break up into eddies, carrying their thermohaline and nutrient sugnatures with them and intermingling with the local wind-induced eddies. Thermohaline and nutrient fronts and frontal eddies are of moderate strength, rarely extending to more than a few hundred meters depth.

In the eastern Pacific geostrophic diffluence between the subarctic and subtropical gyres competes with wind induced convergences and divergencies, resulting in a transition zone that is wide and bounded by weak and shallow thermohaline and nutrient fronts. Upon approaching North America, the influence of eastern boundary currents increases. Fronts sharpen and frontal eddies of both coastal and oceanic origin populate the transition zone.

It is argued that while the gyre scale circulation and the oceanwide physical characteristics of the transitional zone determine the basic zonality and aspects of the species distribution, the observed patchiness of the syoptic distributions is associated intimately with mesoscale circulations and processes linked to the large scale flow.

3AM1994-POC30

## ON THE INFLUENCE OF TIDAL MIXING ON SUMMER CARBON DIOXIDE PARTIAL PRESSURE IN THE OYASHIO AREA

K. Rogachev[1], A. Bychkov[1], P. Tishchenko[1], E. Carmack[2], P.H. LeBlond[3] and C.S. Wong[2]
[1]*Pacific Oceanological Institute, Vladivostok, 690041, Russia*
[2]*Institute of Ocean Sciences, Sidney, B.C., V8L 4B2, Canada*
[3]*University of British Columbia, Vancouver, B.C., V6T 1Z4 Canada*

CTD and carbonate chemistry (total inorganic carbon (TC), total alkalinity (TA) and pH) summer observations performed during three years of detailed surveys east off Kuril Islands are presented. Carbon dioxide partial pressure was calculated from all available sets (TC-TA, TC-pH and TA-pH) using equations and thermodynamic constants advocated by the UNESCO Expert Group and results were in satisfactory agreement. According to this data, extremely low pCO2 values (up to 255 $\mu$atm) were observed within the Bussol Strait anticyclonic ring in August 1991, 1992 and September 1993. However, extremely high pCO2 values (up to 430 $\mu$atm) were found in the Bussol Strait directly. Analysis of physical processes occurring in the Oyashio area has demonstrated that tides act as a dominant regulator of pCO2 distribution in surface waters.

Low pCO2 values within the Bussol Strait anticyclonic ring are connected with phytoplankton blooming which, in turn, is determined by the following factors: enchanced stratification in the upper layer accompanied with intensive tidally generated internal mixing and horizontal convergence at the ring's edges. The importance of convergence as a concentration mechanism for living organisms was shown using the surface drifters data.

High pCO2 values in the deep Kuril Straits are the result of interaction and mixing of surface water with warm intermediate subarctic layer. The unstable to mixing stratification is created by the tidal inflow. The temporal evolution of the TS curves reveals three principal phases of the water structure in the strait: 1) inflow of warm subarctic intermediate layer at depth of 400-500 m; 2) inflow of cold Okhotsk waters in the layer of 100-200 m; 3) water mixing during a certain tidal phase; mixing is going under the condition of maximum volume contraction and produces 26.8 sigma-T water at depths 100-400 m.

Tides are basic mechanism for mixing in both cases, nevertheless, they lead to the qualitatively opposite results in sence of pCO2 distribution for two neighbouring areas. Mixing processes in the anticyclonic rings and Kuril Straits are discussed using potential stability values and non-linear terms of the sea water equation of state.

3AM1994-POC31 Poster

## CONDITIONS FOR TRANSFORMATION OF INTERMEDIATE WATERS BY DIAPYCNAL PROCESSES IN THE NORTHERN PACIFIC

Igor D. Rostov, *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, 690041 Russia*

Double-diffusion processes, i.e. salt fingers and diffusive instability, develop in layers with unstable stratification of temperature and salinity provided there exists a given correlation of signs and values of vertical gradients. These processes are ones of the effective mechanisms for diapycnal mixing and small-scale interleaving of ocean waters.

Basing on the mean multiyear data of temperature and salinity for winter and summer seasons, the structural zones and layers, when double-diffusion processes can be active, have been obtained. It is shown that these zones and layers are associated with boundary position of undersurface and intermediate water masses and oceanic fronts. The above-mentioned data and results of CTD-observations were used for calculation of local and background values of these processes intensity- density ratio value and Turner angle. Basing on these results maps of these characteristics have been plotted. In the maps, to the North and South of subarctic front, two areas corresponding to different types of processes could be seen. The conditions for

intensifying salt finger type process exits in equatorial-tropical and subtropical water volumes during all the seasons (heat and salt fluxes directed downwards). In subarctic zone there are conditions for diffusive instability (fluxes directed to surface). Main features of spatial distribution and depth of these layers well correlate with boundaries and cores of intermediate water masses. Calculated values of vertical heat and salt fluxes induced by double diffusion were compared with climatic values of these fluxes on the ocean surface.

3AM1994-BIO20
## SEASONAL CHANGE IN ZOOPLANKTON BIOMASS IN THE WESTERN SUBARCTIC PACIFIC OFF HOKKAIDO, JAPAN

Hiroaki Saito, Hiromi Kasai and Satoru Taguchi, *Hokkaido National Fisheries Research Institute, Kushiro, Hokkaido, Japan*

Seasonal change in zooplankton biomass was determined during 1990 and 1993 in the western subarctic Pacific off Hokkaido, Japan. Zooplankton was collected with a vertical tow of a twin net fitted with 333$\mu$m net in the one side and with 183$\mu$m and 35$\mu$m net at the other side. The net was towed only in the surface mixed layer. Seasonal cycles in macrozooplankton biomass larger than 183$\mu$m off Hokkaido was similar to the one in North Atlantic. There were two maxima in macrozooplankton biomass, a large one was observed in spring and a small one was in autumn. Spring increase in macrozooplankton was synchronized with spring phytoplankton bloom. In 1993, spring phytoplankton bloom started in May, one month later than another year, and the increase in macrozooplankton was also delayed a month. The relationships between seasonal biomass changes in phytoplankton, microzooplankton and macrozooplankton will be discussed.

3AM1994-POC32 Poster
## WATER STRUCTURE OF ACTIVE LAYER IN SOUTHERN KURIL ISLANDS REGION

Eugene V. Samko and Yury V. Novikov, *Pacific Research Institute of Fisheries & Oceanography (TINRO), 4, Shevchenko Alley, Vladivostok, Russia.*

The purpose of this investigation is to distinguish and to characterize the main thermic water structures in southern Kuril Islands region at summer-autumn period.

The region of investigation was bounded by 42°00' - 45°40'N, 145-151°E. The data of thermic measurements on standard horizons in 0-200 m layer obtained in summer-autumn of 1980-1988 were used.

Frontal zones of the region were classified by the analysis of statistically representative data with usage of Laplasian operator. There were distinguished the following types of frontal zones: stationary oceanic front of Oyashio Current, quazi-stationary coastal front of Oyashio Current, and non-stationary ones tidal shelf front, front of flow entering through Freez Strait and fronts of synoptic eddies. Their stability and frequency were estimated.

Six main types of thermic homogeneous zones dividing by fronts were defined: 1) subtropic (St) southward from the oceanic front of Oyashio Current; 2) subarctic (Sa) eastward from the ocean front of Oyashio Current; 3) Oyashio Current (OC) restricted from one side by coast line or coastal front and from the other side by the oceanic front of Oyashio Current; 4) Kuril (Ku) restricted by front of the entering flow; 5) Soya Current (SC) restricted by coastal front, on South Kuril shallows; 6) tidally-mixed (tm) between coast line and tidal shelf front.

Analysis of distribution of thermic zones at every horizon allowed us to distinguish 9 main combinations of them which generated the main vertical water structures: subtropical

(St), Oyashio Current (OC), Soya Current (SC), Kuril (Ku), tidally-mixed (tm), subtropic transformed (St/OC), subarctic (Sa/ OC), Oyashio tidally-mixed (OC/tm), Oyashio-Soya (OC/SC). Three or more types of thermic zones on different horizons could be observed at fronts.

Seasonal variability of area and thermic characteristics of distinguished structures were examined. The areas of these structures varied in dependence on strengthening or weakening of dynamic processes of their formation.

3AM1994-BIO21 Poster

## NEW DATA ON BIOHYDROCHEMISTRY OF THE BERING SEA

V.V. Sapozhnikov, *Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17A, V.Krasnoselskaya, Moscow 107140, Russia*

VNIRO-TINRO joint cruises in 1990 - 1994 have permitted to find some biohydrochemical features of the Bering Sea. Concentrations of phosphates (3.8 - 4.2 $\mu$M) and nitrates (56.0 - 62.8 $\mu$M) in the layer of oxygen minimum were the highest ever registered in winter. These values' conformity with the stoichiometric ratio of N:P = 16:1 proves the data obtained on the autoflow-analyzer RFA-300 "Alpkem" (USA) to be representative.

Summer determination of urea (2.5 - 7.5 $\mu$M) and ammonia (0.5 - 5.8 $\mu$M) permitted to understand the high rates of photosynthesis (1.5 - 6.0 g C/m$^2$ day) at a complete depletion of nitrates and phosphates (< 0.1 $\mu$M) in the upper euphotic layer.

The obtained massive data on organic phosphorus (0.4 - 1.6 $\mu$M) and nitrogen (6.2 - 12,6 $\mu$M) were used to chart their spatial distribution in the Bering Sea.

The analysis of the activity of alcaline phospatase permits to state that the rate of phosphate regeneration is sufficient to provide high values of primary production, developed on nutrient recycling in the euphotic layer. The limiting concentration of phosphates, which activates the enzymes of alcaline phosphatase, was calculated to be 0.2 $\mu$M. This value corresponds to the constant of half-saturation in the equation of Michaelis - Menten.

August concentrations of dissolved silicate decreased to 0.3 - 1.8 $\mu$M. Silicate values in dissolved organic compounds equaled 12 - 18 $\mu$M. This permits phytoplankton to continue in photosynthesis with no lack of silicates.

3AM1994-BIO22

## FOOD ENVIRONMENT FOR SOME SMALL SIZED FISHES IN THE PACIFIC COASTAL WATERS OF HOKKAIDO IN SPRING

Jiro Seki and Ikutaro Shimizu, *Research Division, Hokkaido Salmon Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira ku, Sapporo 062, Japan*

Coastal waters were important as a habitat to small-sized fishes. From March to June, mainly chum salmon fry, arabesque greenling fry and Japanese surfsmelt appeared in the Pacific coastal waters of Hokkaido. The most dominant of these species was chum salmon fry and it occupied over 90%. These fishes consumed about 20 species zooplankton and some species of insects.

35 species of zooplankton were sampled from March to July and the dominant species sometimes changed during sampling periods. At first the dominant species were cold water living type and warm water living type dominated in July. The major species were

*Pseudocalanus* spp., *Acartia longiremis*, *Acartia tumida*, *Neocalanus plumchrus* and *Eurytemora herdmani*.

These appearance of different zooplankton species determined the availability of food for these fish. We examined the difference of character of changes of the zooplankton biomass, vertical distribution, vertical migration and horizontal distribution.

Total zooplankton biomass formed a peak between late May and early June. Vertical distribution of zooplankton during the day time at upper layers (0-5m) was smaller than at lower layers (under 5m). The characteristics of vertical migration of zooplankton were separated some groups.

Horizontal distribution of number of individual zooplakton at 3m deep changed with distance from sea shore and sampling days. Maximum of individual numbers was 6093 $m^3$ in the middle of May. But the mean distance from peak to peak for almost all zooplankton species was 80m to 120m from March to June.

3AM1994-POC33 Invited

## A NUMERICAL EXPERIMENT ON THE ANOMALOUS SOUTHWARD INTRUSIONS OF THE OYASHIO AND SUBARCTIC CIRCULATION IN THE NORTH PACIFIC

Yoshihiko Sekine, *Institute of Oceanography, Faculty of Bioresources, Mie University, 1515 Kamihama-cho, Tsu, Mie-ken, Japan. 514*

Anomalous southward intrusion of the Oyashio and subarctic circulation in North Pacific occurs from winter to late spring and its cold sea surface temperature has an influences on the global atmospheric circulation. The interannual response of the ocean to the wind stress change over 1961-1987 is examined numerically with special reference to the occurrence of the southward intrusion of the Oyashio and subarctic circulation. It is shown that the clear interannual variation in subarctic circulation is detected for the barotropic response, however, clear baroclinic response is mainly confined to a region east of 140°W. However, the variation in upper layer thickness has a significant positive correlation with the southernmost latitude of the Oyashio and upwelling of the interface in the subarctic circulation are induced by the southward shift of the latitude with no wind stress curl. It is concluded that barotropic response to the change in the wind stress, associated local baroclinic response are essential for the generation of anomalous southward intrusions of the Oyashio and subarctic circulation in the North Pacific.

