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5AM1996-MEQ01 ^o oral
PROSPECT OIL AND GAS OF A LAND AND SHELF PRIMORSKI TERRITORY AND
ECOLOGICAL AFTER EFFECTS EXPLOITATION HYDROCARBONS FOR THE PACIFIC
BASIN

V.A. Abramov and V.A. Abramova, *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, Russia. 690600*

Oil content in the Tumangan river basin and adjacent areas are estimated by extending of prognosis from the Russia territory to the adjacent regions of China and North Korea according to the dates of "tectonospherical geophysics" and the complex criteria of prognosis. The criteria are developed according to the "tectofunnel" (TF) and "focal structures" (FS) or "the central type structures", "the magmatogene columns", "the tectonospherical cones", "the diwa structures".

According to the geological, geophysical and gas-geochemistical data from the Tumangan river mouth up to the Taiganos Peninsula of the Magadan District, the shelf of Sea of Japan (East Sea) and Sea of Okhotsk are promising in view of hydrocarbon deposits.

According to the geophysical and tectonic ("the tectonospherical sinersis") properties of the Khanka FS, the gas and oil deposits are expectant in the Tumangan, Khasan-Tumangan, Lotos, Kraskino, Poima, Nadjin, Onson, Khanchun and Jantazin low-order TF.

Ribbon-shaped Khasan-Tavranchankaya zone forms the southern offset of the Artern-Bikin structural suture. According to the gravimetric and seismic data, the zone attracts the special attention, for it may be compared with the marginal suture as well.

Here, at the depth range of 2.5-5 km (to 10 km)

5AM1996-POC01 ^o oral
THE INTENSITY OF ORGANIC MATTER TRANSFORMATION IN THE SHELF AND
PELAGIC WATERS OF THE BERING AND OKHOTSK SEAS

Alina I. Agatova, N.M. Lapina, *Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), 17v.Krasnoselskaya, Moscow, Russia. 107140*

The rates of organic matter (OM) variability are estimated on the activity of enzymes of different classes of mezo- and microplankton.

The investigations were conducted in the Okhotsk Sea, in the Pacific waters of the Kuril Islands region, and in the western Bering Sea in summer, 1992-1994. OM transformation rates were estimated on the activity of oxidation-reduction enzymes of the electron transport system (ETS) and alkaline phosphatase enzymes.

Studies of the dependence of the rates of the reactions catalyzed by these enzymes on temperature (in the range of 1 - 10°C) showed regular deviations from the Want-Goff rule ($Q_{10} = 2$). The values of energy activation were low ($E_a = 3 - 6$ Kcal/M), which drove active metabolism of hydrobionts in cold waters.

The ETS enzymes activity was maximal in the shelf waters and in the boundary zones of mixing waters. The total activity of ETS in the photic layer of the Okhotsk Sea waters off the Kurils was generally 2-3 times higher, than that in the Pacific waters off the Kurils. In the boundary waters of the Bering Sea and the Pacific the maximal vertical gradient of oxygen was observed along with a high oxygen consumption by microheterotrophs, and the ETS total activity increased 2 - 16 times here. The waters were characterized by a decrease in the concentrations of particulate carbohydrates and proteins.

Areas of the intensive primary production were characterized by the high activity of alkaline phosphatase and negative correlation of the latter with the concentrations of the inorganic phosphorus.

It was shown, that at the low concentrations of inorganic phosphorus, especially on the shelf, up to 80% of primary production could be promoted by the phosphate recycling.

So the shelf rates of production and destruction processes determine the variability of OM concentrations and biochemical composition, more than the deviations in the hydrological regime of the area.

5AM1996-POC02 oral
SHELF-BREAK CANYONS: FLOW PATTERNS AND DEEP WATER ADVECTION DURING AN UPWELLING EPISODE
Susan E. Allen, *Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, BC, Canada. V6T 1Z4*

Shelf break submarine canyons are ubiquitous features of the shelf break. They have been observed to be regions of enhanced upwelling compared to the surrounding shelf break and to be regions of biological (phytoplankton, zooplankton, fish and whale) aggregation.

Recently, advances have been made in determining the flow regime and its dynamics in and around submarine canyons during an upwelling favourable wind episode (of about 3 days duration). Observational and modelling studies have shown the flow to be strongly nonlinear and to have small spatial scales in both the horizontal and the vertical. Even fairly deep within a canyon the flow is often in opposite directions on the two sides of the canyon.

These recent results will be combined to give a descriptive picture of the flow regime for a simple canyon. Some of the dynamics determining the strength and timing of various flow characteristics will be discussed. Particular emphasis will be put on the advection of deep water across the rim of the canyon and onto the shelf.

5AM1996-SB01 invited
CLIMATE INDICATORS AND SALMON SURVIVAL
James J. Anderson, *School of Fisheries and Center for Quantitative Science, University of Washington, Seattle, WA USA*

Evidence suggests that salmon year-class strength is affected by decadal scale climatic/ocean fluctuations. The interactions are complex and most hypotheses to explain observed patterns consider the food web and currents in the North Pacific. Although ocean effects are important, freshwater and estuarine survivals are also major determinants of salmon year-class strength, and for these life history stages the influence of climate is, as yet, not well understood. Some progress is being made though in Columbia River salmon research. Various studies are taking an ecosystem approach, focusing on the interactions of salmon with their predators, forage base and environmental variables, including climate.

I describe four analyses conducted by our Columbia River Salmon Passage (CRiSP) group that suggest climate variations over scales from weeks to decades have affected year-class strength. One study showed that the spring chinook catch pattern follows a decadal scale terrestrial climate index. A second study revealed that strong fall chinook year-classes in the mid 80s correlated with anomalous coastal temperatures in the winter following smolt migration. A third study suggested that spring chinook estuary survival was correlated with the timing of estuary entry relative to the spring transition. A fourth study indicated that the timing of fall chinook smolt migration was correlated

with the cumulative temperature pattern. The significance of these studies and the opportunities for future studies and their management implications are discussed.

5AM1996-FIS01 poster
FOOD CONSUMPTION OF CAPTIVE NORTHERN FUR SEAL (*CALLORHINUS URSINUS*)

Norihisa Baba¹ and Hiroshi Aiuchi²

¹ National Research Institute of Far Seas Fisheries, 7-1, 5-chome, Orido, Shimizu, Shizuoka, Japan. 424

² Muroran Aquarium, Shukutsu 3-3-12, Muroran, Japan. 051

To examine the food consumption two fur seals, male (11 years old estimated) and female (four years old) were reared in an outdoor sea water pool (4.5mx4.5mx2.7m deep). The fur seals were fed once a day on sand lances (*Ammodytes personatus*). The water temperature varied between about -1.8 and +24.3°, while air temperature varied between -4.3° and +28.5°. Amount of food consumed was recorded everyday and body weight was by 10 days. The male seal consumed 3 kg (5370 Kcal) to 10 kg (17900 Kcal) of food per day and its weight increased 70kg in the year. The monthly feeding rate varied greatly during the breeding season (May-August). Annual average of feeding rate was 4% (range; 1-6%, SD; 2%). The female seal consumed approximately 3 kg (5370 Kcal) of food per day and its weight increased 2kg in the year. Food consumption of the female showed no specific monthly pattern, but body weight was high in December-January. Annual average of feeding rate was 13% (range; 9-16%, SD; 2%). It is considered that fluctuations of body weight of the male during summer are related to annual breeding cycle and increase of body weight of female in winter is provided for cold temperature.

5AM1996-SB02 invited
RECONSTRUCTING LONG-TERM HISTORIES OF SMALL PELAGIC FISHES OF THE CALIFORNIA CURRENT

Tim Baumgartner, CICESE, Ensenada, Baja California, Mexico, and Scripps Institution of Oceanography, La Jolla, California, USA

One of the principal obstacles to understanding the nature and causes of the dramatic changes in population sizes and distributions of small pelagic fishes in the California Current, and other large marine ecosystems, is the difficulty of adequately sampling the vast scales in both space and time over which these changes occur. Expansion and contraction of these populations occur over time scales of several decades or more and over spatial scales which encompass the entire California Current System. Retrospective research, using the natural archives in well-preserved sediment records along the continental margin, allows us to address this large-scale variability over a hierarchy of time scales ranging from decadal through centennial and millennial periods.

However, depositional sites which provide such detailed histories of ocean populations are rare, mainly because a number of conditions must be met—the principal one being bottom waters depleted in oxygen. There are three such sites known to exist along the mid-Pacific coast of North America. Fortunately these are located in the middle and near the northern and southern extremes of the California Current. The northern site—on the west coast of Vancouver Island (Effingham Inlet)—was just discovered in December, 1995, through a joint effort of Scripps Institution, I.O.S., Univ. of British Columbia, Univ. of Washington and CICESE. The middle and southern sites are the Santa Barbara Basin off southern California and the Soledad Basin off southern Baja California, Mexico. Work is now underway to use these three sites as geographic reference points for tracking the expansion and contraction of the sardine and anchovy populations through the past 1500 to 2000 years.

This talk will provide an overview of the approaches and methods used to reconstruct detailed histories of the small pelagics from these sites and to investigate the nature and causes of the variability over decadal to centennial time scales. This includes development of site chronologies, time series of

abundances of sardines and anchovies, environmental information indicating changes in ocean climate, and calibration of the paleo data with modern populations and climatic conditions. Finally I will report on the approach being developed to combine information from the three sites mentioned above to integrate the spatial variability with the temporal variability over the California Current.

5AM1996-MEQ02

oral

ORGANOCHLORINES IN MUSSELS FROM PETER THE GREAT BAY

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

Accumulation of trace metals in mussels from Peter the Great Bay, the Sea of Japan, have been investigated by different researchers (e.g., Khristoforova et al., 1993; Saenko et al., 1988). Unfortunately, no data on chlorinated hydrocarbons in mussels were available. To fill this gap, reconnaissance study was conducted by FERHRI specialists in August 1995. Mussels were taken in pristine and relatively impacted areas. Chlorinated hydrocarbons (DDT, its metabolites and isomers of hexachlorocyclohexane, HCH) were analyzed by gas chromatography with electron capture detector.