3AM1994-STA02 Poster

## MODULARIZED REALTIME SURFACE-WATER MONITORING SYSTEM

Yasuhiro Senga and Yasuhiro Sugimori, *School of Marine Science and Technology, Tokai University, 3-20-1, Orido, Shimizu, Shizuoka 424, Japan*

In order to monitor the quality of sea surface water, a realtime monitoring system was developed. The system was composed of a control unit , a babble trap unit and four sensor modules, including two fluorometers with different spectral characteristics, a turbidity sensor module and a triple-sensor module equipped with a temperature, a conductivity and a pH sensors. The excitation and detection wavelengths of each fluorometer are adjusted at fluorescent peaks of chlorophyll a and phycobilin pigment in order to distinguish blue-green alga from diatoms. Each sensor unit has the volume of 3.5 liters, so that the time constant of the total system is about 15 minutes. The system can be mounted on a small fishery boat. Sea surface water is sampled utilizing a sea water pump originally equipped with on the boat. The availability of this system was evaluated through several experimental cruises in coastal area around Japan.

3AM1994-SB06 Invited

## DISTRIBUTION AND FOOD HABITS OF PELAGIC FISHES IN THE SUBARCTIC NORTH PACIFIC

Kenji Shimazaki, Haruo Ogi and Yasunori Sakurai, *Research Institute of North Pacific Fisheries, Faculty of Fisheries, Hokkaido University, Hakodato, Hokkaido 041 Japan*

Several pelagic fishes indigenous to the subtropical region migrate north from the subtropical region to the subarctic region during the summer season. Around the Subarctic Boundary, the species composition and abundance of pelagic fishes are quite complex and variable due to seasonal back and forth crossing of the boundary. Northward migration of these species, including sardines, saury, pomfret, and flying squid, is believed to be a feeding migration touse the abundant biological resources of the subarctic North Pacific. Based on the results of past studies, this seasonal habitat - shift or expansion of the pelagic fishes begins with planktivorous small-sized fishes, and is then followed by piscivorous large sized fishes. Further study is required to determine the ecological significance of these subtropical pelagic fishes in the subarctic North Pacific ecosystem.

3AM1994-BIO23 Poster

## CHARACTERISTICS OF WATER MASS AND PRODUCTIVITY IN THE PACIFIC COASTAL WATERS OF HOKKAIDO IN SPRING

Ikutaro Shimizu and Jiro Seki, *Research Division, Hokkaido Salmon Hatchery, 2-2 Nakanoshima, Toyohiro-ku, Sapporo, Japan. 062*

Characteristics of water mass and phytoplankton productivity in the coastal waters 5 miles off the Pacific side of Hokkaido have been investigated in terms of chlorophyll a and nutrient concentrations in spring from 1987 up to now. Temperature-salinity diagrams revealed four oceanographic water masses in this study area; Oyashio water mass, Engan Oyashio water mass, Tsugaru warm current water mass and coastal mixing water mass.

The Oyashio water mass showed the highest concentrations of chlorophyll a over 10 mg $m^3$ and nutrients (phosphorus, nitrogen and silicate). In the Engan Oyashio water mass, pheopigment concentration was higher than the other water masses and silicate concentration was low. Because the concentration of silicate was low in the Okhotsk Sea, the Engan Oyashio water mass seems to originate from the Okhotsk Sea water. In the coastal mixing water mass, the concentrations of chlorophyll a and nutrient were most variable. In Tsugaru warm current water, chlorophyll a concentration was the lowest but nutrient concentration was relatively high.

In the Pacific coastal waters of Hokkaido, the concentration of chlorophyll a showed more than 10 mg $m^3$ in March and April. Changing the characteristic of the Oyashio water mass in May, chlorophyll a concentration decreased and showed the lowest value in June when the distribution of the zooplankton community was the largest. In June or July salmon juvenile migrate in the coastal waters. The nutrient concentration of the Oyashio water mass was clearly higher than that of the coastal water mixed with fresh water and the Oyashio water seems to contribute the high phytoplankton productivity in the Pacific coastal waters of Hokkaido in spring.

3AM1994-MEQ09 Invited

## APPROACHES TO MARINE ECOSYSTEM MONITORING: A CASE STUDY AT TOKYO BAY

Makoto Shimizu, *University of Tokyo, Japan*

Subtle changes in marine ecosystem are quite difficult to detect and it is necessary to have long observation data to evaluate such changes. We have not so many scientific long observation data, but we have a lot of detailed fishery statistics in Japan. We tried to utilize

such information together with experimental trawl surveys to trace changes in ecosystem structure in Tokyo Bay.

Tokyo Bay is well known to have experienced a severe environmental deterioration after the World War II. The worst period was around 1970 and therafter some recovery in water quality was reported. Generally speaking, environmental quality, both in water and in sediment, is worse in the north, namely inner part, and is better in the south, near the mouth, in the bay. Here we try to describe the responses of biota to theses spacio-temporal changes in environmental quality using 1) species composition of catches obtained from fishery statistics, 2) distribution pattern of each species obtained from trawl survey, and 3) ecosystem structure obtained from model calculation based on fishing yield.

3AM1994-BIO24

## VARIATION IN PHYTOPLANKTON PRODUCTIVITY IN WATERS AROUND THE SUBARCTIC BOUNDARY

Akihiro Shiomoto[1], Yuimasa Ishida[1], Kazuya Nagasawa[1] and Kazuaki Tadokoro[2]
[1]*National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan. 424*
[2]*Ocean Research Institute, University of Tokyo, Nakano, Tokyo, Japan. 164*

The transition domain lies just north of the subarctic boundary around 40°N in the North Pacific Ocean. The southern water of the subarctic boundary can be identified as the subtropical region and the northern water of the transition domain as the subarctic region. Little is known about characteristics of phytoplankton productivity around the transition domain. We measured chlorophyll a concentration maximum photosynthetic rate (capacity of phytoplankton productivity), and size-frationated productivity and chlorophyll a concentration at surface waters along 179° 30'W longitude from 38° 30'N to 58° 30'N at the same period in June to July in 1991-1993 by R/V Wakatake Maru.

Chlorophyll a concentration showed spatial and yearly variations in the subtropical and subarctic regions, whereas it was remarkable low every year in the transition domain. The maximum photosynthetic rates in the subtropical region were several times larger than those in the subarctic region. The values in the transition domain were nearly equal or more than those in the subtropical region. Furthermore, small-sized phytoplanktons ($<2\mu m$) were abundant in every region in all years. Small-sized phytoplanktons contributed to productivity in the subtropical region and transition domain, whereas large-sized phytoplanktons ($2\text{-}10\mu m$ or $>10\mu m$) did in the subarctic region.

3AM1994-BIO25 Poster

## NEW DATA ABOUT COMMUNITIES OF PLANKTON AND NEKTON OF THE FAR EASTERN SEAS IN CONNECTION WITH CLIMATE - OCEANOLOGICAL REORGANIZATION

V.P. Shuntov and E.P. Dulepova, *Pacific Research Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, Vladivostok, 690600, Russia*

In the Second Annual Meeting of PICES the data about the beginning of large reformation in pelagic ecosystem of Far-eastern seas were obtained in the beginning of 90th years (Shuntov et al, 1993). In 1993 researches gave the new data about this problem. In majority regions the total biomass of fish changed. The quantity of squids changed in less degree (table 1).

## Table 1

Biomass (t/km$^2$) of fish, squids, jelly-fish in June-August 1991 (1) and 1993 (2) in epipelagic zone (0-50 m)

| Areas | Western Part Bering Sea | | South Part Okhotsk Sea | | Pacific Kamchtka Waters | | Pacific Kuril Waters | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Fish | 0,98 | 0,47 | 1,70 | 1,0 | 0,39 | 0,22 | 1,16 | 0,46 |
| Squids | 0,21 | 0,25 | 0,10 | 0,16 | 0,56 | 0,35 | 0,33 | 0,44 |
| Jelly-fish | 0,02 | 0,56 | 0,08 | 0,21 | 0,02 | 1,43 | 0,19 | 0,45 |

Early it was reported, that in connection with less quantity of pelagic fish in the 90th years, the quantity predatory zooplankton is increased. This conclusions were done for summer date. For summer period of 1993 new information answers this conclusion fully. Besides in many regions the quantity of jelly-fish is increased during the last time (table 1).

At the same time it was established, that in south part the quantity is not increased predatory zooplankton, but euhpausiids.

In addition to summer data, reformations were analyzed in composition of plankton in 80-90th in the fall period (table 2). Table 2 shows, that in the fall obvious increase of predatory plankton (sagiita)takes place only in Bering Sea. Interannual changes were obvious in quantity of plankton groups. In all areas biomass of copepods is decreased appreciably. In some regions, in particular in Okhotsk and Bering seas, biomass of euhpausiids is rather increased. At present time pelagic communities of Far-east region are in transitional condition, because further alterations in plankton and nekton should be expected in future.

## Table 2

Correlation (%) of unpredatory and predatory plankton in the fall 80-90th (0-200 m)

| Areas | Unpredatory Plankton | | Predatory Plankton | |
|---|---|---|---|---|
| | 80th | 90th | 80th | 90th |
| Western part of Bering Sea | 49-54 | 35-39 | 46-51 | 61-65 |
| South part of Okhotsk Sea | 58-61 | 44-63 | 39-42 | 37-56 |
| Pacific Waters of Kamchatka | 36-53 | 42 | 47-64 | 58 |
| Pacific Waters of Kuril Islands | 46-50 | 55 | 54-50 | 45 |

3AM1994-POC34 Poster

## ABOUT NONCRITICAL CONTROL AT THE SILL CREST

S.V. Simonenko, *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, 690041 Russia*

For the theoretical prediction of the wave packet upstream the sill on the north shelf of the Okhotsk Sea (Simonenko, Kogan; PORSEC'92) were used Long's (1972) assumptions for the existence of upstream jump and first order KdV equation (Lee, Beardsley; 1974) for the numerical modeling of the internal waves generation. The existence of a globally unsteady regimes for inhomogeneous EKdV model (Melville, Helfrich; 1987) points to the need for cautions in attempting to use steady hydraulic models.

The unsteady numerical hydraulic model of two-layer flow over two-dimensional topography is proposed. The Godunov's method and Lypidevsky's (1994) proposal about the similarity of the initial value problem of the breakdown of a break was used for the numerical modeling of the shallow-water equations (Su; 1976).

The numerical results were obtained for the 1/4 period of harmonic oscillation of the sill that corresponds to the observed increase of the sectionally averaged tidal velocity up to 0,2m/s during 15 min. The numerical modeling supports the assumption (Simonenko, Kogan; 1992) about the internal hydraulic jump formation upstream the sill. Modelling also shown the internal hydraulic jump formation downstream the sill. The conditions on the sill crest was noncritical in the sence of the Long's (1972) and Baines's (1984) theoretical models.

3AM1994-MEQ10

## DISTRIBUTION OF THE POLLUTANTS IN THE WESTERN PART OF THE BERING SEA

S.A. Sokolova, N.G. Storozuk, V.B. Gorjunova and I.A. Nemerovskaya, *Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17a V.Krasnoselskaya, Moscow, 107140, Russia*

Heavy metals' concentrations in water and in bottom sediments; chlororganic pesticides (ChOP) in water; hydrocarbons in water, bottom sediments, mesoplankton are described. Average concentrations of heavy metals (Fe, Zn, Cu, Mn, Co, Al, Cd, Ni, Cr, Pb) in this region are calculated and compared with the average concentrations of heavy metals established for the Pacific ocean water. Heavy metals' concentrations in surface microlayer are considerably higher than those in surface layer (0-0.5 m), especially for Pb, Cd, Fe, Zn, Cu. Heavy metals' concentrations in the bottom sediments from different stations have similar values and correspond to the levels established for the northern and eastern part of the Bering sea according to literary data 1981, 1984, 1988.

Chlororganic pesticides (DDT, DDE, DDD, a- and y-HCH) are present in all analyzed water samples. Average concentrations of HCH and DDT correspond to the values, established for the Bering Sea northern and eastern parts (according to the literature). ChOP levels in surface microlayer are slightly higher than those in surface layer. Extremely high DDE values are observed southward of Olutor bay and southward of the Camchatka bay.(10 - 100 mg/l). At the same time the toxicity of this water samples is established by means of using echini (early ontogenesis stages) and sea unicellular algae as test organisms.

The aliphatic hydrocarbons and polynuclear aromatic hydrocarbons levels and composition in different ecosystem components are described. It is established, that in spite of the high hydrocarbons' values in surface water (average value 42.3 mg/l), the alkane composition indicates the natural genesis of hydrocarbons.

3AM1994-MEQ11 Invited

## CUMULATIVE EFFECTS OF ANTHROPOGENIC STRESSORS: RESEARCH IN A NEAR-COASTAL ECOSYSTEM OF THE USA.

John E. Stein[1], Lyndal Johnson[1], Annette Olson[2], James E. West[3], Chris Prescott[4] and Usha Varanasi[1]

[1]*Northwest Fisheries Science Center, National Marine Fisheries Service NOAA, Seattle, Washington, U.S.A.*

[2]*School of Marine Affairs, University of Washington, Seattle, Washington, U.S.A.*

[3]*Washington Department of Fish and Wildlife, Olympia, Washington, U.S.A.*

[4]*Puget Sound Water Quality Authority, Lacey, Washington U.S.A.*

Environmental degradation often induces ecological effects not discernible at the level of individual organisms. This is particularly evident in the coastal ocean where co-occurring anthropogenic insults, such as nutrient and contaminant inputs, habitat alteration, and excessive fishing may produce cumulative effects in the resident biota. The merits of ecosystem level research in the management of vulnerable regions have long been recognized. However, only recently have tools capable of addressing ecosystem level complexity become generally available. Advances in computing technology, development of sophisticated analytical

methods, regulations that stipulate ecosystem considerations, and increasing public awareness of multiple environmental problems have encouraged environmental agencies to pursue ecosystem level objectives. The complexity of an ecosystem approach requires multi-disciplinary, inter-agency cooperative programs. Puget Sound, on the northwest coast of the USA, is a marine system where extensive scientific and institutional resources exist for investigating effects of human activities on marine biota. Recently, a multi-disciplinary program of cooperative ecosystem research was initiated to investigate the cumulative effects of anthropogenic stressors in Puget Sound's central basin. This investigation will utilized existing comprehensive data sets on resident species and environmental stressors as well as conduct additional studies. The research will initially focus on modeling direct stressor impacts on a benthic fish (English sole *Plueronectes vetulus*) population that has been extensively studied and exhibits a sensitivity to contaminants. Subsequently, the model will be expanded to include indirect effects on the English sole population mediated through prey and predator organisms. Moreover, institutional and economic analyses will be incorporated to assess economic implications of impacts. The research program designed represents one of the first to assess in a comprehensive way the relative contribution of multiple anthropogenic stressors on a population of a marine fish species and to examine the findings relative to economic considerations. The presentation will describe the conceptual model within the context of previous and ongoing research.

3AM1994-BIO26

## EAST-WEST COMPARISON OF YEAR-TO-YEAR AND DECADAL SCALE VARIATIONS IN PLANKTON BIOMASS AND ITS PHYSICAL ENVIRONMENT IN THE NORTH PACIFIC

Takashige Sugimoto, Kazuaki Tadokoro and Noriyuki Koizumi, *Ocean Research Institute, University of Tokyo, Nakano, Tokyo 164, Japan*

El-Nino events and El-Nino dominated decades are influential to the variations on marine environment, not only in the eastern and central North Pacific but also western boundary regions, such as the Kuroshio path, the southward intrusion of the Oyashio and the vertical mixing in the upper ocean, through PNA pattern formation and the variation in meander pattern of the westerly wind in the atmosphere.

Atmospheric conditions of weak winter monsoon in the Far East in El-Nino years, such as in early 1972, 73, 79, 83, 89, 92, etc., induced higher chlorophyll a concentration in the upper mixed layers of the Kuroshio and its coastal waters. Strong winter monsoon induces too strong vertical mixing in the western boundary current and its coastal waters during the spawning season of many pelagic fishes in late winter. However, it induces higher chlorophyll-a concentration in the southern subtropical regions where subsurface chlorophyll maximum is formed ever in winter.

Decadal scale variations in the zooplankton biomass in the Bering Sea, the Okhotsk Sea and the Western and the Central Subarctic regions have similar tendency. Zooplankton biomass during 1976-85 Is about twice as high as those in late 1950s and early 1960s. However, the biomass during 1965-75 is much higher than those, although its year-to-year variation is large. The difference and the similarity of these variations, including physical environment, are compared with those in the eastern boundary region.

3AM1994-STA03 Poster

## MONITORING OF SUBARCTIC SURFACE FRONTS IN 1988

Jun Suwa[1], Masahisa Kubota[2] and Yasuhiro Sugimori[2]
[1]*The University of Electro-Communications, Department of Electronic Engineering, 1-5-1, Chofugaoka, Chofu, Tokyo 182 Japan*
[2]*Tokai University, School of Marine Science and Technology, 3-20-1, Orido, Shimizu, Shizuoka, 424 Japan*

In recent years, it has been widely recognized that marine plastic debris do damage to not only human activities but also lives of creatures in the ocean. In order to resolve this problem, it is important to understand spatial distribution, movement, and convergent mechanism of marine debris. Since a oceanic frontal zone can be regarded as one of the convergent regions of marine debris, we can usually find many floating matters such as bubbles and marine plants along a frontal zone. In the present study, we monitored sea surface temperature and salinity using a monitoring system mounted on a merchant vessel (Toyofuji #14), which regularly made a round-trip across the North Pacific every month, from May to October in 1988. The surface temperature and conductivity were observed every 5 minutes with the real-time continuous monitoring system(Model ACT-20) developed by ALEC Electronics Co. The device has temperature accuracy of 0.1C and conductivity accuracy of 0.06 mS. Analysis of sea surface temperature and salinity data collected from the six round-trip transpacific cruises indicated that the subarctic surface fronts is formed at a boundary between two water masses of different origin, which is consistent with the suggestion of the past studies. Past studies also showed that the subarctic front is characterized by the absence of a density front in the upper 100m because the strong horizontal temperature and salinity gradients. However, a surface density front associated with the subarctic front was observed in the present study.

3AM1994-FIS27

## FEEDING STRATEGY OF JUVENILE CHUM SALMON (*Oncorhynchus keta*) IN THE JAPAN SEA OFF NORTHERN HONSHU, JAPAN

Toshiya Suzuki[1], Kazuya Nagasawa[2] and Masahide Kaeriyama[1]
[1] *Hokkaido Salmon Hatchery, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira ku, Sapporo 062, Japan*
[2]*National Research Institute of Far Seas Fisheries, Orido, Shimizu, Shizuoka 424, Japan*

Stomach contents of juvenile chum salmon (*Oncorhynchus keta*) captured in tow nets in the Japan Sea off northern Honshu were compared with the composition of pelagic zooplanktons collected in NORPAC nets for variations related to predator size. Species and size of prey consumed by juveniles for prey, juveniles appear to intensify their feeding selectivity to large prey as they grow. Chum salmon change their phenotypes of feeding strategy at 50-60 mm fork length when they develop from fry to fingerling: fish less than these sizes feed opportunistically on various types of prey, while those larger than these sizes forage widely for large prey.

3AM1994-FIS28

## SHIFT IN CHUM SALMON (*Oncorhynchus keta*) FOOD HABITS DUE TO CHANGES IN PINK SALMON (*O. gorbuscha*) ABUNDANCE IN THE CENTRAL NORTH PACIFIC OCEAN AND BERING SEA

Kazuaki Tadokoro[1], Yukimasa Ishida[2], Nancy D. Davis[3] and Shoji Ueyanagi[4]
[1]*Ocean Research Institute, University of Tokyo, Minamidai, Nakano-ku, Tokyo, Japan*
[2]*National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, Orido, Shimizu, Shizuoka-ken, Japan*
[3]*Fisheries Research Institute, School of Fisheries, College of Ocean and Fishery Science, University of Washington, Seattle, WA, U.S.A.*
[4]*School of Marine Science and Technology, Tokai University, Orido, Shimizu, Shizuoka-ken, Japan*

The food habits and abundance of six species of Pacific salmon (*Oncorhynchus* spp.) and the biomass of prey organisms were examined in the central North Pacific Ocean and Bering Sea in the summer of 1991 and 1992. Salmon were caught by surface longline using the same level of fishing effort for both years. Chum (O. *keta*) and pink (O. *gorbuscha*) salmon were the predominant species in the study area and represented 44% and 41% of the total catch (n=1215) in 1991, and the distribution of these species approximately overlapped. In 1992, chum salmon was 87% of total catch (n=603), but the catch of pink salmon decreased to 1% of total catch due to the odd/even year fluctuations of Asian pink salmon abundance that are distributed in the study area. When pink salmon were not abundant, we observed that chum salmon shifted their diet from non-crustaceous zooplankton (appendicularians, jelly fish, pteropods, chaetognaths and polychaetes) to a diet similar to pink salmon, namely crustaceous zooplankton (euphausiids, amphipods and copepods). Annual biomass (wet weight; $mg/m^3$) of crustacious zooplankton was negatively correlated with the number of pink salmon caught in 1991 ($r=0.586$; $p\leq0.05$) and number of chum salmon caught in 1992 ($r=0.616$; $p\leq0.05$). Due to the shift in chum food habits when there is a high abundance of pink salmon and to the negative correlations we have demonstrated between crustaceous zooplankton biomass and abundance of curstaceous zooplankton consumers (pink and chum salmon), we suggest that there is a limitation in the capacity of crustaceous zooplankton to provide energy for salmon production.

3AM1994-STA08 Invited

## MONITORING OF LOWER TROPHIC LEVEL VARIABILITY AND RESPONSE TO LONG-TERM FORCING IN THE SUBARCTIC PACIFIC OCEAN

Satoru Taguchi, *Hokkaido National Fisheries Research Institute, 116 Katsura-koi, Kushiro 085, Japan*

The subarctic Pacific Ocean consists of the Alaskan gyre and the western Subarctic gyre with a couple of seasonally ice covered marginal seas such as the Bering Sea and the Sea of Okhotsk. The western Subarctic gyre is the unique water mass, with can be modified by trapping of a warm core ring, in the subarctic Pacific Ocean. The Alaskan gyre and the western Subarctic gyre show a strong seasonal thermocline. Winter mixing does not occur below 100 m in the former gyre while it occurs deeper than 200 m in the latter gyre. This difference in the physical structure of water mass in winter may cause a different low trophic level variability at the near surface ecosystem between two water masses, and the low trophic level may respond differently to long-term forcing. To monitor those variabilities and responses, ship observation has been the main effort based on either continuous or discrete determinations. Some determinations, for example, microzooplankton are still dependent mostly on the discrete sampling. Technological developments with acoustics, optics, and satellite should be achieved to overcome the present difficulties encountered in the subarctic Pacific Ocean.

3AM1994-POC35 Invited

## RATES OF NORTH PACIFIC INTERMEDIATE WATER FORMATION

Lynne D. Talley, *Scripps Institution of Oceanography, La Jolla, CA 92093-0230*

North Pacific Intermediate Water (NPIW) originates in the Mixed Water Region between the Oyashio and Kuroshio, as a mixture between the relatively fresh and cold Oyashio water and the saline, warm Kuroshio water. A formation rate of about 6 Sv of new NPIW is estimated, with NPIW defined as lying between 26.65 and 27.4 sigma theta, which is roughly the range affected by air-sea interaction in the Oyashio and Okhotsk Sea. Of this, approximately half comes from the Oyashio and half from the Kuroshio. This rate of "formation" is compared with the East Kamchatka Current and Oyashio transports, exchange with the Okhotsk Sea, and estimated renewal rate in the Okhotsk Sea. It is shown that the ventilation rate for the subtropical gyre in this density range is slow.