Content of total DDTs ranged from 5.9 to 16.2 ng/g (dry weight), sum of HCH isomers - from 4.6 to 7.5 ng/g. These values are comparable with organochlorine concentrations in the IAEA-142 intercomparison sample (mussels from Ireland): total DDTs about 16.8 ng/g and total HCHs about 1.3 ng/g, dry weight. Similar concentrations of DDTs (from "not detected" to 7.1 ng/g, dry weight) were observed in mussels around Japan (Morita, 1989). In the US coastal areas content of total DDTs is significantly higher: geometric means for 1986-1990 varied from 35 to 47 ng/g, dry weight (O'Connor, 1992).

In 1996-1998 analysis of organochlorines and trace metals in mussels from Peter the Great Bay will be continued in cooperation with the researchers from Republic of Korea, Japan and probably from other Pacific countries.

5AM1996-BIO01

oral

THE IMPORTANCE OF PELAGIC FISHES IN THE MARINE ECOSYSTEMS AND FISHERY IN NORTH WEST PACIFIC

V.A. Belayev, *Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia.*
690600

North West Pacific is one of the most productive zone in the World Ocean. Mass pelagic fishes (saury, mackerel, sardine, anchovy) are base of high fish productivity. Naturally its play very important role in the marine ecosystems of the North West Pacific (NWP).

Far-East sardine is the last example of role of pelagic fishes in marine ecosystems because it was the dominant species (abundance and biomass) in the 1970-1980s in the NWP. Area distribution became very large and length of migrations extended many times if compared with the previous period.

We must say that role of sardine considerably vary in time and in space.

Sardine was stable element of some ecosystems - East China Sea, Kuroshio Current, south part of Japan / East Sea - before growth of abundance. It was usual elements of these ecosystems, but it was not dominant species. Growth of abundance of sardine began in the early 1970s. Abundance and biomass reached peak in the middle 1980s. Calculated biomass of it in the area distribution was 50-65 million tons. Large extend of migrations show large moving of energy in time and in space.

North, northwest migrations (feeding) and South, South-West ward migrations (winter-spawning) take place relatively quickly. Consequently biomass of pelagic fishes of subtropic complex

flow to the cold biotope (in the period of high abundance). In this chance sardine, mackerel, saury, anchovy take large part of space in the ecosystems of Northern part of Japan /East Sea, south part of Okhotsk Sea and Pacific side of Kuril Islands. We saw this process very clear during period of high abundance of Far East sardine. Biomass of this species was so high that Russia (USSR) caught sardine in these regions very effectively. Catch in the cold Okhotsk Sea reached in 1989 241.300 ton. We can say that in this period biomass of sardine in Okhotsk Sea (south part) was look like with biomass of another mass fish - walleye pollock. Sardine plays very great role in the ecosystem of Okhotsk Sea during 4-5 months from 1980 to 1990 but its biomass was lower than biomass of walleye pollock. At the same time biomass of sardine in Japan / East Sea was 50-60% from total biomass of all pelagic species during year. Same situation was in the ecosystem of Kuroshio current. Sardine played more less role in the feeding period in the ecosystem of East China Sea and south east part of Japan because it left south regions in spring-summer seasons.

Therefore we can see re-distribution large biomasses of pelagic fishes during one year from South ecosystems to North ecosystems and annual variations of importance of different species in the different ichthyocenoses.

Really role of sardine in subtropic pelagic complex was the same as role of walleye pollock in subarctic complex in the NWP. Naturally these processes influence to annual changes of fishery grounds, fishery of different countries, catch of different countries and structure of fishery.

On example sardine was caught only by Japan and Republic of Korea during period of low abundance. But during period of high abundance Russia (USSR) and Democratic Peoples Republic of Korea began catch it very much. All these processes lead to the development of purse seiner industry, creation of new technologies and re-distribution of fishery press from another species to sardine.

5AM1996-POC03

oral

THE THERMAL CURTAIN HYPOTHESIS: (1) PHYSICAL BASIS FOR STATIONARY MIXING STRUCTURES IN THE NORTH PACIFIC OCEAN

Edward B. Bennett and Eddy C. Carmack, *Applied Ocean Sciences*, 804 Lakes Boulevard, Parksville, BC, Canada. V9P 2P8

Many of the thermohaline structures which are characteristic stationary features of the world's oceans have been linked to the densification that always accompanies mixing of different seawaters (Bennett, 1996). The temperature-salinity relationships observed in late winter at and near the Subarctic Front in the North Pacific Ocean demonstrate this link, and are included in the family of lines in a T/S correlation diagram whereon densification is maximized, and thus where mixing drives the ocean towards a state of minimum potential energy. Such lines, called *moisteres*, are argued to represent preferred thermohaline pathways for turbulent exchange of heat, salt and freshwater. In a T/S correlation diagram *moisteres* are seen to be concave upwards; since isopycnals are concave downwards, it follows that there is one temperature, the cabbeling temperature, at which the density of a *moistere* is a maximum. At surface pressure and over salinity ranges found in the world's ocean, the cabbeling temperature is near 10°C. Lateral mixing between warm salty subtropical waters and cool fresh subarctic waters is constrained to be *moisteric*, producing maximum density waters at and near the cabbeling temperature, resulting in convection and surface convergence, and thus forming the Subarctic Front. This subpolar thermohaline front marks the equatorward boundary of the so-called *thermal curtain*, a stationary structure of water mass subduction separating subtropical and subarctic water masses. Surface temperature and salinity data collected during the Canada/Russia/U.S. International North Pacific Climate (INPOC) study are presented to support the thermal curtain hypothesis.

5AM1996-POC04 oral
INTERANNUAL FLUCTUATIONS OF THE SEA SURFACE TEMPERATURE (SST) IN
THE NORTHWEST PACIFIC
I.S. Berman, VNIRO, 17a V.Krasnoselskaya, Moscow, Russia. 107140

We analyzed the interannual SST fluctuations in the North-Kuril region in 1992-1995 and Southeast Kamchatka region in 1993-1995 in seasonal aspect, and there was revealed a number of regular features.

In 1988 deceleration the Earth's revolution began, and it continues now (Klyashtorin and Sidorenkov, 1993). The index of irregularity in the daily Earth's revolution is measured with the much greater precision than hydrometeorological elements (in particular the SST). This index allow us to do the operative monitoring of the global climatic fluctuations.

The deceleration of the Earth's revolution caused in its turn the deceleration in the rate of rise in the global SST.

The reverse situation was observed however in the above mentioned regions of the Northwest Pacific in 1992-1995/

The SST in the north part of the North-Kuril region in the spring (May) was lower (in 1993) at first, then rose (by 1°C) in 1995. The SST in central and south parts of the same region rose (from 1992 to 1995) by 1,7°C on the average in the centre, and by 0,5°C in the south almost everywhere and continuously.

In the summer (July-August) the SST in the Southeast Kamchatka region went up (from 1993 to 1995) by 4-5°C everywhere and continuously. In the north and central parts of the North-Kuril region the SST increased in 1993 (by 3-4°C), then dropped in 1994 (by 2-3°C), and again rose in 1995 (by 5-6°C). In the south part of this region the SST rose (from 1992 to 1995) by 1-2°C almost everywhere.

The SST in the Southeast Kamchatka region in the autumn (September-October) was lower by 1-1, 5°C (from October 1993 to September 1994) everywhere. In the north and central parts of the North-Kuril region SST rose (from October 1992 to September 1994) by 1-2°C almost everywhere. But there was observed a considerable lowering of SST in this region (by 2-4°C) in September 1994 against October 1993. The SST in the south part of this region rose at first (in October 1993) by 1,5-2°C, and then went down (in September 1994) by 1-3, 5°C everywhere.

In winter (November 1992, December 1995) the SST naturally decreased at all the North-Kuril region by 1-2, 5°C.

The analysis of the interannual fluctuations of the SST in the above mentioned regions showed that 1994 was the "coldest" year (from 1992 to 1995); possibly it was abnormally cold, while 1995 was the "warmest" in the same period (possibly abnormally warm). The lowering of the SST was observed in the Southeast Kamchatka region, north and south parts of the North-Kuril region in the same seasons as a result of the intensification of the cyclonic vertexes in these places (in particular over the seamount in the south part of this region).

The trend of the interannual fluctuations of SST makes it possible to forecast the fluctuations of the quantity of fishing species in the above mentioned regions of the Northwest Pacific.

5AM1996-FIS02

poster

FOR QUESTION ABOUT SALMONS HOMING

Inga V. Biryukova, Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600

The peripheric part of olfactory analyzer development was investigating in the two species of salmon (*Oncorhynchus masu* and *Oncorhynchus keta*) by electron scanning microscopic method. Likeness of the olfactory organs general plan and development date were demonstrates. Specific distinctions in quantitative parameters of olfactory rosetta, the folds' number, length and width, the olfactory epithelium common area, the ecological coefficients, the receptor cells and secretory cell's density were show. *Masu* was characterizing highest value's parameters of olfactory organ. It is obviously connecting with more high level her olfactory system sensibility.

5AM1996-BIO02

oral

SEASONAL AND INTERANNUAL VARIABILITY OF STOCK STRUCTURE AND DISTRIBUTION OF GONATID SQUID *BERYTEUTHIS MAGISTER* (GONATIDAE) IN THE WESTERN BERING SEA DURING 1993-1996 IN RELATION TO THE OCEANOGRAPHIC CONDITIONS

Vyacheslav A. Bizikov and Andrew V. Verkhunov, Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), 17V. Krasnoselskaya Street, Vladivostok, Russia. 107140

The biology and environment of gonatid squid *Beryteuthis magister* had been studied from spring to fall 1993-1996, by means of simultaneous synoptic-scale bottom trawl and CTD surveys on the western Bering Sea continental slope. Two seasonal groups of *B. magister* were found in the region: spring-summer-hatched and autumn-winter-hatched ones. Each group has been growing, maturing and spawning on the Olyutorsky-Navarin slope for about 8 months. They come from the south-east with the Bering Sea Slope current (BSC), but it is not plausible that their hatchlings complete the circle around the whole Sea during juvenile stage (that is about 5 months). Apparently, the successive generations use different spawning grounds around the Bering Sea Basin. Thus, the number and size of squid stock in the north-western Bering Sea directly depends on the recruitment, entering the region from the south - east six months earlier.

The distribution pattern of both adult and juvenile species shows a close relation to regional oceanography, and follows both its annual and interannual variability. Adolescents just passively follow the pattern of the BSC, and used to accumulate in the anticyclonic eddies, while adults actively steer themselves to locations of potential spawning grounds. The oceanographic indices of these locations were obtained.