The formation density of the salinity minimum associated with NPIW is attributed to the winter surface density in the Mixed Water Region, and is affected by cabbeling (Yun and Talley, PICES abstract submitted) and possibly double diffusion. The relative importance of these two processes in creating downward buoyancy flux and convergence at the NPIW densities is explored. The overall mechanisms for water mass transformation in the NPIW density range within the Okhotsk Sea, western subarctic Pacific, and Mixed Water Region will be reviewed.

3AM1994-STA05 Invited

## SUMMARY OF VARIABILITY OF PHYSICAL CONDITIONS IN THE SUBARCTIC NORTH PACIFIC

Lynne D. Talley and Xiaojun Yuan, *Scripps Institution of Oceanography, La Jolla, CA 92093-0230 USA*

A brief summary of studies of variability in SST, sea surface height, atmospheric forcing, circulation, and water properties for the subarctic Pacific is given, with emphasis on the central and eastern regions. Most studies have been for the first few variables, with much less attention paid to salinity distributions and circulation including the barotropic component. The importance of salinity for near-surface stratification is quantified.

3AM1994-FIS29 Invited

## RECRUITMENT VARIABILITY OF PELAGIC STOCKS IN THE YELLOW SEA ESPECIALLY HERRING IN RELATION TO ENVIRONMENT

Qi-Sheng Tang, *Yellow Sea Fisheries Research Institute, Qingdao, People's Republic of China*

There may be two patterns of recruitment variability of pelagic stocks in the Yellow Sea. Some species, like Spanish mackerel, silver pomfret and anchovy, appear to be relatively steady. The reason for these species is not clear. Perhaps it is due to an unusual combination of natural and anthropogenic conditions; recruitment variability is particularly large for Pacific herring. There is no strong relationship between spawning stock and recruitment, and environmental condition such as rainfall, wind, and daylight are the primary causes affecting the herring recruitment successes and failures in the Yellow Sea. Long-term changes in biomass may be correlated with the 36 year cycle of dryness/wetness oscillation in eastern China.

3AM1994-SB07 Invited

## PLANKTON COMMUNITY IN THE SUBARCTIC PACIFIC UNSORTED PASTURE OF THE SEA

Akira Taniguchi, *Faculty of Agriculture, Tohoku University, Aoba-ku, Sendai, Miyagi 981, Japan*

V. Hensen had argued more than a hundred years ago that productivity of fish populations in the sea is determined by productivity of plankton community. J. Johnstone had likened later the plankton to pasture. This led people to an expectation that carrying capacity of particular sea area can be estimated rather easily by knowing plankton productivity. Major interest of biological oceanography has then shifted to modern physiological studies on plankton productivity.

Although fish and plankton are simply said to be component parts of the polaric ecosystem, infrastructure and process involved in each component are far more than simple. Even a relationship between single fish species and zooplankton is very complex as shown by A. Hardy. His picture suggests that the "pasture of the sea" in not necessarily high quality one but actually an unsorted pasture or a mixture of forage plants and weeds. This fact makes determination of carrying capacity or the "pasture-ground in the sea" difficult. To know species composition of zooplankton community should be first step to reliable estimation of the

carrying capacity. To analyze the status of matching/mismatching between fishes and plankters in both temporal e.g. seasonal and diurnal scale and spatial e.g. horizontal and vertical scale is also essential. Without knowledge in such classic concepts modern data on productivities can not work properly in determination of the carrying capacity especially of the sea areas like subarctic Pacific where environmental and biological parameters fluctuate very widely in both spatial and temporal scales.

3AM1994-FIS30 Poster

## SPATIAL PINK SALMON DIFFERENTIATION DURING ANADROMOUS MIGRATION IN CONNECTION WITH CLIMATIC-OCEANOLOGICAL REORGANIZATIONS IN THE FAR EASTERN SEAS

O.S. Temnykh, *Pacific Research Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, Vladivostok, 690600, Russia*

Anomalous oceanological situation in summer, 1993, in the Far Eastern Seas caused pink salmon migration ways changes and its redistribution between regions. Pink salmon avoiding of high dynamical zone which was a barrier for the ocean water spread in the Okhotsk sea in northern Kuril region was a salient peculiarity of its anadromous migration in the Okhotsk in 1993. Mainly, pink salmon migrated to the Okhotsk sea through Mid-Kuril Straits, then to the north-west and the north directions. The direction of anadromous migration in the western Bering Sea was more northern in comparison with previous years. The pink salmon redistribution between south and north parts of its area was confirmed by similarity of total pink salmon biomass calculated on basis of coastal and sea surveys. The coastal and sea estimations of pink salmon biomass were in the range 220-240x$10^3$t. This fact is considered as an argument in favour of pink salmon population organization hypothesis being described by "fluctuating stocks" model. According to this model intensive individual exchange between local stocks is possible under certain environmental changes.

Investigation carried out on morphological (including peculiarities of scale structure) differentiation of pink salmon of Bering and Okhotsk Seas (discriminant analysis with using 17 morphometric sings) indirectly prove this hypothesis. Accuracy of classification of several pink salmon samples in Bering and Okhotsk Seas is 30-48%. Addition of eighteenth sign (ratio of pink salmon weight without viscera to length) significantly improves the results of pink salmon classification between samples in Bering and Okhotsk Seas. Nevertheless, error of classification (6-28%) can be explained as a result of individual exchange between regions.

3AM1994-BIO27 Poster

## HORIZONTAL DISTRIBUTION AND SEASONAL CHANGE OF EPIPLELAGIC *CHAETOGNATHA SAGITTA ELEGANS* IN RELATION TO HYDROGRAPHY AROUND THE KURILE AND HOKKAIDO ISLANDS IN THE WESTERN SUBARCTIC PACIFIC OCEAN

Makoto Terazaki[1], Hiroaki Saito[2], Hiromi Kasai[2], Tokihiro Kono[2], Yasuhiro Kawasaki[2] and Satoru Taguchi[2]
[1]*Ocean Research Institute, University of Tokyo, Minamidai, Nakano, Tokyo 196, Japan*
[2]*Hokkaido National Fisheries Research Institute, Kushiro 085, Japan*

Spatial distribution and seasonal change of the epipelagic chaetognaths along the Kurile Islands and off southeast Hokkaido, respectively, in the western subarctic Pacific Ocean, were investigated during the period from May 1990 to October 1992. *Sagitta elegans* was dominant species among the epipelagic chaetognaths in the study area. Juvenile of *S. elegans* was distributed along the path of the mixed water with was determined by the Acceleration Potential Anomaly (APA) calculated at the isopycnal surface of 26.6. The location of the path of the mixed water significantly varied annually in relation to climate change. Captures of *S. elegans* were made at temperature ranging from 4.5 to 22.2°C. The juvenile distribution, however, was restricted mostly between 1 and 4°C of potential temperature determined at the

isopycnal surface of 26.6. Variability in the juvenile abundance along the path of the mixed water could be caused by grazing loss by predators rather than the food limitation since microzooplankton, which was known to be prey for juveniles, was abundant enough to meet the food requirement by the juveniles in the study area. Adults occurred in spring (April-May) and young individuals (juvenile and stage 1) were abundant in summer (June-July) when the remarkable thermocline was developed. Main spawning period might be suggested as April-May with a possible second spawning period in a fall.

3AM1994-FIS31 Poster

## TROPHIC STRUCTURE OF FISH COMMUNITY FROM THE BOLSHAYA RIVER ESTUARY (WESTERN KAMCHATKA)

A.M. Tokranov and V.V. Maximenkov, *Kamchatsky Institute of Ecology and Nature Management of the Far Eastern Branch of the Russian Academy of Sciences, and Kamchatka Research Institute of Fisheries and Oceanography, Petropavlovsk-Kamchatsky*

Research done in 1990 through 1992 in the Bolshaya River estuary strongly suggest that fish community (31 species) comprises "constant" species (19% of the ichthyofauna) distributing mainly within estuary or spending here most of their life time, and species migrating from the sea (81%). The latter are split into "migratory" fish (36%), appearing in the estuary during anadromous and catadromous migrations, and "temporary" ones (45%) carried with the tidal movements of water masses from the sea of Okhotsk.

Species composition of zooplankton and drift is poor, and their abundance is low (on the average , 8 specimen/l). Biomass of nektobenthos (primarily, mysid Neomysis mercedis) and benthos (mainly, amphipods, cumaceans Lamprops korroensis, and chironomid larvae) trends to be high (up to 3-5 $g/m^3$ and 60 $g/m^2$ , respectively). This is a reason for which most of fish in the estuary feed on bottom and demersal organisms.

Food relationships within fish community in the estuary involve two strategies: competition for food among fish preying on similar food items, and predator-prey relations. The first type is specific for most species (including adult fish and their juveniles) except 5 species of fish-eaters (*Salvelinus malma*, S.leucomaenis, *Osmerus mordax dentex*, Megalocottus platycephalus, *Platichthys stellatus*) for which the second type of relationships is common. The first three species are concentrated for feeding in pelagic waters, while the other two occupy for this purpose demersal waters.

3AM1994-BIO28 Invited

## LONG-TERM VARIABILITY OF ZOOPLANKTON BIOMASS AND ENVIRONMENT

Akira Tomosada[1] and Kazuko Odate[2]
*Tohoku National Fisheries Research Institute, 3-27-5 Shinhama, Shiogama, Miyagi, Japan. 985*
[1]*Fisheries Oceanography Division*
[2]*Resoures Management Division*

Odate (1991) compiled 17,242 zooplankton biomass data collected by national and regional fisheries research organizations, and published a report entitled "Distribution of zooplankton biomass in the northwestern Pacific Ocean, 1951-1988, mean wet weight of collections by year, month and 1-degree squares". From this report, Odate classified the data into "Oyashio" area, "Transition" area and "Kuroshio" area, and created timeseries data sets in each area. These three areas are separated by thermal regimes at 100m depth: i.e. <5°C for the Oyashio, 5-15°C for the Transition, and >=15°C for the Kuroshio areas.

Here, we analyze the correlation between the long-term variation of zooplankton biomass and that of physical environment parameters using Odate's data sets supplemented with 1989 and 1990 data. As physical parameters, water temperature of the coastal zone of

Transition area, meteorological data recorded at Nemuro and Miyako, and atmosphere circulation indices in the northern hemisphere are considered. Miyako is a town located in the northern district of Honshu, Japan, confronting the Transition area defined above.

Cross correlation analysis with and without time lag were performed on the smoothed data (running mean). As a result, we found the air-pressure at Miyako exhibited a strong negative correlation to the zooplankton biomass in the Transition area. In 4-year-running mean time series data, the air-pressure varied preceding to the variation of zooplankton biomass with a correlation coeffiecient (r) 0.71. From this result, the contribution of air-pressure to the variance of zooplankton biomass is calculated as about 50% ($r^2$) in the Transition area. As the air-pressure at Miyako represents meteorological events occurring around neighbouring areas, it can be concluded that the temporal changes in zooplankton biomass and air-pressure are coupled negatively in the Transition area.

As a mechanism for the effect of air-pressure to the zooplankton biomass, it is considered that low pressure induces rough state of sea surface, which promotes vertical convection of water column. Vertical convection of water transports nutrients from deep layer to euphotic zone, hence activates primary production by phytoplankters and then growth of zooplankton grazers. Unfortunately, we have neither nutrient nor phytoplankton time series data at present to test this likely scenario.

3AM1994-BIO29
## COMPARISON OF PACIFIC HYDROTHERMAL VENT ASSEMBLAGES
Verena Tunnicliffe, *School of Earth & Ocean Sciences, University of Victoria, Victoria, B. C. Canada. V8W 2Y2*

Midocean spreading ridges and backarc basin ridges in the Pacific are hydrothermally active. Sulphur-laden waters support chemoautotrophic production and organisms not known beyond the vent habitat. Documentation of the types of animals, their systematic position and their distributions tell us much about ocean floor history and the responses of evolving assemblages. Over 340 species are recorded from Pacific hydrothermal vents on Juan de Fuca Ridge, East Pacific Rise, and the western Pacific back-arc basins including the Japan Trough. Of these species, 96% are known nowhere else but vents; nearly 50% represent genera that are new to science. We are exploring the hypothesis that this systematic novelty is a result of extended isolation and in situ evolution. Different hydrothermal sites do, however, communicate to the extent that closely related species are found in adjacent provinces. The composition of the Juan de Fuca Ridge fauna reflects the 30 million year separation from the East Pacific Rise due to the interposition of the North American Plate. The western Pacific vent fauna has many elements in common with the East Pacific Rise with which there is a connection via the southern Pacific. Differentiation increases northward to the Marianas/Japan province reflecting increased spatial and temporal separation. There is a greater similarity between vent faunas on the eastern and western margins of the Pacific that either show with nearby seep communities. It appears that geographic spread of an endemic vent fauna has taken precedence over invasion from local areas.