The study brought up a number of important questions. Whether in the eastern Bering Sea the stock structure of *B. magister* is similar? Where are the other major spawning grounds of *B. magister* in the Bering Sea? Does *B. magister* perform migrations in the deep sea?

The study shows the commercial fishery potential of the *B. magister* in the Bering Sea, but its complete life history can be understood only when covering both the western and eastern parts of the Sea.

5AM1996-SB03

poster

RETROSPECTIVE ANALYSIS OF ENVIRONMENT FACTORS AND INTEGRAL ASSESSMENT OF ENVIRONMENT FACTORS IN ECOSYSTEMS

Lev N. Bocharov, *Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

Practically each biosystem may be subdivided into two subsystems: biological object and environment. The second subsystem consists of both physico-chemical and biological factors. Thus, the description of biosystem state is divided into two problems at a certain period of time: the description of environment conditions and the description of object state.

Environment conditions are usually described by the vector parameters indicating to their different qualities. In fact such description is not simple. One of the main problems of ecological research is to distinguish the principal and important factors of environment. These factors have an influence on the organism availability and its conditions favourability (group of organisms, species, community) in the habitat in order to include them at the describing environment conditions. This problem is usually decided as reduction of the vector space descriptions which geometrically may be interpreted as the choice of the certain subspace in the initial space descriptions. The problem is often solved by the computation of different factors information capacity in the description of environment conditions. Beside the estimation methods of information capacity used in medicine and biology and based on the correlation coefficients. The theory of pattern recognition in ecological research needs various statistical measures as divergence.

Method put forward by author based on the calculation of information quantity is more common method of estimation of the ecological factors significance. In the analysis of biosystems are used both the vector models and models with the high aggregated parameters. So, it is necessary to change the vector description of environment conditions by scalar description. For this purpose we have suggested the characteristics which reflect ecological □favourability□ of the environment.

5AM1996-FIS03

oral

STUDYING THE EFFECT OF OCEAN CURRENTS ON RETURNING SALMONS: RESULTS FROM A FINE RESOLUTION COASTAL MODEL

Marie-Claude Bourque and Paul H. LeBlond

Department of Earth and Ocean Sciences, University of British Columbia, 6270 University Blvd., Vancouver, B.C., Canada. V6T 1Z4

Controversies still arise in explaining the mechanisms involved in salmon migration. The influence of the physical environment on Sockeye salmon return timing is still poorly known. Numerical modelling is a useful tool to study such problems where data are sparse. We therefore combine a fine resolution (5 km, 1 hr) circulation model of the Northern Coast of British Columbia with an individually-based model of salmon migration. The circulation model is three-dimensional and based on the non-linear primitive equations governing ocean dynamics. The individually-based model of salmon migration allow each salmon to be subjected to the surrounding ocean currents and to have its own behaviour such as orientation and swimming speed. Preliminary experiments done using tidal currents alone show a good correlation between the number of returning salmon and tidal currents. This indicates that tidal currents influence grouping of returning salmon, which in turn can affect sampling strategies.

5AM1996-FIS04

oral

DISTRIBUTION OF JUVENILE POLLOCK RELATIVE TO FRONTAL STRUCTURE NEAR THE PRIBILOF ISLANDS, BERING SEA

Richard D. Brodeur¹, Matthew T. Wilson¹, Phyllis J. Stabeno², Jeffrey M. Napp¹ and James D. Schumacher²

¹ Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, WA 98115-0070, U.S.A.

² Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, WA 98115-0070, U.S.A.

A tidal front exists around the Pribilof Islands in the eastern Bering Sea which separates weakly stratified nearshore water from the strongly stratified middle shelf water farther offshore. Enhanced mixing and vertical flux of nutrients at the structural front results in high abundance of phytoplankton, zooplankton and micronekton. Using physical, acoustic and trawl observations from September 1994 and 1995, we examine the abundance, distribution patterns and size composition of age-0 walleye pollock in relation to this front.

The frontal region occurred 12-20 km offshore during both years, but the width of the front during 1995 was about twice that in 1994. The thermocline was also much shallower in 1995. The isothermal (<8°C) inner domain had low chlorophyll and both small and large zooplankton concentrations. The highest chlorophyll and small zooplankton concentrations occurred seaward of the front and they decreased thereafter with increasing distance from shore. Large zooplankton (mainly euphausiids) were most abundant in the stratified offshore waters below the thermocline which occurred around 40 m. Age-0 walleye pollock dominated the midwater fish catches during both years (>84% by weight, >99% by number) although large medusae dominated the biomass of the overall catch. Age-0 pollock densities averaged about three times higher in 1994 than in 1995. The size distributions of age-0 pollock were similar in both years, averaging 51.2 and 54.6 mm in 1994 and 1995, respectively. Pollock densities decreased, but mean size increased with increasing distance from shore. Underwater observations using a Remotely Operated Vehicle revealed that age-0 pollock were closely associated with large scyphomedusae near the thermocline during the daytime and moved toward the surface apparently to feed at night.

5AM1996-SB04

invited

INTERANNUAL VARIATIONS IN ZOOPLANKTON BIOMASS IN THE GULF OF ALASKA AND COVARIATION WITH CALIFORNIA CURRENT ZOOPLANKTON BIOMASS

Richard D. Brodeur¹, Bruce W. Frost², Steven R. Hare³, Robert C. Francis⁴ and W. James Ingraham, Jr.¹

¹ Alaska Fisheries Science Center, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115

² School of Oceanography, Box 357940, University of Washington, Seattle WA 98195

³ International Pacific Halibut Commission, P.O. Box 95009, Seattle, WA 98145

⁴ School of Fisheries, University of Washington, Seattle, WA 98195

Large-scale atmospheric and oceanographic conditions affect the productivity of oceanic ecosystems both locally and at some distance from the forcing mechanism. Recent studies have suggested that both the Subarctic Domain of the North Pacific Ocean and the California Current have undergone dramatic changes in zooplankton biomass that appear to be inversely related to each other. Using time series and correlation analyses, we characterized the historical nature of zooplankton biomass at Ocean Station P (50°N, 145°W) and from offshore stations in the CalCOFI region. We found a statistically significant but weak negative relationship between the domains. We investigated whether such a relationship arises from different forcing mechanisms or as an opposite response to the same mechanism. We found that the seasonal peak of both data sets occurred in the summer but that the CalCOFI data lagged the Ocean Station P data. An ocean surface drift simulation model showed that winter trajectories started at Ocean Station P and along 145°W drifted preferentially into the California Current and the Alaska Current before and after the 1976-77 regime shift, respectively. We

examined physical and biological conditions which may lead to this inverse relationship between these two ecosystems and discuss implications of these results for higher trophic levels.

5AM1996-FIS05 oral
THE THERMAL CURTAIN HYPOTHESIS: (2) IMPLICATIONS TO SALMON DISTRIBUTIONS IN THE NORTH PACIFIC
Eddy C. Carmack and Edward B. Bennett, *Institute of Ocean Sciences, P.O. Box 6000, Sidney, BC, Canada. V8L 4B2*

Welch (1996) has recently analyzed all available historical salmon catch data from the open North Pacific and concluded that (1) salmon exhibit strong species-specific responses to temperature; (2) the southern edge of the salmon distribution is a step function; (3) north of the southern boundary salmon abundance is largely insensitive to temperature in most seasons; and (4) the thermal boundaries appear to have been stable for at least 40 years. We here advance the so-called *thermal curtain hypothesis* which hold that his behaviour can be explained by bimodal convection patterns which act to subduct freshwater mixtures from the open ocean. The zone of bimodal convection is marked by a surface density maxima. The summer (warm, 10 to 11°C) thermal limit is related to stationary convection and subduction near the cabbeling temperature of sea water (Bennett, 1996) while the winter (cold, 6 to 7°C) thermal limit is related to wintertime mixed-layer deepening north of the Subarctic frontal zone. Removal of freshwater mixtures from the upper ocean in this region is thought remove environmental cues required by salmon for migration. Physical (CTD) data obtained along meridional sections during the Canada/Russia/U.S. International North Pacific Climate (INPOC) study in 1992 and 1993 are presented to illustrate structure of the thermal curtain.

5AM1996-FIS06 invited
BET-HEDGING AND THE STORAGE EFFECT IN NATURAL AND EXPLOITED POPULATIONS
Peter Chesson, and Sonya Dewi. *Research School of Biological Sciences, Australian National University, Canberra ACT 0200, Australia*

Bet-hedging life-history strategies theoretically evolve in response to a variable physical or biological environment and tend to minimize the effects of deleterious conditions for population growth while still permitting advantage from favorable conditions. For example, high survival of iteroparous adults minimizes the impact of recruitment failure while allowing high recruitment rates at other times, replenishing adult stocks. Bet-hedging can also take the form of dispersal of juveniles in a spatially heterogeneous environment or polyphenism where the offspring of an individual have different phenotypes adapted to different environmental conditions. These various forms of bet-hedging may all be found in the same population, with selection favoring one form over others depending on the circumstances.

Bet-hedging strategies can have consequences at the community level when the various species compete for limiting resources or are affected by density-dependent predators, potentially including commercial fishermen. Such competition or predation may tend to reduce species diversity. However, if the species differ in their responses to varying environmental conditions, bet-hedging life histories may lead to the storage effect where species coexistence is promoted because a species at low density can take advantage of favorable conditions for population growth while not suffering too greatly from unfavorable conditions.

Altered mortality schedules due to fishing must reduce bet-hedging that relies on adult survival, may increase vulnerability of a population to extinction and may destabilize species interactions by harming the storage effect. In the longer term, natural selection may lead to prominence of other forms of bet-hedging and other forms of the storage effect but cannot be expected to reverse the likely damage to a community from the shorter term.

5AM1996-BIO03 poster
ENVIRONMENTAL VARIABLES INFLUENCING THE DISTRIBUTION AND ABUNDANCE OF JUVENILE FLATFISHES IN SITKINAK STRAIT, KODIAK, ALASKA
Liz Chilton and Brenda L. Norcross
Institute of Marine Science, University of Alaska, Fairbanks, AK USA 99775-1080

Research focusing on environmental variables and their relationship with juvenile flatfishes in the Sitkinak Strait area of Kodiak Alaska were studied in August of 1995. Abiotic factors such as geological and physical oceanographic variables in a nursery area may affect the distribution and abundance of juvenile flatfishes. One objective of this study is to test the separate and combined affects of sediment type, bottom topography and current velocity on the distribution and abundance of juvenile flatfishes. The east and west side of Sitkinak Strait are oceanographically different with respect to sediment type, bottom topography and exposure to open-ocean currents. A total of 46 individual stations were sampled; five sites on the east side of Sitkinak Strait at depths of 20, 60, and 80 meters and three sites on the west side of Sitkinak Strait at similar depths. The four most abundant juvenile flatfishes caught were rock sole (*Pleuronectes bilineatus*), arrowtooth flounder (*Atheresthes stomias*), Pacific halibut (*Hippoglossus stenolepis*), and flathead sole (*Pleuronectes classodon*). Samples of juvenile flatfishes were collected from sites of similar sediment type and depth for comparison of CPUE of juvenile flatfishes with respect to sediment type, bottom topography and current velocity. Correlations between CPUE data for the juvenile flatfishes sampled from these stations and the sediment type and bottom current velocities at each station will be presented.

5AM1996-SB05 invited
DECADAL SCALE HISTORICAL CHANGES IN PACIFIC HALIBUT AVERAGE WEIGHT-AT-AGE
William G. Clark and Steven R. Hare, *International Pacific Halibut Commission, 250 Oceanography Teaching Building, University of Washington, P.O. Box 95009, Seattle, WA 98145-2009, USA*

Fish of the most common age groups in Alaska now weigh less than half what they did twenty years ago. In British Columbia the decline in average weight at age has been smaller--about 25%--and fish there are now about the same size as fish of the same age in Alaska. Historical data show that halibut size at age is now about what it was in the 1920s and 1930s, before an abrupt increase in growth rates. On the whole, the data suggest two distinct growth regimes for halibut in Alaska. The underlying physical or biological mechanisms at work are not known with certainty, but are probably part of a recently detected alteration in the general circulation of the North Pacific during the late 1970s and 1980s.

5AM1996-FIS07 oral
MARINE GROWTH OF FRASER RIVER SOCKEYE SALMON: THE ROLE OF HABITAT AND ABUNDANCE
Sean C. Cox and S.G. Hinch, *Institute for Resources and Environment, Westwater Research, University of British Columbia, 1933 West Mall Annex, Vancouver, BC, Canada. V6T 1Z2*

Recent studies on the ocean ecology of Pacific salmon (*Oncorhynchus* spp.) have shown that the southern limit to the distribution of sockeye (*O. nerka*) is limited by seasonal and interannual shifting of thermal boundaries. These changes may result in increased sockeye salmon density, especially during years of warm sea surface temperature (northward shifting isotherms) and high sockeye abundance. We assessed the role of this thermal habitat by constructing a time series of abundance of sockeye salmon in the Gulf of Alaska (GOA) from 1952-1992, inclusive. This was done by applying virtual population analysis to catch and escapement data from the major Bristol Bay and Fraser River sockeye stocks. The abundance time series was combined with estimates of mean annual thermal habitat available in the Northeast Pacific Ocean from 1961 to 1992, inclusive. Resulting sockeye density estimates ranged from 4 to 85 sockeye/km² for maturing age 1.2 fish and 36 to 206

sockeye/km² for all ages combined. Final body length of Fraser River sockeye was negatively related to the density of maturing age 1.2 sockeye in the GOA. Regression coefficients were significant in ten stocks for females and eight stocks for males. Sockeye density explained 22-54% of the variability in body length of Fraser River sockeye. We attempt to identify critical seasons where thermal habitat may be important.

5AM1996-POC05 oral
SIMULATION OF BAROTROPIC AND BAROCLINIC TIDES OFF NORTHERN BRITISH COLUMBIA

Patrick F. Cummins and L.Y. Oey, *Institute of Ocean Sciences, P.O. Box 6000, Sidney, BC, Canada. V8L 4B2*

The tidal response of northern British Columbia coastal waters is studied through simulations with a three-dimensional, prognostic, primitive equation model. The model is forced at the boundaries with the principal semi-diurnal and diurnal constituents. Experiments with stratified and homogeneous fluid are compared. The barotropic response shows good agreement with previously published studies of tides in the region. A comparison with tide gauge measurements indicates that average relative rms differences between observations and the model elevation field are less than 5% for the largest constituents.

An internal tide is generated in cases where the model is initialized with a vertical stratification. Diagnostic calculations of the baroclinic energy flux are used to identify regions of generation and propagation of internal tidal energy. With a representative summer stratification, the integrated offshore flux is about 0.5 gigawatts, higher than previously estimated from theoretical models. Comparisons between observed and modelled M2 current ellipses are discussed for several moorings and demonstrate the significant influence of the internal tide.

5AM1996-POC06 oral
STRUCTURE OF SURFACE WATER TEMPERATURE IN THE NW JAPAN/EAST SEA

Mikhail A. Danchenkov¹, A.A. Nikitin² and I.A. Goncharenko¹

¹ *Far Eastern Regional Hydrometeorological Research Institute, 24 Dzerzhinsky Street, Vladivostok, Russia. 690600*

² *Pacific Research & Fisheries Institute (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

One natural region of the Japan Sea- the Korean Bay- to the end of 20 century has remained the least investigated one.

In this work by data of satellites and vessels (1979-1995) the features of water temperature distribution are determined.

At the sea surface the thermal fronts were picked out on example of summer period of 1993. Main from them - Subarctic (Polar) front - was traced along 40 N to the east from 136 E. To the west from 136 E this front was divided on 2 frontal lines. North-western line was identified by 20-21 C isotherms, south-western one - 22-23 C. To the west from 131 E south-western line was subdivided also on two, one of which is pulled to the coast of Korea (39.5 N) and another one is along the coast of southern Korea. First line is identified by isotherms 21-22 C, and second one - 22.5 C - 23.5 C. In a southern part of the Sea along 36 N is located southern front with water temperature of 23-24 C.

Except them there are 3 coastal fronts. One of them is located along the coast of northern Korea between 41 N and 42.5 N, another one - along the coast of the Primorye between 132 E and 136 E, and third one- along the coast of Sakhalin up to 50 N. During autumn the Primorye front spreads along coast from 42 N to 52 N and in the beginning of a winter goes down to 40 N, strengthening the temperature gradients.

Between lines of Subarctic front interfrontal zones where the mixing of different waters is are located.

Coastal North-Korean front traced from March to June limits a zone of a cold water along the coast of northern Korea that separated from cold water along the Primorye coast.

In western part of the Sea 2 stationary eddies with a centers in points: 37.0 N, 130.5 E and 38.5 N, 129.5 E were allocated. Except it just at the south of the Korean Bay (39.0 N, 129.0 E) small anticyclonic eddy is met very often.

This eddies are situated at the south of frontal lines.

Between 130 E and 132 E a interesting feature of surface temperature field was noted: band of warm waters within the limits are marked numerous (3-5) anticyclonic eddies. Inside this band anticyclonic eddy was noted in point 40.5 N, 131.0 E most often. This band is oriented not strictly on 131 Å. but inclines on the west. North-western line of Subarctic front is caused by this path.

5AM1996-POC07 oral
**ANALYSIS OF CLIMATE CHANGE TENDENCY IN THE FAR EAST SEAS AREA
(BERING, OKHOTSK, JAPAN / EAST SEAS)**

Nina A. Dashko¹, and S.M. Varlamov²

¹ *Far East State University Department of Meteorology 8 Sukhanova Street, Vladivostok, Russia. 690600*

² *Far-Eastern Regional Hydrometeorological Research Institute, 24 Fontannaya Street, Vladivostok, Russia. 690600*

The climatic conditions for last century are changing and we are interested to evaluate this changes and their tendency in region of Far East Seas (Bering, Okhotsk and Japan / East Seas). In this work the tendency of climate change for a region of the East (Japan) sea was evaluated. We used data for Russian, Korean and Japan stations. The analysis of monthly mean air temperature linear trends shows significant increasing of the air temperature background from October-November to May-July for all stations (positive trend). For southern (Korean) stations most significant is background temperature growth in spring and early summer, March-June. The negative trends are observed only in summer and early autumn.

The linear trends analysis for the monthly sums of precipitation shows that for the study period trends are not statistically significant. Its sign can vary from month to month. The distinctive characteristics of precipitation are their large inter-year variability. Monthly sums of precipitation do not show the regular variations of precipitation regime in the Japan (East) Sea region in recent century.

The number of days with negative air temperature in stations shows the tendency to decreased in recent 50s. It also suggests the tendency for warming of climate in winter. In winter the atmosphere typically receives the heat from ocean. If $T_w = \text{const}$, the heat loss by ocean can be proportional to $T_a * W$ [or $T_a * (W * W)$], where W is wind speed value. The sums of daily product $T_a * W$ and $[T_a * (W * W)]$, when $T_a < 0 - C$ in the cold time of year were calculated for the coast stations. For example, in the Western Japan Sea (East Sea) these characteristics have the tendency to decrease the absolute values. This demonstrates the tendency to decrease the heat loss by the Western Japan (East) Sea in recent 50s in winter.

5AM1996-SB06

poster

CLIMATE VARIABILITY IN THE NE PACIFIC ASSESSED THROUGH TREE-RINGS CHRONOLOGIES

Patricia Dell'Arciprete¹, Nathan Mantua², and Robert C. Francis¹,

¹ *University of Washington, Fisheries Research Institute, Box 357980, Seattle, WA 98195-7980, USA*

² *University of Washington, Joint Institute for Study of Atmosphere and Ocean, Box 351640, Seattle, WA 98195-1640, USA*

It has been shown in a number of previous studies that climatically sensitive tree-ring data contain information on atmosphere/ocean interactions. To evaluate the potential for reconstructing past climate variability beyond the times of the instrumental records, we explore the relationships between tree-ring chronologies from the Alaska/Pacific Northwest area and sea-level pressure, land air temperature, precipitation, and sea-surface temperature in the NE Pacific.

We also conduct a search for teleconnections between the Pacific Northwest climate variability and El Niño/Southern Oscillation (ENSO) predating the instrumental climate record. We do this by comparing tree-ring based paleo-climate reconstructions for the Alaska/Pacific Northwest region with coral-ring-based paleo-ENSO reconstructions from the equatorial Pacific.