3AM1994-POC36
## CURRENT MEASUREMENTS OF THE FIRST BRANCH OF THE OYASHIO IN THE SOUTHEAST OFF CAPE ERIMO, HOKKAIDO
K. Uehara and H. Miyake, *Faculty of Fisheries, Hokkaido University, Minato-cho 3-1-1, Hakodate, Japan. 041*

The First Branch of the Oyashio current generally develops in the southeast Cape Erimo, Hokkaido. To clarify characteristics of the current, temperature and current vectors were measured hourly with a mooring system (Aanderaa Current Meter) for 7 years from 1985 to 1993. Values of the annual mean speeds at the depth of 400 m and 500 m were scattered

around 10 and more cm/sec ( in 1986 it increased unexpectedly to 29 cm/sec). Averages of their current direction per year were almost the same as 200 degree. On the other hand, mean speeds at the depth of 1000 m and 1500 m were from 3 cm/sec to 5 cm/sec. The monthly mean speeds at the depth of 500 m in 1991-1993 showed their maximum in February, being 24 and more cm/sec with directions of 210 - 225 degree. We will discuss the current data with hydrographic ones.

3AM1994-STA03 Poster

## OCEANOGRAPHICAL MONITORING BY THE JAPAN METEOROLOGICAL AGENCY

Takeshi Uji and Takashi Yoshida, *Marine Department, Japan Meteorological Agency, Tokyo, Japan*

Marine Department of the Japan Meteorological Agency(JMA) develops a monitoring system that will satisfy effectively the needs for physical, chemical and biological data from ocean and contiguous region.

JMA has been conducting oceanographic surveys in the seas adjacent to Japan and the western North Pacific on board the six observation ships. A routine survey has been carried out every seasons in the seas adjacent to Japan for more than thirty years and twice a year in the western north Pacific for more than twenty-five years. Basic physical, chemical, and biological parameters have been measured. Background level of heavy metals have been monitored since 1972. A program to monitor petroleum started in 1976. In 1989 the JMA started to monitor green house gases(carbon dioxide, methans, and so on) in the western North Pacific.

JMA operates ocean data buoys in seas adjacent to Japan. The buoys measure maritime meteorological parameters, water temperatures and wave.

JMA observes waves, tides and water temperatures at coastal stations.

These observations and programs are closely related to international programs, such as WESTPAC, IGOSS, WOCE, GIPME, GAW, GLOSS and so on.

3AM1994-POC37 Poster

## VARIABILITY OF WIND CONDITIONS OVER THE WESTERN NORTH PACIFIC IN WINTER MONSOON PERIOD

Helena I. Ustinova, *Pacific Res. Inst. of Fisheries & Oceanography (TINRO), Shevchenko Alley,4, Vladivostok 690600, Russia*

In this paper, various features of variability of the wind conditions over the western North Pacific (30 - 55°N, 130 -160°E) in winter monsoon period are discussed. Analysis is based on the long-term series of computing daily wind fields (1930-1985). Extreme and average values of wind speed, dominant direction, number of days in month with wind speed >15, 20 and 25m/s, repeatability of wind for various intervals of speed and 8 major directions were estimated. For estimation of intensity of winter monsoon complex characteristics were calculated: monthly sums of speed northwesterly and north wind.

In a large part of the study area, wind speed is high in 1939-1940, 1946, 1966, 1973, low in 1930-1933, 1959-1962. Interannual changes of wind speed are largest in the north-western part of the study area, and slight at 30 N. Direction of winter monsoon was very stable in 1933 and 1936. The maximum of monthly sums of speed northwesterly and north wind is observed in 1968 and 1972, minimum in 1959. In the spectra of wind speed there is a major spectral peak around a period of about 9 yr and 25 yr for a large part of the study area in

the interannual period band. The spectra of sums of speed northwesterly and north wind have spectral peaks at the periods of 2.4, 3.2, 5.7 and 9 yr.

3AM1994-MEQ12
## DISTURBANCE OF GAMETOGENESIS OF MARINE INVERTEBRATES AS A MECHANISM OF BOTTOM COMMUNITY TRANSFORMATION UNDER ENVIRONMENTAL STRESS

M.A. Vaschenko and P.M. Zhadan, *Institute of Marine Biology and Pacific Oceanological Institute, Russian Academy of Sciences, Vladivostok 690041*

A very important question for understanding the effects of environmental stress on reproduction is what life cycle stage is the most vulnerable. Embryos and larvae are generally accepted to be more sensitive to toxicants than adult animals. Nevertheless our laboratory experiments revealed that gametogenesis of sea urchins is 10-100 more sensitive to hydrocarbons and heavy metals than embryogenesis in acute experiments. Our recent studies of the reproductive function of sea urchins and scallops from clean and polluted areas (Peter the Great Bay, the Sea of Japan) are in agreement with the results of laboratory experiments. In particular, larval development of the sea urchins Strongylo-centrotus intermedius from the low polluted area proceeded in the water from the same area was accompanied by death of the most part of larvae or cessation of their development. At the same time the offspring of the animals from unpolluted station showed normal development in the water from the same low polluted area. This fact confirmed our hypothesis that the loss of invertebrates ability to produce normal gametes is the first step in the disturbance of bottom community reproduction. Impossibility of larvae from the clean areas to survive in polluted waters and to restore invertebrates populations is the next step. Finally, disappearance of the species sensitive to pollution leads to destruction and degradation of the bottom communities. The conclusion is discussed that disturbance of gametogenesis is the earliest display of the tendency to transformation of marine communities under anthropogenic stress.

3AM1994-POC38
## ON THE COMPLEX STUDY OF THE NORTH PACIFIC AND MARGINAL SEAS

Anatoliy S. Vasiliev, *State Oceanographic Institute, Marine Dynamics Division, Kropotkinsky per.6, 119838 Moscow, Russia*

The main results of a study on the Asian-Pacific marginal seas of Russia and their interaction with subtropical and arctic gyres in the North Pacific are presented. The problems of natural and anthropogenic changes in climate and weather are considered, and certain ideas on state control and positive development of the marine ecological systems are proposed. Extensive field measurements and data analysis executed by the Russian Hydrometeorological Committee and the Russian Academy of Sciences are related to the significant national and international programs, including:

- Investigation of processes of the Northern Pacific intermediate water mass (NPIW) formation and jet-stream systems in the marginal seas and the ocean (CESNP-NPIW);
- Investigation of climate in the Northern Pacific (ICNP);
- Development of the oceanographic data base on the Northwestern Pacific and marginal seas (BOD-PICES);
- Development of theory and computer prognostic systems for fish and invertebrates state and migration in the marginal seas of Northern Pacific (Ecological Simulation of the Oceanological Systems - ESOS).

3AM1994-POC39 Poster

## THEORETICAL ANALYSES OF SEASONAL VARIABILITY OF MAIN PHYSICAL FIELDS IN THE OKHOTSK SEA

A.S. Vasiliev and F.F. Khrapchenkov, *Pacific Oceanological Institute, Far-Eastern Branch, Russian Academy of Sciences*

On the basis of hydrodynamic simulation, in the bounds of system model for complex monitoring and state forecast, it is carried out analyses of seasonal variability of main physical fields in the Okhotsk Sea as well as general circulation of water considering water exchange with the adjacent regions through the straits. Dynamic structures of the Okhotsk Sea are considered month by month, external fields (fields of the atmospheric pressure, surface temperature and salinity) being monthly averaged. For calculations the authors considered topographic and orographic peculiarities of the sea, as well as water exchange through the straits.

In the surface layers, general circulation possesses a cyclonic character. It is also observed complex dipole structure of cyclonic and anticyclonic formations near the coast of Sakhalin Island, in the southern part of the sea and along the Kuril Islands. On the periphery of these formations and along the coast-line, the following jet-streams are well exposed: North-Okhotomorsk, East-Sakhalin , Soya, Kamchatka jet-stream. Their structure considerably changes from season to season, it is conditioned by the rearrangement of the atmospheric pressure field over the Okhotsk Sea. Topographic and orographic peculiarities and water exchange through the straits bring significant corrections in an integral sense. Results of numerical experiments gave the opportunity to precise the existing notions on the Okhotsk Sea waters dynamics and their seasonal variability.

Created automated information-prognostic computer technology of complex monitoring allows to carry out monitoring in a real time scale upon receiving the data on water surface temperature and the atmospheric pressure. This technology was used for monitoring of main physical fields in the Okhotsk Sea in Cruise 25 of the R/V "Akademik A. Nesmeyanov" in September of 1993.

3AM1994-BIO30 Invited

## ENVIRONMENTAL CHANGES IN THE WESTERN SUBARCTIC REGION AND POPULATION FLUCTUATIONS OF PELAGIC FISHES

Tokio Wada[1] and Makoto Kashiwai[2]
[1]*National Research Institute of Fisheries Science, 12-4 Fukuura, 2-chome, Kanazawa-ku, Yokohama, Kanagawa-ken, Japan. 236*
[2]*Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, Hokkaido, Japan. 085*

The western subarctic region is a main feeding ground for plankton feeding pelagic fishes. In the region, the subarctic transition zone between the Kuroshio and Oyashio fronts is also important as a nursery ground for their juveniles. There are two possible factors affecting long-term fluctuation of the pelagic fish: environmental fluctuation and interspecific competition. The environmental fluctuation affects the species replacement among the fishes as a trigger.

Japanese sardine population reached the maximum in 1980s. With the population increase, the sardine enlarged the feeding ground so as to secure the food resources requiring to maintain the high population abundance at the cost of individual growth. The sea surface temperature (SST) anomaly in the waters off Honshu and Hokkaido was mostly negative through the 1980s. The area of the transition zone was decreased but the Oyashio region was increased in the same period.

Contrary to the changes in Japanese sardine, chub mackerel population reached a peak in 1970s when the SST was relatively high and the area of the transition zone was large. And

then, the northern limit of migration of the mackerel shifted to southward corresponding to the change from high to low in SST at the beginning of 1980s.

These observations suggest that the environmental changes in the western subarctic region eventually control the productivity of the pelagic fishes. However, we have not known how the environmental changes, especially changes in the transition zone, affect to the reproductive success or determination of year-class strength of the pelagic fishes.

3AM1994-FIS32 Invited

## RECRUITMENT OF B.C. HERRING: THE SEARCH FOR LIMITING FACTORS

Daniel M. Ware, *Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, BC, V9R 5K6, Canada*

A 53 year time series (1935-87) of west coast of Vancouver Island herring year-class strength (measured as age 2+ recruits) was reconstructed from a transfer function relating Taylor's (1964) estimates of the strength of the 1935-59 year-classes, and an age-structured model estimate of the strength of the 1951-87 year classes (Schweigert et al. 1992). The correlation between these two time series over the 8 year period of overlap was highly significant (p=0.006). Previous research, plus new findings presented here for the first time, have identified three environmental factors that have appeared to limit herring year-class size since 1935: 1) local winter (DJF) wind stress (measured as Ekman Transport at 48°N) prior to the birth of the year class; 2) hake biomass (hake is a principal predator of herring); and 3) annual water temperature in the first year of life. The reason why these variables are viewed as limiting factors derives from the distinctive "triangular, or rampshaped" distribution of year class strength in relation to each of these variables. These distributions triangular shape indicates that when the limiting environmental factor has a low value it has little effect in determining year class strength. However, as the value of the environmental factor rises it plays an increasingly stronger role in limiting the size of the year class.

Statistical analysis indicates that poor year classes tend to be associated with above average temperatures, above average winter Ekman Transport (high downwelling-favourable wind stress), and above average hake abundance. Conversely, good year classes tend to be associated with below average values of these three factors. These findings are being used to forecsat herring recruitment two years in advance. The suspected biological basis underlying how these factors affect herring recruitment is discussed.