5AM1996-POC08

oral

THE ANNUAL CYCLE IN SHELF-EDGE TO DEEP OCEAN GRADIENTS IN SINKING PARTICLES AND THEIR COMPOSITION OFF VANCOUVER ISLAND CANADA

Kenneth L. Denman¹, M.A. Pena¹, R. Forbes¹, R.E. Thomson¹ and S.E. Calvert²

¹ *Institute of Ocean Sciences, P.O. Box 6000, Sidney, BC, Canada. V8L 4B2*

² *Department of Oceanography, University of British Columbia, 6270 University Blvd., Vancouver, BC, Canada. V6T 1Z4*

We have deployed moored sequential sediment traps during summer 1990 and since October 1993 at a depth of 200 m at five sites (for selected periods) adjacent to Vancouver Island Canada in water depths ranging from 500 m to 2500 m. C:N ratios and stable isotope ratios indicate materials of primarily marine origin. Annual and spring bloom particle fluxes appear to be higher at the sites nearest to the continental shelf. There is an indication of an annual cycle in the sinking particle C:N and C_{organic}:C_{carbonate} ratios at all sites since October 1993. Large biogenic silica (opal):C_{carbonate} and C_{organic}:C_{carbonate} ratios indicate that the phytoplankton community is dominated by diatoms most of the year and that the region is efficient at removing CO₂ from the surface layers through by means of sinking organic particles.

5AM1996-FIS08

poster

TO THE PRESENT SITUATION OF THE RED KING CRAB POPULATION, PARALITHODES CAMTSCHATICA, AT THE WESTERN KAMCHATKA

V.N. Dolzhenkov and V.I. Myasoedov, *Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

The Western Kamchatka red king crab is the most important to fishery. TINRO is carrying out the regular assessment trawling surveys for this crab since 1957. The last complete survey was conducted in 1992. In 1995 trawling were conducted mainly in the Southern part of the Western Kamchatka shelf.

In order to detect changes in the population of this crab sizesexual structure dynamics and biological condition were considered, basing on data collected in 1981, 1992 and 1995.

Trawl and crab pots catches showed an obvious tendency towards decrease in share and mean size of harvested males in all the studied regions off the Western Kamchatka. Harvested males share

decreased almost twice during 1981-95 year period in the whole Western Kamchatka population. Especially low percentage of such males (6-12%), as well as considerable decrease of their dimensions (from 178 to 160 mm) was observed in the northern regions, where harvest is the most intensive. Negative trend was also present in southern regions of the Western Kamchatka shelf, where two-fold decrease of abundance and density of male stocks was revealed in 1995 comparably to 1992.

Sharp increase of dry females share was seen in catches. For example, their relative abundance increased 5 to 6 times in the northernmost Khairusov region during 1981-95 year period. The obvious reason for that was deficiency of large size producer-males.

The above presented data suggest, that the Western Kamchatka population of red king crab is in unfavourable condition, and requires urgent measures for regulation of its exploitation.

5AM1996-SB07 poster
TIME SERIES MODELS OF RELATIONSHIPS BETWEEN ALASKAN SALMON CATCH AND LARGE-SCALE CLIMATE PHENOMENA
Mary W. Downton and Kathleen A. Miller, *National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307, USA*

Using multivariate time series models, relationships are shown between Alaskan commercial catch of pink, chum, and sockeye salmon and measures of large-scale climate in the Pacific basin during 1925-94. Climate measures used are the North Pacific Index (NPI), which is an index of the Aleutian low pressure system, and surface temperatures in large homogeneous regions of the North Pacific. All three species are shown to be related to the NPI, and each species to be even more strongly related to temperatures in a particular region of the North Pacific. The effects appear to occur during the years of ocean entry. In addition, the models show a significant species interaction indicating that the abundance of chum salmon is positively related to the abundance of pink salmon two years earlier. The relationships between salmon catch (adjusted for the impact of hatcheries) and the NPI weaken during the period of rapid increase in salmon abundance that began in the late 1970s; however, the relationships with temperature remain strong. Significant step-increases in all three species point to an environmental change in 1977. The step-increases are only partially explained by the models, suggesting that other large-scale oceanographic changes should be explored.

5AM1996-MEQ03 poster
WATERS POLLUTION AND ECOLOGICAL SYSTEMS OF PETER THE GREAT BAY
Vladimir Dulepov, and Natalia Lelioukh, *Institute for Marine Technology Problems, Far East Branch, Russian Academy of Sciences, 5-a, Sukhanov Street, Vladivostok, Russia. 690600*

In the last two decades an ecological condition of sea coastal waters of Primorye Territory, especially its southern water areas - Peter the Great Bay (Japan Sea/East Sea) - became worse to a greater extent.

The reasons of pollution localization in coastal zones have dual character: on the one hand, there is the constant inflow of polluting substances (industrial, agricultural and household runoff); on the other hand - natural barriers, caused by distinctions of hydrochemical and hydrologic shelf and abyssal water strata, prevent from their dispersion in the sea. This creates steady pollution of sea environment in coastal zones (in the bays and gulfs of the water areas discussed the extreme allowable meanings on the average are 1-3 norms in heavy metals, 1-5 in petrochemicals, 3-4 in phenols).

Mazut pollution of a coastal zone, the accumulation of heavy metals and toxicant substances in zostera, reduction of zostera areas, silting as well as qualitative change of bottom deposits lead to deterioration of conditions for feeding, functioning and reproduction of most invertebrates and fishes inhabiting the Peter the Great Bay.

For instance, the Gold Horn Bay, where the total index of pollution is 4 times higher than extreme allowable meanings and the silt layer is about 4-5 m, becomes practically extinct. The silting in Amur Bay on polluted sites reaches 1-2 m; the animals are unavailable, among plants - only zosteria.

Thus, the species disappear from ecological systems, structure and functional bonds are broken, resulting in destruction of sea ecological systems.

5AM1996-SB08 oral
**TIMING AND CONSEQUENCES OF THE SPRING AND FALL WIND TRANSITIONS
ALONG THE WEST COAST OF NORTH AMERICA**

Curtis C. Ebbesmeyer¹, Richard A. Hinrichsen² and W. James Ingraham, Jr.³

¹ *Evans-Hamilton, Inc., 731 N. Northlake Way, Seattle, WA 98103*

² *Columbia Basin Research, School of Fisheries, 1325 Fourth Ave., University of Washington, Seattle, WA 98101*

³ *National Marine Fisheries Service, Alaska Fisheries Science Center, NOAA, 7600 Sandpoint Way NE, Seattle, WA 98115*

Each year the coastal winds along the west coast of North America (Between approximately San Francisco at 38°N and the Queen Charlotte Islands at 52°N), switch between the southerlies of winter and the northerlies of summer (spring transition), then return to winter winds (fall transition). The spring transition arrives later with rising latitude causing an abrupt transition at fixed locations along the coast. Conversely, the fall transition progresses southward, typically at greater speed than the spring transition. As the transitions evolve north and south, the coastal surface currents and river effluents, coastal water masses and associated ecosystems, respond with varying spatial patterns. For example, at the spring transition the Columbia River effluent shifts swiftly from a coastal hugging plume in winter, to a tongue-like plume directed toward the southwest.

The latitudinal evolution of the transition dates each year since 1899 is presented based on synthetic winds computed from monthly sea level atmospheric pressure fields (1899-1945), and daily fields (1946-1995). Histories of the annual transition dates and the length of summer and winter seasons are analyzed. At Cape Mendocino in the southernmost portion of the transition band of latitudes, the maximum wind speed in summer varies three-fold from 6 meters per second in the 1940s, to 18 meters per second in 1977, decreasing to 10 meters per second in 1995. Our understanding of the sustainability of west coast fisheries can be enhanced by examining decadal and century-long variations.

5AM1996-BIO04 poster
**HYDROMETEOROLOGICAL CONDITIONS OF THE OKHOTSK SEA POLLOCK
REPRODUCTION IN 1994**

N.S. Fadeev and V.P. Pavlychev, *Pacific Fisheries Research Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

Last year TINRO-Centre is conducting regular expeditions that allow to study the conditions of pollock reproduction in the sea of Okhotsk. Biological investigations for the hydrological regime - meteorological, ice, thermal conditions, water dynamics.

As an example, the expedition on the scientific fish ship named "Novokotovsk" in January - April of 1994 along the Western Kamchatka was carried out.

Some results of this expedition are presented.

It has been established that cyclonic trajectories at the Earth, formed in the Japan Sea and in the Kuroshio area in January-February had predominating northern component as compare to normal

(Voronina,1987). Warm air masses moved from the southern latitudes to the sea of Okhotsk. As a consequence, appreciable flow of warm waters from the Pacific ocean to the eastern part of the sea of Okhotsk and ice conditions was anomal. Sea ice square was significantly less than normal in March and April of 1994.

Tidal character of water temperature changes in the layer 0-250 m has been defined at the many days station in the northjkhotsk shelf (57 10' N and 150 00' E).

It has been determined that the greatest concentration of the pollock caviar in April of 1994 was observed in the region of 54 30' - 55 30' N at the Western Kamchatka.

It was conditioned by some factors, namely, at these latitudes relatively calm meteorological conditions were marked, large ice fields were absent and constant flow of relatively warm Pacific ocean waters was observed. Obviously, it is typical oceanographical situation for the west Kamchatka shelf that is confirmed, in the majority of cases, by high concentrations of pollock caviar.

5AM1996-POC09 oral
CLASSIFICATION OF THE SHELF WATER CIRCULATION OFF THE WESTERN KAMCHATKA

A.L. Figurkin, Pacific Research Fishery Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600

The data of 15 cruises, obtained in springs 1983-96 in region 50 - 57N, 153E - Western Kamchatka have been used. It was found that variety of circulation patterns may be reduced to two different situations. As the major criterion it has been used the fact of availability or absence of shallow southward Compensational Current along the coast of the Western Kamchatka. When the Compensational Current is weak or absent (springs 1983, 1984, 1987, 1989, 1990, 1992, 1995), dynamic topography patterns consist of the northern shelf water cyclonic circulation (west off 153-154E) and enormous anticyclonic circulation of the West Kamchatka Current water extended to the coast. In the years of the intensive Compensational Current (springs 1985, 1986, 1988, 1991, 1993, 1994, 1996), area of anticyclonic circulation is diminished because cyclonic circulation is formed in cold dense shore water. The number of eddies of any forms in region increase from 6-7 to 12-15 and the total heat of the upper 0-100 m really decrease in the years of intensive Compensational Current. In such years coastal water salinity of upper 0-75m was higher than the West Kamchatka Current water salinity whereas water salinity continually increased westward from Kamchatka in the years when Compensational Current was weak or absent. Intensity of the Compensational Current correlates with intensity of the East-Sakhalin Current, and is accompanied by salinity increase in coastal waters of the West Kamchatka and East Sakhalin and by salinity increase of pre-bottom in the northern part of the Shelikov Bay. Interannual fluctuations of winter severity and wind stress are, probably, the reasons of southward transport variety of cold water from northern shelf of the Okhotsk sea.

5AM1996-POC10 oral
REGIONS OF HIGHLY SALINE SHELF PRE-BOTTOM WATER FORMATION IN THE OKHOTSK SEA

A.L. Figurkin, Pacific Research Fishery Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600

The data, obtained in the shelf of the Okhotsk Sea after ice melting (April-June 1983-1995), have been used. It found several regular regions of highly saline pre-bottom water near the freezing point. In the northern part of the Shelikov Bay (early May) waters with salinity 33.45 - 33.90psu were observed at depth 60-120m. The densest water ever observed here was near to bottom (78m) with salinity 34.01psu and temperature -1.73° C at 61°10N, 158°0E. Waters with salinity 33.45-33.85psu were located at 143-146°E south-east from Okhotsk at depth 110-150m in late May. Waters salinity

33.40-33.55psu were observed to the east from Shantarskiy Islands in late May - June. Salinity values 33.70 - 33.85psu were found at depth 40-70m in the Sakhalin Bay under the surface layer of Amur low-salinity water. Two regions of highly saline water: between Cape Elizabeth and 52°N - 33.30 - 33.50psu and from 50°30N to 48°30N - 33.20 - 33.40psu were located along East Sakhalin in mid June. All regions of highly saline dense water, that are described above, have cyclonic circulation type along their boundaries.

5AM1996-SB09 oral
VARIATIONS IN ALASKAN SOCKEYE SALMON ABUNDANCE DURING THE PAST 500 YEARS DETERMINED FROM SEDIMENT CORE ANALYSIS
Bruce P. Finney, *Institute of Marine Science, University of Alaska, Fairbanks, AK 99775, USA*

Records of prehistoric variations in salmon abundance are reconstructed from analysis of stable nitrogen isotopes in sediment cores. This new application of N isotopes is based on the observation that Pacific salmon supply nutrients into freshwater systems when they return to spawn. Nitrogen derived from adult salmon is enriched in $\delta^{15}\text{N}$ relative to terrestrially-derived N. Thus input of salmon-derived N can be quantified by analysis of $\delta^{15}\text{N}$. Changes in the number of returning adult salmon will be reflective by downcore changes in sedimentary $\delta^{15}\text{N}$. Strong positive correlations are observed between downcore changes in $\delta^{15}\text{N}$ and historical changes in sockeye escapement in several lakes. Sedimentary $\delta^{15}\text{N}$ has been analyzed in three lakes from Kodiak Island, Alaska. The records span the past 350 to 650 years and show many common features in $\delta^{15}\text{N}$ and hence, inferred escapement. Significant minima occurred during the early 1800s and the mid-1900s, while prominent maxima are observed around 1700, the mid to late 1700s, and the late 1800s. These common patterns suggest control by large-scale processes. The period of low salmon abundance during the early 1800s corresponds with a prolonged period of anomalously cold SST throughout a large region of the North Pacific. In contrast, the period of low salmon abundance observed during the mid 1900s cannot be explained by a similar SST pattern. This indicates that other factors, such as commercial harvest, may influence long-term trends in salmon abundance at these sites.

5AM1996-POC11 oral
CROSS-SHELF EXCHANGES OFF VANCOUVER ISLAND
Michael Foreman and Richard Thomson, *Institute of Ocean Sciences, P.O. Box 6000, Sidney, BC, Canada. V8L 4B2*

Three-dimensional model simulations of tides and buoyancy currents off the west coast of Vancouver Island demonstrate the importance of topography along the shelf-break in generating water mass exchanges onto the shelf. The summer Shelf-Break Current which flows in a southeastward direction centred roughly over the 500 metre isobath is seen to have diversions onto the shelf at most canyons. The energy associated with tidally-generated diurnal shelf waves is also shown to be trapped and dissipated in a series of sinks whose location appears to be dictated by a match/mismatch relationship between the shelf break topography and the respective tidal frequencies. The importance of this energy dissipation and the on-shelf flow will be discussed with regard to nutrient supply and larvae retention issues.

5AM1996-POC12 oral
NEAR SURFACE CHANGES IN THE MIXED LAYER AT OCEAN STATION PAPA IN THE NORTHEAST PACIFIC OCEAN
Howard J. Freeland, *Institute of Ocean Sciences, P.O. Box 6000, Sidney, BC, Canada. V8L 4B2*

Sea-surface temperatures in the northeast Pacific Ocean show a warming trend, and salinities show a declining trend in data collected over the last 60 years. Both of these conspire to reduce the

density of the surface layer over a large area of the northeast Pacific. The declining surface density changes the energetic requirements for the formation of surface mixed layers, and observations at Ocean Station Papa indicate that mid-winter mixed layer depths are showing a marked decline. The reduction in the depth of penetration of the winter-time mixed layer should reduce the amount of nutrients supplied to the upper ocean each winter. Observations suggest that near surface nutrient levels are declining but still remain above levels that might inhibit productivity. This decline rate is compared with a simple model.

5AM1996-MEQ04 invited
CYCLING OF CONTAMINANTS THROUGH THE ATMOSPHERE: LONG-RANGE TRANSPORT VS. REGIONAL DEPOSITION
Yuan Gao, Rutgers University, Institute of Marine and Coastal Sciences, P.O. Box 231, New Brunswick, NJ 08903, USA

There is an increasing amount of evidence that the atmosphere can be an effective transport path for contaminants entering the oceanic regimes, both remote and coastal. Atmospheric measurements at Midway Island in the North Pacific along with meteorological analyses reveal that high concentrations of certain anthropogenic substances coincide with peaks of Asian dust transport. At Bermuda in the North Atlantic, the major sources for pollution derived trace elements such as antimony and selenium are believed to be anthropogenic emissions from North America. The atmosphere also plays a critical role in carrying chemicals to the coastal zone. This is evident for the coastal estuaries adjacent to large population/industrial centers, such as the New York-New Jersey Harbor/Bight. The atmosphere in these areas is heavily impacted by pollution emissions, resulting in enhanced air-to-sea deposition rates of pollutants. Because significant amount of toxic substances enter coastal waters through the atmospheric pathway, either by precipitation washout or by particle dry deposition, their concentrations are elevated not only in coastal waters and biota but also in sediments. A detailed discussion regarding the relative importance of atmospheric deposition compared to other processes will focus on the New York-New Jersey Harbor/Bight, a heavily polluted region that is also characterized by intensive coastal upwelling.

5AM1996-FIS 10 oral
INTERRELATION BETWEEN HYDROMETEOROLOGICAL AND BIOLOGICAL PARAMETERS OF MARINE FARMS OF PRIMORYE (POSSIET BAY, SEA OF JAPAN / EAST SEA)
Larissa A. Gayko, Institute of Marine Biology, FEB RAS, Vladivostok, Russia. 690041

The aim of this research is finding the statistic dependencies between hydrometeorological characteristics and productivity of cultivated organisms in order to select statistically valuable predictors for making up forecasting schemes. The set of 21-year period observations was processed to find out the dependence: the mean values of water and air temperature, salinity, spat density on the collectors were calculated; the duration of ice period, the points of rising of water and air temperatures above 00C, the sums of temperatures were calculated. Ecologically based periods are determined in the annual cycle of development of the pubertal grown *Patinopecten Yessoensis* (Jay): wintering, the periods from rising the temperature above 00C till the beginning of spawning, the spawning itself and plankton development. Rather close relationship is obtained between the density of spat on the collectors and the sum of temperatures for these periods, the duration of periods themselves, variability of water temperature during the spawning period, duration of ice period. The results allow to hope on the possibility of early predicting of the type of the year from the point of view of vafourable planted material for yielding.

5AM1996-FIS11

poster

SPATIAL-TEMPORAL DISTRIBUTION OF WATER TEMPERATURE AND SALINITY AT THE AREA OF THE MARICULTURAL NATURAL RESERVE "ZALIV VOSTOK" (SEA OF JAPAN / EAST SEA)

Larissa A. Gayko, *Institute of Marine Biology, FEB RAS, Vladivostok, Russia. 690041*

The area of our studies, Vostok Bay, is used as a survey area for scientific investigations in the Institute of Marine Biology. Its northern part was declared as an integrated marine reserve. Our studies were dealing with the changes of the water temperature and salinity in the bay, proceeding under various time schedules. The obtained results allow us to conclude that the temperature and salinity regime in Vostok Bay shows noticeable diurnal, month, seasonal, and annual variation. The daily temperature variation is most pronounced in the upper 5 m layer. A strikingly expressed water stratification is a remarkable feature of the water temperature distribution in closed bights throughout summer season. The annual schedule of surface water temperature reveals single minimum and single maximum (-1.6 grade C in January - February and 24.3 grade C in August; 22.93 (in August and 33.58 (December). In different years both quantitative and qualitative changes of water temperature distribution pattern were observed. We made the statistical analysis of the water temperature and salinity. The period of temporal variations of water temperature and salinity at 0, 5, 10 m levels in the Vostok Bay. The specific features of the regime of water temperature in Vostok Bay are defined by simultaneous effects of numerous factors, mostly the climate pattern and water circulation.

5AM1996-FIS09

poster

DYNAMICS OF YIELD REMOVAL IN RUSSIAN ECONOMIC ZONE (JAPAN SEA) IN CONNECTION WITH CHANGES OF HYDROMETEOROLOGICAL CONDITIONS AND SUN ACTIVITY

G.M. Gavrilov, *Pacific Research Fisheries Centre (TINRO-Center), 4, Shevchenko Alley, Vladivostok, Russia. 690600*

The Japan sea ichthyofauna numbers more than 800 fish species, about 230 of them inhabit Peter the Great Bay, 176 - North Primorye and 193 - Tatar Strait.