3AM1994-FIS33 Poster

## ABUNDANCE AND DISTRIBUTION OF DEMERSAL FISHES ALONG THE COAST OF SOUTHEASTERN HOKKAIDO

Kazutoshi Watanabe[1], Keizo Yabuki[1], Tomonori Hamatsu[1] and Orio Yamamura[2]
[1]*Hokkaido National Fisheries Research Institute, Katsurakoi 116, Kushiro, Hokkaido, Japan 085*
[2]*Hokkaido University*

To clarify the peculiarity in the distribution of demersal fishes, we analyzed the catch statistics of commercial fishery from the early 1970's and the data of bottom trawl survey from 1988 to 1992. The results showed that walleye pollock and threadfin hakeling were highly abundant with segregated distribution by depth. In the area shallower than 300m, the pollock were dominant, in contrast, the hakeling mostly appeared in the area deeper than 300m. This segregation might be the result of the competition for food. Abundance of demersal fishes have been decreasing as a whole. We discuss the cause of decline in demersal fish stock in the coastal fishing ground of the southeastern Hokkaido.

3AM1994-BIO31 Poster

## HYDROGRAPHIC MONITORING IN CONJUNCTION WITH CATCHES FROM A SET-NET

Kazuyoshi Watanabe, Kazuyuki Otsuka, Kohei Kihara and Hidekatsu Yamazaki, *Laboratory of Fisheries Oceanography, Tokyo University of Fisheries, 5-7, Konan 4, Minato-ku, Tokyo 108*

We have deployed a buoy telemetry system in Tateyama Bay which is located at the mouse of Tokyo Bay, in order to monitor the hydrographic conditions adjacent to a set-net. The system is composed of a weather station and two separate buoys for a thermistorchain and current meters, respectively. At the weather station we have observed wind direction and speed, solar radiation, total of radiation, precipitation, atmospheric pressure, air temperature and humidity. The temperature sensors have been suspended from 2m to 79m depth at 3m interval. And the current meters were located at 5m and 25m depth. The primary objective of our study is to collect hydrographic conditions which appear to relate with high catches of fish in the net. In addition to the buoy system we have made CTD and ADCP survey from the T/R/V Seiyo-maru in the bay at a monthly interval.

We will present several noticeable features observed in the bay, and discuss the potential impact of these processes to fishing at the net.

3AM1994-FIS34 Invited

## MORTALITY IN EGG AND EARLY LARVAL STAGES OF SARDINE *Sardinope melanostictus* IN THE NORTHWESTERN PACIFIC

Yoshiro Watanabe, *National Research Institute of Fisheries Science, Japan Ministry of Agriculture, Forestry, and Fisheries, 2-12-4 Fukuura, Kanazawa-ku, Yokohama 231, Japan*

Daily instantaneous mortality rates (IMR) in egg and early larval stages of the Japanese sardine *Sardinops melanostictus* were estimated for 13 years 1978-1990 based on the stage-duration -standardized abundance of eggs, yolksac larvae, and post-first-feeding larvae of 6-8mm TL. The durations between the stages were estimated by temperature dependent incubation time for eggs and yolksac larvae. The duration between yolksac and the post-first-feeding larvae was fixed for 5 days using growth rate of 0.5mm/day.

Abundance of eggs, yolksac larvae, and the post-first-feeding larvae all increased through the 1980's and reached quite high levels at the end of the decade when the population started a decline. Daily IMR's fluctuated in a range 0.50-1.47 between egg and yolksac stages and 0.14-0.64 between yolksac and post-first-feeding stage. Overall daily IMR between egg and the post-first-feeding larvae tended to decrease through the 13 years studies. This, together with increase in egg production, resulted in high abundance in the post-first-feeding larvae at the end of the 1980's. Recruitment of 1988-1990 year classes, however, failed in spite of high abundance of post-first-feeding larvae.

3AM1994-SB08 Invited

## GROWTH VARIATION AND POPULATION DYNAMICS OF SALMONOIDS IN THE NORTH PACIFIC

David W. Welch[1], Yukimasa Ishida[2], Victor Bugaev[3], Skip McKinnell[1], and Katherine Myers[4]
[1]*Pacific Biological Station, Nanaimo, B.C., Canada, V9R 5K6*
[2]*National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan 424*
[3]*Pacific Research Institute for Fisheries and Oceanography, Petropavlovsk-Kamchatsky, Russia 68302*
[4]*University of Washington, Seattle, Washington, U.S.A. 98195*

Pacific salmon populations around the Pacific Rim show significant changes in average body size over time. We present a survey of these changes for the major salmon producing nations, and an examination of the evidence that marine growth rates are density-dependent interactions do occur, and that they seem to be consistent with predictions made on the basis of trophic positioning: the abundance of salmon species feeding at low levels in the food

chain appears to affect the growth of species feeding higher up the food chain, but not vice versa. However, these relationships also depend on the age groups sometimes show quite different changes. We summarize these changes by briefly discussing what types of research are likely to be most productive in resolving these relationships in future. Establishing whether marine growth rates of salmon are truly density-dependent is not just of management concern; determining whether current levels of salmon abundance can graze down their own food supply should provide considerable insight into the productivity of the North Pacific Ocean for all species.

3AM1994-FIS35 Invited

## EVIDENCE OF SPECIES REPLACEMENT IN THE BERING SEA PELAGIC FISH COMMUNITY

Vidar G. Wespestad[1] and Nikolai I. Naumenko[2]
[1]*Alaska Fisheries Science Center, Seattle, Washington, 98115 USA*
[2]*Pacific Institute Fisheries and Oceanographic Research, Kamchatka Branch, Petropavlovsk, Kamchatka, Russia*

Three fish species predominate in the Bering Sea pelagic community, walleye pollock, *Theragra chalcogramma*, Pacific herring, *Clupea pallasi*, and capelin *Mallotus -villosus*. Pollock is currently the far dominant species, comprising the bulk of the fishery resource in both the western and eastern Bering Sea. However, data suggest that herring was previously much more abundant. Capelin also currently appears to be at low levels of abundance, has previously been observed to occur at greater levels of abundance. In both the eastern and western Bering Seas an inverse relationship has been found to exist between herring and pollock abundance. In both areas herring was abundant in the 1960s and pollock occurred at low abundance. In the 1970s herring declined and pollock increased in abundance. Capelin, never as abundant in the Bering Sea as in other areas, such as the Barents Sea , Iceland, and Northwest Atlantic, appear to increase its abundance in Bering Sea during the transitions between pollock and herring abundance. All three species utilize the same pelagic food resource. The cycle in herring and pollock abundance appears to be regulated by long term climatological cycles which give a competitive advantage to either pollock or herring. Capelin, with a much shorter life span, appears to increase in abundance during the period of change between pollock and herring, exploiting the open niche.

3AM1994-POC40 Poster

## A NEW DATA ABOUT THE ICE BOUNDARY IN BERING SEA

L.P. Yakunen, *Far Eastern State University, Octyabrskaya,27, Vladivostok 690600, Russia*

There are many data about iciness in Bering Sea since XIX century. But most regular observing data is only from 1959 to 1991 years with decade discretenees of observation.

Analysis of this data base give opportunity to prepare most objective inter and annual dynamics of iciness. The results of analysis of these information show that there is a maximum of iciness observing in March - April. Its value is about 20-56% of sea area. In average ice cover is persist about 10 months, but in extreme years iciness may change from 7 to 12 month.

3AM1994-MEQ13

## NEW MONITORING METHOD OF MARINE POLLUTION WITH TOXIC CHEMICALS ACCUMULATED IN SQUID LIVER (SQUID WATCH)

Hisashi Yamada, *Environment Conservation Division, National Research Institute of Fisheries Science, 6-31-1, Nagai, Yokosuka, 238-03, Japan*

The monitoring of toxic chemicals in seawater is important and useful research to consider their impacts on aquatic ecosystem. Monitoring of marine pollution by measuring the

toxic chemicals accumulated in organisms has been carried out for many years by using mussels (Mussel Watch). As marine pollution is feared to be worsening in the world oceans, it is necessary to develop a new method of monitoring in a global scale. Squid is widely distributed all over the world. It, therefore, has a potential to serve as a monitoring organism. In this research, the feasibility of squid as a monitoring organism is examined by using organotin (TBT and TPT) and PCBs as toxic chemicals. Furthermore, a current status of marine pollution due to these chemicals is examined in the world oceans including the North Pacific.

The concentrations of TBT, TPT and PCBs in squid livers of 16 species were determined. The TBT concentration in levers of *Sepia esculenta*, *Rossia pacifica* and *Watasenia scintillans* was low compared to that of other species. The concentrations of TBT and TPT were not significantly different in the liver of Ommastrephidae. Ommastrephidae was suitable to the monitoring organisms. The TBT concentration in the squid livers depended on the TBT concentration in seawater, and it was high in the squid caught in the seawater of higher TBT concentration. The BCF was estimated from the TBT concentration in seawater and the squid liver, and it was 22,000 for TBT. The concentrations of TBT, TPT and PCBs were high in squid liver caught in the northern hemisphere compared to those in the southern hemisphere. These distributions of TBT, TPT and PCBs concentration in livers apparently reflect the actual situation of marine pollution to a certain extent.

3AM1994-FIS36

## FOOD WEB STRUCTURE OF DEMERSAL FISH ASSEMBLAGES: TROPHIC PATHWAYS AND ANTHROPOGENIC INFLUENCE

Orio Yamamura, *Hokkaido University, Division of Marine Ecology, Research Institute of North Pacific Fisheries*

Trophic pathways supporting the shelf/slope demersal fish community off Sendai Bay was studied based on a total of 8,650 stomachs of fish collected during May and November, 1989 - 1992. Food web structure was described for a total of 16 fish assemblages, which was obtained by the cluster analysis of trawl samples based on species composition. As a relative importance of a trophic linkage, an index considering diet and dominance of predator was calculated.

In every assemblage, each of which were dominated by a gadiform species, the importance of pelagic prey (e. g. *Euphausia pacifica*, Copepods, Pacific sardine and myctophid fishes) was high. Whereas its importance was exclusively high during May (87.6-100%), it decreased during November (55.1 - 82.5%) when benthic prey and fishing discard, Pacific saury *Cololabis saira* contributed up to 34.3% and 23.9%, respectively.

According to catch statistics of 40 years ago, the fish assemblage in the study area had been dominated by benthos feeding species (rock fish and flatfishes). These fishes are more substratum-related, dependent upon benthic prey, and more vulnerable to trawl fishing than the present gadiform dominants, walleye pollock, Pacific cod and hakelings. Therefore it is concluded conclude that the fish fauna and the trophic pathway in the study area have been changed due to the anthropogenic factor, fishing activities.

3AM1994-POC41 Invited

## SIMULATION OF THE NORTH PACIFIC INTERMEDIATE WATER FORMATION

Goro Yamanaka, Yoshiteru Kitamura and Masahiro Endoh, *Meteorological Research Institute, Nagamine 1-1, Tsukuba, 305 Japan*

Numerical investigation of the NPIW formation is made with an ocean general circulation model. The model has 2 deg. x 1 deg. horizontal resolution and 28 vertical levels with realistic bottom topography. Temperature and salinity of the Levitus climatology and wind stresses of the Hellerman & Rosenstein climatology are imposed at the sea surface.

Restoring temperature and salinity in the northern marginal seas allow outflow of the less-saline water into the interior. We examined two types of parameterization for subgrid mixing processes as (1) horizontal harmonic mixing and (2) isopycnal mixing.

A model with horizontal mixing scheme simulates a salinity minimum layer at the depth of the observed NPIW with annual mean forcing. Minimum value of the salinity is higher than the observed. Density in the salinity minimum layer is not uniformly 26.8 (sigma theta). A wind-driven clockwise circulation dominates over the intermediate depth range (500-800m). Experiments with and without outflow from the marginal seas suggest that source regions of the model NPIW are both the Okhotsk and Bering Seas. Salinity balance in the model shows importance of the horizontal diffusion upon basin-wide spreading of the NPIW.

It is shown that isopycnal mixing scheme better simulates detailed structure of the salinity minimum and density. With the annual mean forcing, however, the salinity minimum is located on a density surface shallower than the observed. Seasonal forcing experiment with winter convection is expected to improve this point.