Bottom and demersal fishes are the base of the North Japan sea ichthyofauna and make about 80% of Russian economic zone fishes. 14 commercial species are represented among the bottom and demersal fishes of moderate-coldwater north boreal fishery-geographical complex (FGC). The main commercial fishes of FGC are flounders (12 species), sculpins (38), greenlings (2), cods (2); of pelagic fishes - walleye pollock and herring, of diadromous fishes - pink salmon and chum, but of moderate - warmwater southboreal FGC - Pacific sardine and mackerel. In the 40s of short duration, capelin - arctic boreal species was of commercial value. The total fish catch in the Russian economic zone of the Japan sea for the last 55 years was about 10 mln. t., while annual catches varied from 58,4 in 1941 up to 520 thous. t. in 1982. Average yield removal in Peter the Great Bay made 5,3 t/km², in Tatar Strait - 1,2 t/km², in Russian zone - 1,4 t/km², in the Japan sea - 2,1 t/km² including commercial invertebrates. In different years in Russian zone independence on fluctuation of abundance and fishery intensity, yield removal underwent significant interannual changes, on the average from 0,9 t/km² in the 70s up to 2,5 t/km² in the 80s. The most abundant yield removal fell on the 50s, 60s and the first half of the 80s of current century. The yield decrease was observed in the 40s, 70s, and 90s in connection with long-term fluctuations of the main commercial fishes stocks caused by changes of atmospheric processes, oceanological conditions and sun activity. The increase of fish removal of moderate - coldwater northboreal FGC (pollock, cod, navaga, greenlings, herring) has occurred from the early current century in time of meridian and eastern types of atmosphere circulation over the eastern part of the Northern hemisphere at the period of total water cooling in the Japan sea and increased values of sun activity. The yield removal of moderate-warmwater southboreal FGC (Pacific sardine, mackerel and anchovy) has increased only in time of development of zonal processes in atmosphere, decreased values of sun activity and total water warming in the North-Western part of the Japan Sea.

5AM1996-MEQ05

poster

BUILDING A GEO-REFERENCED KNOWLEDGE BASE FOR ARCTIC CONTAMINANTS

Sharon George, Gunter Weller, Susan Hills, Kara Nance, Christine Packett and Olga Parsons

Cooperative Institute for Arctic Research (CIFAR), University of Alaska, Fairbanks, AK 99775 U.S.A.

In general, the knowledge of pollution levels and their effects in the Arctic environment are poor. Complex environmental conditions hamper the prediction of accumulation and migration of pollutants from both distant and local sources in Alaska. Furthermore, the interconnections among past and existing environmental studies and monitoring programs in Alaska are not well known.

Following a period characterized by restricted access to large parts of the Arctic, information on programs and institutions addressing environmental questions in the Arctic are essential. In addition, the parameters assessed and methodologies used including spatial and temporal coverage, related parameters with regard to specific measurements and information on where and how this data can be retrieved are required. Further, information on planned environmental assessment studies and information on existing programs in addition to environmental studies that have been carried out are key.

For the past year, CIFAR has been working on a project to begin to address some of these issues for Alaska. We are working on three interrelated tasks: (1) Data Synthesis which addresses the integration of contamination data from past projects and the design of a geo-reference knowledge base, (2) Observation/Monitoring which is capturing information on existing programs and studies and will initiate an assessment of the adequacy and gaps in the data, and, (3) Communications which seeks to promote communication with the users and providers of contamination data as well as release information.

5AM1996-POC13

oral

SOME FEATURES OF WATER EXCHANGE THROUGH THE OKHOTSK SEA BUSSOL AND KRUZENSHTERN STRAITS: EVIDENCE FOR DEEP VENTILATION OF THE NORTH PACIFIC

Sergey V. Gladyshev¹ and Steve C. Riser²

¹ *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, Russia. 690041*

² *School of Oceanography, University of Washington, Box 357940, Seattle, WA 98195, USA*

Applying T-S analysis to the very detailed hydrographic surveys in Bussol and Kruzenshtern Straits during 1989, 1991, 1995, some stable features of the thermohaline field are discovered. An especially complex picture was obtained in Bussol Strait. There was a strong Okhotsk Sea water signal in the upper layer of deep eastern Bussol trench during all surveys. This discharge to the North Pacific had a jet-like feature and was traced a distance more than 15 miles from the Strait. As a result, the North Pacific warm intermediate layer became much weaker and fractured south-west of Bussol Strait. Part of this modified waters again returned in Bussol Strait through deep western trench. Deep Okhotsk sea water penetrated to the North Pacific in the bottom layer of the western trench in April 1995 and a modified deep North Pacific water flowed through the eastern one. These water mixed in the strait and flowed down along the bottom in the deep Kuril Basin. The most likely reason for this deep circulation pattern in Bussol Strait is tidal motion that defines the current field there. The prevailing semidiurnal Okhotsk Sea component of the tide causes preferential flow (and transport) to the North Pacific ocean through the deep southern part of Bussol Strait and, vice versa, the North Pacific semidiurnal component works in the northern area of the strait. The boundary between this areas is situated along the central part of Bussol Strait. Additional prominent features of circulation were found for Kruzenshtern Strait. There was a permanent jet-like signal of the North Pacific water in this strait. In April 1995 the North Pacific intermediate and deep water passed through the northern part of the strait near Trap Rocks. This water was followed as a large North Pacific plume with a radii 90 miles from the strait in the Okhotsk Sea, along slope bottom of the Deep Kuril Basin. A very modified portion of the North Pacific intermediate water also was discovered near the West-Kamchatka coast in the Tinro Deep. Water exchange has seasonal and interannual variability in

Kruzenshtern Strait. In June 1991, the jet-like feature of the North Pacific water was located in the central part of the strait, 5-7 miles to the south-west of its April 1995 position. A very small fraction of this water flowed along the Kuril Chain to the Kamchatka Peninsula and there was no broad North Pacific plume in the Okhotsk Sea in June 1991.

5AM1996-POC14 oral
INVESTIGATION OF DEPENDENCE OF SUMMER THERMODYNAMICS OF WATERS OF SAKHALIN-KURIL REGION FROM WINTER-SPRING ATMOSPHERIC PROCESSES
Svetlana Yu. Glebova, Yury V. Novikov and Eugene V. Samko, *Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

Character of dependence of thermodynamic conditions in Sakhalin-Kuril region (41-53 N, 142-162 E) in July-August from atmospheric processes in January-May was investigated on an example 1991-1995.

As initial information the data of 15 cruises, executed in region in considered period, are used. Anomalies of surface water temperature (ASWT) were calculated in each year separately for Pacific and Okhotsk parts of the region. Also on maps of relative dynamic topography 0/500 □ speeds of main geostrophic streams of considered region were calculated.

The intensity of circulation of atmosphere was evaluated by Katz indexes, calculated on monthly average charts of surface pressure. Indexes, received for each month, averaged for the whole period (January - May).

The joint analysis of interannual course of Katz indexes, ASWT and speeds of main streams has shown following:

- Complete conformity in variability of a total Katz index and ASWT, especially for Okhotsk part of the region;
- Dependence of surface water temperature from intensity of northwest atmospheric transfers;
- Influence of intensity of air exchange on difference of course of ASWT in Pacific part of the region;
- Dependence of speeds of main currents only from season course of Katz indexes particularly for each year of supervision.

The conducted analysis testifies to availability of asynchronic connection atmospheric and hydrology processes in considered region.

5AM1996-SB10 invited
RETROSPECTIVE ANALYSIS OF THE SOUTHERNMOST POSITION OF THE FIRST INTRUSION OF THE OYASHIO
Kimio Hanawa, *Department of Geophysics, Graduate School of Science, Tohoku University, Aoba-ku, Sendai, Japan. 980-77*

The first intrusion of the Oyashio (FIO) in the Mixed Water Area east of Honshu Island, Japan gives a essential influence on the primary production, positions of the fishing ground and the aqua culture in the many bays along the Sanriku Coast. Therefore, to reproduce the historical behavior of FIO is very important and useful in consideration of time series of various quantities obtained in this area.

Using the two methods, time series of the annual mean southernmost position of FIO is reproduced since the beginning of this century to 1995. One is the method which uses the prediction model for the southernmost position of FIO proposed by the authors group. The prediction model is a multiple regression model using a pressure field in winter over the North Pacific. The other is a simple regression model which uses the annual mean water temperature obtained in the Sanriku Coast.

Both two methods give a very similar time series from 1950s to the present: since 1950s to mid 1970s, FIO takes relatively northern positions, but since then to 1990s FIO intrudes more southern latitudes. On the other hand, time series before 1950s by the two methods are very different. This suggests that the so-called climate jump in atmospheric circulation over the North Pacific occurred around 1950s.

5AM1996-MEQ06 invited
ANALYSES ON THE VARIATIONS IN MARINE CARBON CYCLES ACCOMPANIED WITH SHIFTS OF PLANKTONIC ECOSYSTEM STRUCTURE

Shigeki Harada¹ Masataka Watanabe¹, Hiroshi Koshikawa², Kazumi Sato²

¹ *Laboratory of Marine Environment, National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, Japan. 305*

² *Department of Industrial Chemistry, Science University of Tokyo, 1-3 Kagurazaka, Shinjuku-ku, Tokyo, Japan. 162*

We have developed a large-scale mesocosm (marine enclosure: 5m in diameter and 18m in depth) in the Seto-Inland Sea, Japan. Vertical circulation system was deployed in the surface layer (0-5m) to suspend non-motile phytoplankton species such as diatoms and then to maintain natural ecological conditions between species.

During several experiments with different initial biochemical conditions, variations in carbon transfer from dissolved inorganic states into zooplankton were monitored using ¹³C tracer. Every few days, seawater within the mesocosm was collected in bottles (4.5 L) and incubated for four hours after the addition of ¹³C-bicarbonate.

The significance of ¹³C transfer into zooplankton was affected by the coupling of specific phyto- and zooplankton species e.g. higher ¹³C transfer was observed in the ecosystems dominated by Copepoda & centric diatoms and Doliolida & dinoflagellates but lower in those dominated by Copepoda & dinoflagellates and Doliolida & centric diatoms. Such ecological interactions have resulted in the succession of dominant phytoplankton species every several days together with the effects of changing nutrient (N, P, Si) availability.