3AM1994-POC42 Invited

## STUDY OF OCEANIC CARBON CYCLE USING OCEAN BIOGEOCHEMICAL GENERAL CIRCULATION MODEL: VERTICAL DISTRIBUTION OF PARTICULATE ORGANIC CARBON FLUX IN OCEANIC CARBON CYCLE

Yasuhiro Yamanaka, *Center for Climate System Research, University of Tokyo, Tokyo, Japan*

Distributions of chemical tracers in the world ocean are well reproduced in an ocean general circulation model with include biogeochemical processes (biogeochemical general circulation model). Both the export production and the averaged remineralization depth are factors sensitive to controlling the contrast of concentration of tracers between the surface and deep water. The rain ratio, a ratio of production rate of calcite against that of particulate organic carbon (POC), should be modified by the remineralization depth because such a depth of POC is (absolutely) different with that of calcite. The rain ratio is found to be 0.07-0.08. Case studies changing the profile of POC flux show that the phosphate distribution can be reproduced only when the observed profile of POC flux by sediment traps are used. The analysis of phosphate budget shows that the phosphate cycle is apparently closed in the equatorial and North Pacific.

3AM1994-BIO32 Invited

## HYDROGRAPHIC STRUCTURES OF THE SUBARCTIC TRANSITION ZONE IN THE NORTH-WESTERN PACIFIC

Ichiro Yasuda, *Tohoku National Fisheries Research Institute, 3-27-5 Shinhama, Shiogama, Miyagi, Japan. 985*

The area east of Japan is the confluence zone of the Kuroshio and the Oyashio, the western boundary currents of the subtropical and subarctic circulations in the north Pacific. There are some distinctive hydrographic features peculiar in the western confluence zone. Double front structures consist of the Kuroshio front and the Oyashio (subarctic) front. In the interfrontal zone, water-mass characteristics are different from those of the source waters, suggesting that active mixing and convection take place. The Oyashio singularly extends southward near the east coast of Japan (the Oyashio southward intrusion). Some vigorous, warm-core rings stay for more than a few years. In the area east of 150°E, the Kuroshio Extension bifurcates, and one branch flows northeastward. We discuss these features with relation to pelagic fish migration and primary production.

3AM1994-BIO33 Poster

## AGING OF NEON FLYING SQUID, *Ommasatrephes bartramii*, IN THE NORTH PACIFIC

Akihiko Yatsu[1], Satoshi Midorikawa[2] and Yuju Uozumi[1]
[1]*National Research Institute of Far Seas Fisheries, 7-1, Orido, 5 chome, Shimizushi, Shizuoka, 424, Japan*
[2]*Japan Fisheries Information Center*

*Ommasatrephes bartramii*, grow more than 50 cm in mantle length (ML). The growths of this species have been studied using consecutive series of length frequency distribution or recaptures of tagged animals. However, the length based method is generally inappropriate for first-growing squids which undergo large scale migration. In the 1980's, statolith microstructure was found to be useful for aging squids. We observed longitudinal section of statoliths by light microscopy of scanning electron microscopy. We counted number of increments of statoliths taken from 176 squids (158-460 mm ML), which were obtained from the North Pacific (36-43N, 143E-160W) in June - October, 1991 and July 1992. Width of each increment sharply decreased from 5-7$\mu$m to about 2$\mu$m at approximately 80-100th increment with an intervention of a transport area where increments were inconspicuous. Possible causes of this phenomenon are (1) migration from subtropical to transitional and subarctic waters and (2) onset of diel vertical migration . The relationship between ML and number of increments (I) were ML = 1.42 + 11.53 (N=157) for 153E-160W. The statolith from a 460 mm squid had about 300 increments. Out of the 19 squids taken from 143-146E, seven individuals indicated much faster growth than the rest of the squids examined.

3AM1994-BIO34

## NUTRIENT-CHLOROPHYLL INTERRELATIONSHIPS IN THE OYASHIO/KUROSHIO INTER-FRONTAL ZONE DURING PHYTOPLANKTON BLOOM.

Katsumi Yokouchi, Akira Tomosada, Yutaka Matsuo, and Hiroya Sugisaki, *Tohoku National Fisheries Research Institute, 3-27-5 Shinhama-cho, Shiogama, Miyagi-ken, Japan. 985*

Temporal changes in horizontal distributions of chlorophyll a and nutrients were investigated in the Oyashio/Kuroshio Inter-frontal Zone in April through June 1992, in conjunction with hydrographic structure of the water columns. High-chlorophyll due to phytoplankton blooming was observed in Oyashio water and its periphery in April to May. Low-nutrient, low-chlorophyll (LNLC) water covered Kuroshio region and a Warm Core Ring throughout the whole study period. In late May to June, the LNLC water penetrated into Oyashio and its marginal waters where the phytoplankton bloom had been ceased. Widespread high-nutrient, low-chlorophyll (HNLC) waters were observed in the transition area from April to mid May. The HNLC water was replaced by LNLC water from late May onward in the inshore region west of 156 E without showing prominent increase of chlorophyll. The HNLC water was observed persistently in the offshore regions ranging from 156 E to 180 E. Vertical stability of water columns of LNHC regions was greater than that of HNLC regions. In terms of vertical distribution pattern of chlorophyll, LNLC waters were characterized by the near surface maxima, LNHC waters the subsurface maxima, and HNLC waters the lack of maxima. Primary productivity normalized by chlorophyll in HNLC waters was about two times greater than that of LNHC waters, suggesting active phytoplankton growth in HNLC waters. As mechanisms for the maintenance of low phytoplankton biomass in HNLC waters, a vertical transport of phytoplankton cells beyond euphotic layers and possible high zooplankton grazing pressure are hypothesized.

3AM1994-BIO35
## PRIMARY PRODUCTIVITY OF THE YELLOW SEA AND THE EAST CHINA SEA
Sinjae Yoo, *Korea Ocean Research & Dev. Inst., Ansan P.O. Box 29, South Korea. 425-600*

Despite high fish productivity, not much has been known for the primary productivity and phytoplankton dynamics of the Yellow Sea and the East China Sea. The results of recent surveys suggest higher values for the annual primary productivity than the previous estimates for theses seas.

Analysis of CZCS data indicates that phytoplankton dynamics of the two seas are under the control of quite different factors: In the Yellow Sea, it is the stratification process and tidal mixing, while in the East China Sea, it is the runoffs from the Changjiang River that control the phyto-plankton dynamics. Primary productivity and phytoplankton dynamics of these seas are compared and discussed here.

3AM1994-POC43
## VARIATIONS OF OYASHIO COLD WATER DISTRIBUTION
Takashi Yoshida, *Japan Meteorological Agency, Tokyo, Japan*

Oyashio Cold Water is the North Pacific subarctic water which distributes in the sea east of Japan. Mean distribution pattern, mean seasonal variation, and year to year variation of the Oyashio Cold Water are shown based upon the digital data set which contains monthly distribution patterns of the Oyashio Cold Water for the period from 1961 to 1992. The monthly patterns are mostly determined from monthly temperature distributions at the depth of 100 meters. Significant difference is found between mean distribution patterns of April and November. Mean southern limit of the Oyashio Cold Water extent in November is at lat. 41.5 degrees north, and it progresses toward south in April up to lat. 39.5 degrees north. Seasonal variation is clearly found in the change of the Cold Water size. The size is largest in March and smallest in November. Mean difference of the size between the two months is 7x10000 square kilometers. Significant year to year variation is found in the maximum Cold Water size in spring. Difference of the maximum size in spring between the largest and the smallest is 14x10000 square kilometers. The variation which seems to correspond with the climatic shift in the North Pacific in middle 1970's is found in the time series of the maximum size in spring.

3AM1994-BIO36 Poster
## FECUNDITY AND SPERM STORAGE OF *Chionoectes japonicus (Brachyura; majidae)* IN THE SEA OF JAPAN
Ikuko Yosho, *Japan Sea National Fisheries Research Institute*

The red queen crab, *Chionoectes japonicus*, lives in deep sea floor of about 400 and 2700 m deep where the range of water temperature is about 0.15 - 5°C in the Sea of Japan. Although the information on its reproduction was quite limited, some studied have shown that most females extrude eggs in spring and the developments of ovaries and brood are phased and lasted about two years.

Mature females of *Chionoectes japonicus* were collected at south-east off Sado Island in the Sea of Japan in April 1994. Most females in pre-spawning and intermediate phases had only old sperm in a pair of spermathecae, while more than 70% of post-spawning females had sperm freshly ejaculated to add to old one. As it is known that matured females do not moult any longer after attaining their sexual maturity, these suggest that many females copulate shortly before spawning in a hard-shell condition. Females buried about 26000 - 32000 eggs at the presence of newly ejaculated sperm just after copulation and number of eggs positively correlated with the carapace width of female, but about 15000 eggs with only old sperm. The amount of sperm remained in spermathcae did not seem to affect the next copulation.

3AM1994-POC44 Invited

## THREE DIMENSIONAL NUMERICAL STUDIES OF THE CIRCULATION IN THE NORTHEAST OF THE EAST CHINA SEA AND THE AREA SOUTH OF JAPAN

Yao-Chu Yuan and Wei-Bing Guan, *The Second Institute of Oceanography, SOA, Hangzhou, China. 310012*

Based on the hydrographic data obtained during Oct.-Nov., 1992 by R/V Shoyu Maru, a three dimensional nonlinear model and a modified inverse model both are used to compute the circulation in the northeast of the East China Sea and the area south of Japan. The results show that: (1) The Kuroshio southeast of Kyushu originates from two currents. One comes from the Kuroshio at the Tokara Strait, its volume transport (VT) is 27.5 x $10^6 m^3/s$ during Oct.-Nov., 1992. The other comes from the currents east of the Ryukyu Islands, its VT is 30.0 x $10^6 m^3/s$ during Oct.-Nov., 1992; (2) During Oct.-Nov., 1992 the path of the Kuroshio south of japan is N type, and the VT through 138°E section is 64. 2 x $10^6 m^3/s$; (3) There are countercurrents and meso-scale anticyclonic warm eddies on the right of the Kuroshio south of Japan; (4) The nonlinear and the $\beta$ effects are less than 15% and 8% for affecting the velocity fields, respectively.

3AM1994-POC45

## CHARACTERISTICS AND FRONTOGENESIS OF THE SUBARCTIC FRONT IN THE NORTH PACIFIC

Xiaojun Yuan and Lynne D. Talley, *Scripps Institution of Oceanography, Physical Oceanography Research Division, 9500 Gilman Drive, La Jolla, California, U.S.A., 29093-0230*

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 near the 33.0% isohaline outcropped while the southern boundary is defined by the outcropping of the33.8% isohaline. 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. 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 minimal start within the subarctic frontal zone in the eastern North Pacific.

Daily surface wind stress data at 2°x2° grid from 1977 to 1987 in the North Pacific is analyzed for its temporal and spatial variation. The wind stress and its curl have strong annual cycles near the subarctic frontal zone. The positive wind stress curl in the subarctic gyre shifts southward, across the front in winter. The subarctic frontal zone occurs in the region of maximum annual mean Ekman convergence from spring to summer in the eastern North Pacific. In western North Pacific, the frontal zone is south of the maximum energy center of wind stress energy in this frequency band. An interannual variation of wind stress with three years period is found in the eastern North Pacific.

3AM1994-MEQ15

## LIMITATION OF COD AS AN INDICATOR FOR THE BETTER ASSESSMENT OF THE POLLUTANT IMPACT ON STRUCTURE OF THE MARINE ECOSYSTEM

Ichiro Yuasa and Yoshitaka Fujioka, *Ministry of International Trade and Technology, Chugoku National Industrial Research Institute, 2-2-2 Hiro-Suehiro, Kure City, Hiroshima Pre., Japan*

In the Seto Inland Sea, the largest bay in Japan, eutrophication has progressed rapidly since 1960's with the increase of nutrients and organic matter supplied from land due to industrialization and urbanization in the coastal region. By the Seto Inland Sea Conservation Law enacted in Oct. 1978, pollutant load in terms of the chemical oxygen demand (COD) has been reduced to half, resulting in the corresponding decreasing trend of COD concentration averaged per annum.

In spite of this apparent improvement of water quality, it should be noted that little data is accumulated as to the change of the ecosystems in the Seto Inland Sea. Y. Fujioka's data is the only one of this kind from the observation of the coastal fauna at the fixed points around Kure City, Hiroshima prefecture from FY1960 to FY1990 in every summer. From his data number of species at Nagahama is 20 on FY1990 compared with 85 on FY1960. Even at Kashima, located far from urban communities and industrial region, number of species has been reduced by half. The change of the marine ecosystem in the coastal sea doesn't correspond to the change of COD concentrations, suggesting that the monitoring of organic matter can't seize the impact of pollutants on structure of the marine ecosystem. Conceivable causes of such an ecosystem change are disappearance of intertidal flat and seaweed bed by reclamation. Akashiwo and oxygen-deficient water mass by cutrophication etc. It is concluded that use of an indicator for the organic matter borne in water such as COD alone is not sufficient to express the water quality but the need for systematic monitoring and analysis of biological indicator is imminent.

3AM1994-POC46

## WHAT PROCESS SETS THE DENSITY OF THE NORTH PACIFIC INTERMEDIATE WATER AT 26.7-26.8$\sigma_\theta$

Jae-Yul Yun and Lynne D. Talley, *Department of Oceanographpy, Korea Naval Academy, Chinhae, Kyungnam, 645-797, Korea*

It is known from earlier studies that the North Pacific Intermediate Water (NPIW), defined as the main salinity minimum in the subtropical North Pacific, is present at density levels of 26.7-26.8$\sigma_\theta$ and an ultimate source of the NPIW is the Oyashio winter mixed layer of densities of 26.5-26.6$\sigma_\theta$. A question then arises; what process is responsible for setting the NPIW density at those levels? An inverse method is employed to determine the responsible process, using CTD data observed in the western and central North Pacific.

The results indicate that when the cold, fresh subpolar source water, that is, the subsurface intrusion of the Oyashio winter mixed-layer water, meets with the warm, saline subtropical source water, the cabbeling occurs with a maximum at densities of around 26.60-26.65$\sigma_\theta$ and increase the density of the mixed water by about 0.1$\sigma_\theta$. We think that this higher density of the mixed water formed by the cabbeling process sinks to a density level of about 26.7-26.8$\sigma_\theta$, spreads along the density level in order to satisfy the mass conservation constraint, and fills the entire intermediate layer of the subtropical North Pacific. The percentage of sinking water mass to a total water mass in a density range of 26.4-2.0$\sigma_\theta$ is found to be0.1%. Therefore, we propose that the cabbeling process is responsible for setting the density of the NPIW at 26.7-26.8$\sigma_\theta$.

3AM1994-POC47 Poster

## DOUBLE-DIFFUSIVE MIXING IN THE SLOPE WATERS OFF THE EAST COAST OF THE KAMCHATKA PENINSULA AND THE NORTHERN KURIL ISLANDS

I.A. **Zhabin**, V.P. Tapinov and G.I. Yurasov, *Pacific Oceanological Institute, Vladivostok, Russia*

The characteristics of water properties along the east coast of the Kamchatka Peninsula and the northern Kuril Islands are considerably different from oceanic regimes. The slope waters (East-Kamchatka subtype of Subarctic structure) characterized by strongly marked dichotermal stratum with the extremely low temperatures and largest depths of the intermediate temperature maximum. Analyses of CTD data from a series of cruises indicated that within this area considerable seasonal changes in the vertical thermohaline structure occur, as it is show by the pronounced upward displacement of isolines between subsurface minimum and intermediate maximum of temperature. Within this layer vertical temperature and salinity gradients are appropriate for the double-diffusive convective instability and double-diffusive fluxes can dominate in the vertical exchange.

The long-term mean and CTD data are used to calculate density ratio R, Turner angle Tu and double-diffusive heat and salt fluxes. The most favorable background stratification conditions for double diffusion are existed off the eastern Kamchatka Peninsula and northern Kuril Islands coast. The double-diffusive processes are more effective in winter. During the spring-summer period a thickness of the layer (where this processes can be important) and double-diffusive fluxes are decreased. The step-like structure which was observed in the profiles taken in the area with near zero geostrophic currents shears may be interpreted as evidence for the occurrence of double-diffusive convection. Double-diffusion associated with intrusions can also operate in the frontal zone of the East-Kamchatka Current. Estimates of the horizontal eddy diffusivity and heat flux show that small-scale mixing processes can take part in modification of the water masses in this region.

3AM1994-POC48 Poster

## SOME FEATURES OF THE THERMOHALINE STRUCTURE IN THE GULF OF ALASKA RECIRCULATION AREA

I.A. **Zhabin** and G.I. Yurasov, *Pacific Oceanological Institute, Vladivostok, Russia*

A pronounced component of flow in Alaska Stream has a tendency veers south, closing circulation in the surface layer of the Alaska Gyre. These southern branches can penetrate through the Ridge Domain which lies between Alaska Stream and Subarctic Current (Favorite et al.,1976).

In order to examine location of the southern branches of the Alaska Stream and oceanographic structure in the recirculation area the sea surface temperature and salinity (SAIL) and CTD data collected along 50°N in the Cruise 57 R/V PRILIV (spring 1992) are used.

The major branch of the Alaska Stream which closes circulation in the west limb of the Alaska Gyre and three minor branches within of the Ridge Domain can be distinguished. As indicated geostrophic currents calculations these cold and delute surface structures are located within or near the boundary of the flows streaming southward. The main features of the thermohaline structure of these flows are similar. At the vertical profiles taken near the fronts associated with the cold and delute regions the numerous intrusive features are observed. The largest values of the fine structure Cox numbers occur in the vicinity of this fronts. The lateral fluxes and eddy diffusivities are calculated with the Joyce (1977) model. The calculated eddy diffusivities, O ($10^2$ -$10^3$ $m^2$ $c^{-1}$ ) for heat and O ($10^2$ $m^2$ $c^{-1}$ ) for salt indicate that considerable lateral mixing occurs within halocline between the Alaska Stream branches and Ridge Domain waters.

3AM1994-POC49 Poster

## INTERANNUAL VARIABILITY OF WATER DYNAMICS IN OKHOTSK SEA

I.A. Zhigalov and A.L. Figurkin, *Pacific Research Institute of Fisheries and Oceanography(TINRO), Shevchenko Alley 4, Vladivostok 690600, Russia*

In Okhotsk sea there are next basic structure elements of water dynamics: flowing of Pacific waters through straits of North Kuril Islands, West Kamchatka and compensated currents, cyclonic circulation in the middle of the sea, East-Sakhalin current and its countercurrent, anticyclonic water circulation above South Kuril deep-water tresh, the current of Northern part of Okhotsk sea.

It was established, that in summer period and in separate years intensive flow of Pacific waters through straits between islands Ketoy and Matua (1986, 1991, 1992) and also through southern part of straight Bussol (1988, 1991) and through the northern part of Friza straight (1992), has been observed. Simultaneously a considerable variability is observed in the point of northern and western limits of penetration of these waters into the Okhotsk sea. Current of Eastern Sakhalin is also distinctive element of water circulation, but sometimes it is not observed (1992); in 1993 (in South-East of Sakhalin) the moving of waters has been observed, but only to the north-south direction. From the other side, in 1989 the current of Eastern Sakhalin occupied not only shelf but the slope part of island as well. The main flow of current of Western Kamchatka in different years was at the interval from 151°E till 155°E.

The results of calculations, made by the data of hydrological observations for cold period(January-April) show that horizontal circulation of waters on the area, which is free from ice, is not constant from year to year. For example, in 1990 the current of western Kamchatka was week and it was displaced to the west till 151°E, and coastal countercurrent was well developed. In 1992 on the contrary, this countercurrent has been not observed. In 1992 and 1993 the main transfer to the north, which corresponds to the current of Western Kamchatka took place along the meridian 154°E.

3AM1994-MEQ14 Invited

## IMPACTS OF ORGANO-TIN POLLUTION ON MARICULTURED CLAM, *VENERUPIS PHILIPPINARUM*

Ming-Jiang Zhou, Tian Yan, Jun Li and Zhangyan Li, *Institute of Oceanography, Academia Sinica, People's Republic of China.*

In situ experiments were carried out in a tide zone area near Jiaozhou Bay, Zingdao, China, where the clam, *Venerupis philippinarum* was heavily maricultured. The purpose of the experiments was to investigate the potential impacts of organo-tin (triphenyl tin, TPT, in particular) pollution on the maricultured clam, *V. philippinarum* and the benthic community in the area. The results of the 120 day experiments showed that: 1) Heavy TPT pollution caused dramatic drop on the clam population both in biomass (724g $m^{-2}$ down to 273g $m^{-2}$) and in number (350ind. $m^{-2}$ down to 100 ind. $m^{-2}$), 2) No young clam ( <1cm> ) was found in heavily polluted sediments indicating that the younger was more sensitive to TPT pollution and that further reduction of the clam population may occur in the future in the area, 3) The structure of the benthic community in the clam cultured area changed significantly due to TPT pollution. Polychaetes and snails become dominant species while bivalve was affected. The diversity index and homogeneity index, however, remained high, and 4) Attention should be paid to the use of TPT in tide zone mariculture area to avoid or reduce the potential impacts of TPT on mariculture industry and marine ecosystem.

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3AM1994-POC50 Invited

## LONG-RANGE TRANSPORT OF AEROSOL AND AEROSOL BLACK CARBON FROM CHINA TO WESTERN PACIFIC

Ming-Yu Zhou, *National Research Center for Marine Environmental Forecasts, Beijing, China*

The aerosol samples were collected over Beijing city and rural station near Shanghai and on board research ships in four cruises over the East China Sea and Western Pacific Ocean to investigate long-range transport of aerosol and aerosol black carbon (BC) from China to the downwind seas and ocean. The morphology and chemical properties of aerosols were discussed during their long-range transport. The BC data were used to verify a simple one-dimensional transport model. in the marine boundary layer with prevailing westerlies of 5 m $s^{-1}$, the BC total deposition rate, including both dry and wet depositions, was computed as $1x10^{-5}$ $s^{-1}$, and the half-life was estimated to be 19 h. The residence time was approximately five days, concentrations subsequently diminishing to the background level. Longer lifetime and farther transport would be probable in the free troposphere. Because BC particles have great surface areas and very absorbent of electromagnetic waves, their concentration and distribution in the atmosphere may have profound effects on radiation budgets and climate change.

3AM1994-BIO37

## SEASONAL DYNAMICS OF ZOOPLANKTON COMPOSITION AND BIOMASS IN TWO SUBARCTIC AREAS OF THE PACIFIC OCEAN

Yury I. Zuenko, Larisa N. Bokhan and Victoria V. Nadtochy, *Pacific Research Institute of Fisheries & Oceanography (TINRO), 4, Shevchenko Alley, Vladivostok, Russia*

Succession of zooplankton in 0-100 m layer in the areas off southern Kuril Islands (North-West Pacific) and off Primorye coast (the Japan Sea) during July-October of 1980, 1988 and February-August of 1992 is investigated. The most numerous species of zooplankton in both areas (located in moderate belt northward from Subarctic front) were: Copepoda (*Calanus cristatus, Calanus plumchrus, Eucalanus bungii, Metridia pacifica*), Euphausiacea (*Euphausia pacifica, Thysanoessa longipes*), Amphipoda (*Parathemisto pacifica, Parathemisto japonica*), Chaetognatha (*Parasagitta elegans*). Changes of their biomass in dependence on sea surface temperature (SST) were traced.

There was found that after spring bloom of phytoplankton in April-May (to July in the coolest water of Kuril Straits) every group and species of zooplankton had their "blooms" when SST had reached a certain value. It looked as "windows" of SST which were the most preferable for each species growth: 7-9°C and 13-15°C for C. *plumchrus*, 4-6°C for C.*cristatus* (this species was numerous in the Japan Sea only), 8-9°C for *E. bungii*, 9-10°C for M. *pacifica* (in the Japan Sea), 6-7°C and 11-12°C for *E. pacifica* (in the Pacific), 5-7°C and 16-18°C for *T. longipes* (in the Japan Sea), 8-9°C for Amphipoda, 7-8°C and 11-12°C for Chaetognatha. So far as these SST were reached in different times in each zone of specific hydrological regime, the composition of plankton had spatial variation in every certain moment. The "blooms" of zooplankton species moved from the warm water zones to cold water ones like "waves".