Our results underlined the importance of planktonic ecosystem structure on marine carbon cycles which should be linked with the cycling of contaminants in marine ecosystems.

5AM1996-BIO05 oral
EFFECTS OF ANNUAL TEMPERATURE VARIATION ON THE TIMING AND GEOGRAPHIC DISTRIBUTION OF HERRING SPAWNING LOCATIONS IN BRITISH COLUMBIA

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

Records of the date, location and size of herring spawns have been recorded in British Columbia since the 1930's. Recently we updated these records and georeferenced the locations. We analyzed these records to determine if changes in the timing and distribution of spawning were associated with temperature or climate change. Our analyses show that during the last 60 years, herring have used many different areas, with a cumulative length of about 5000 km (about 20%) of the British Columbia coastline. Of these 5000 km, nearly 80% of all the spawn records occur within 1000 km (about 4% of the coast). Within a single year, the maximum (cumulative) length of spawning is usually about 400-600 km. Some general locations are used repeatedly among years. Other locations are used infrequently. With respect to spawn timing, the analyses confirm earlier findings that (i) herring spawn earlier in warmer years; (ii) spawning time varies directly with latitude and (iii) fjord

populations spawn later than adjacent populations in more exposed waters. With respect to spawn distribution, the analyses show that (i) some locations are used nearly consistently over time, (ii) some are used only once or twice; (iii) others are used intermittently, from several years to several decades, followed by periods of disuse. These 'intermittent' records are the most interesting because there are indications that some distribution changes are associated with major climate changes, such as El Nino. The implications of these results affect our understanding of herring life history, stock structure and management.

5AM1996-POC15

oral

A PRELIMINARY REGIONAL CIRCULATION MODEL OF THE EASTERN BERING SEA

Albert J. Hermann¹ and Phyllis J. Stabeno²

¹ *Joint Institute for the Study of the Atmosphere and the Oceans, University of Washington, Seattle, WA 98195, USA*

² *Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, USA*

We have developed a preliminary regional circulation model, as a component of the Southeast Bering Sea Carrying Capacity program. Our rigid-lid primitive equation model is based on a recent version of the S-coordinate Primitive Equation Model (SPEM) of Haidvogel et al. (J. Comput. Phys., 1991). The model domain spans the eastern Bering Sea shelf and basin with a horizontal resolution of 12 km and five topography-following vertical levels. We specify barotropic flows of appropriate magnitude through Unimak Pass, Amukta Pass, Bering Strait, and the North Aleutian Slope Flow (NASF) at the western boundary. Salinity and temperature fields are nudged back to observed values at each of the inflow passes. Wind forcing is based on the climatological pattern described in Bond et al. (J. Climate, 1994). The coarse vertical and horizontal resolution of this preliminary rigid-lid model, and the lack of tidal information, precludes many physical processes known to occur in the region. However, we are able to replicate several of the first order features of the area, including: a strong eastward current along the northern boundary of the Aleutians (the NASF) and northwestward along the shelf break (the Bering Slope Current), weak flows on the middle shelf, a moderate northwestward flow along the Alaska coastline, vigorous flows along the Siberian coastline, and a vigorous outflow through the Bering Strait. We explore the impact of seasonally varying inflows through the passes as it affects the interior flows generally, and basin/shelf exchange in particular.

5AM1996-FIS12

oral

EVALUATING RISK OF ENERGY DEPLETION AND MORTALITY IN UPRIVER MIGRATING SALMON

Scott G. Hinch and Peter S. Rand, *Westwater Research Unit, Institute for Resources and Environment, University of British Columbia, Vancouver, BC, Canada*

Once entering freshwater, adult salmon rely solely on energy reserves to reach spawning grounds. Many stocks of Fraser River sockeye travel over 1,000 km upriver, use most of their energy reserves enroute, and may suffer high enroute mortality in years of difficult passage. Understanding natural mortality at this life history stage, and the environmental factors contributing to it, will help in stock conservation and management. We used electromyogram radio telemetry, a technique that transmits information on tail beat frequency, to investigate the energetics of upriver migrating adult sockeye. We developed a stochastic energy model to evaluate the risk of body energy depletion, a measure assumed to be correlated to incidence of migratory difficulty leading to inriver mortality. We integrated data on fish size, river conditions, bioenergetics, migration rates and direct measures of swimming activity from electromyogram telemetry. Bioenergetic losses were predicted using an established algorithm that accounts for weight-, temperature- and activity-dependent metabolism. Model predictions compared well with empirical measurements of body energy obtained from migrating sockeye. Sensitivity analyses suggest that variability in migration activity was an important contributor to variability in predicted final energy content. Based on Monte Carlo simulations, we conclude that critically low energy content could arise in 20-30% of migrating sockeye under "typical" environmental

conditions. Sustaining spawning populations may become more difficult in the future if river conditions become less favorable for migration or if ocean conditions become less favourable for growth and energy storage.

5AM1996-POC16 oral
FORECASTING THE SEA SURFACE TEMPERATURE ANOMALIES IN THE PACIFIC OCEAN
William W. Hsieh, *Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, BC, Canada. V6T 1Z4*

The great advances over the last decade in El Nino forecasting has raised the question whether mid latitude sea surface temperature anomalies (SSTA) can also be forecasted. This problem is of great practical interest as the SSTA are known to influence the salmon fisheries. The UBC Climate Prediction Group has been studying seasonal forecasting of SSTA in the tropics using two different approaches, (a) the neural network method and (b) the adjoint data assimilation method with simple coupled atmosphere-ocean models. Monthly tropical Pacific SSTA forecasts by the neural network method are being issued over the Web (<http://www.ocgy.ubc.ca>). Efforts to improve the forecasts of the tropical Pacific SSTA and extensions to higher latitudes are underway.

5AM1996-BIO06 oral
CLIMATE AND THE LIFE HISTORY OF SOCKEYE SALMON
Leonardo Huato, *Fisheries Centre, University of British Columbia, 2204 Main Mall, Vancouver, BC, Canada. V6T 1Z4*

In this paper we study the effects that temperature and food concentration may have on final body weight, habitat shift timing, and expected fecundity of sockeye salmon. We modeled the life history of sockeye salmon in three habitats (lake, coast, ocean) and use dynamic programming to calculate the strategy that maximizes fitness under average monthly temperature and food concentration for each habitat. The best habitat is selected on the basis of growth potential and survival given the current weight of the fish and the month of the year.

The first results of the model indicate that the size-dependent mortality pattern suggested for the combined coastal and oceanic habitat does not recreate the life history of sockeye. The model suggest that size-selective mortality very likely occur only in the coast and it should be higher than that of the oceanic habitat.

The model calculates a matrix consisting of the best set of decision for a range of body weights for each month. We use this matrix as the behavioral decision matrix in an individual-based model to explore the response of sockeye to changing temperature and food concentration. Our goal here is to reproduce the observed pattern of decreasing body size and the possible consequences that a change in the age of return may have on survival and egg production.

5AM1996-POC17 invited
PHYSICAL PROCESSES OF EXCHANGE BETWEEN CONTINENTAL SHELF WATERS AND THE NEARBY OCEAN
John M. Huthnance, *Proudman Oceanographic Laboratory, Bidston Observatory, Birkenhead, UK*

Continental shelf waters meet the deep sea over the steep continental slope. There is a need to elucidate the processes that determine the quantities, transformation and fate of materials transported between the shelf and ocean, the measurement and definition of exchange processes, and the development of prognostic models of exchanges.

Physical processes control the large-scale movement and irreversible small-scale mixing of water and its constituents. At the shelf edge, the steep topography may inhibit ocean-shelf exchange, but in combination with stratification gives rise to special processes and modelling challenges.

An assessment is made of coastal-trapped waves; along-slope currents, instability and meanders; eddies; upwelling, fronts and filaments; downwelling, cascading; tides, surges; internal tides and waves as potentially influential processes in ocean-shelf exchange, according to their scales and context.

More specific discussion is given of the "secondary" cross-slope flow associated with along-slope forcing and flow, and of relationships between distributions of suspended particulate matter and the controlling dispersion and sources, notably resuspension.

Some studies to improve the assessment of exchange processes are discussed.

5AM1996-SB11 invited
FIVE DECADES OF SURFACE CURRENT VARIABILITY IN THE GULF OF ALASKA AND BERING SEA CONSTRUCTED WITH THE OSCURS MODEL - IT'S TIME FOR SOME NEW INDICES OF FLOW

W. James Ingraham Jr.¹ and Curtis C. Ebbesmeyer²

¹ NMFS, Alaska Fisheries Science Center, NOAA, 7600 Sandpoint Way NE, Seattle, WA 98115-0070

² Evans-Hamilton, Inc., 731 Northlake Way, Seattle, WA 98103

New information on interannual and decadal variability of surface currents in the North Pacific Ocean and Bering Sea was derived from a time series of drifter tracks (1947-95) simulated with the OSCURS (Ocean Surface Current Simulations) model. The potential insight and space-time diversity from such synthetic data derived through modeling far supersedes accuracy limitations.

The start point for a winter circulation index was chosen at Station PAPA (50°N, 145°W), where the 3-month winter trajectories (Dec.-Jan.-Feb.) proceeded toward the northeast into the Gulf of Alaska, but year-by-year the trajectories showed a dominant bimodal character in their north-south and east-west components. The components of surface flow covaried with the Diversion Rate (NDR) for sockeye salmon, and the Washington State Oyster Condition Index (OCI).

The start point for a spring circulation index was chosen north of Unimak Pass (55°N, 165°W) to investigate the variability of currents that take walleye pollock eggs and larvae northeastward to their summer nursery grounds on the eastern Bering Sea Shelf.

In OSCURS daily surface current vector fields were computed on a 90 km grid using gridded daily sea level pressures and empirical functions for wind and wind drift currents with the addition of long-term mean geostrophic currents (0/2000 db). The model was tuned to reproduced trajectories of satellite-tracked drifters (drogued at 20 m) from the Gulf of Alaska. Motivation to develop OSCURS grew out of the need in fisheries research for new indices which describe variability in ocean surface currents.

5AM1996-BIO07 oral
LIFE HISTORY OF MAJOR ZOOPLANKTON SPECIES IN THE SOUTHERN JAPAN SEA: A REVIEW

Tsutomu Ikeda, Hokkaido University 3-1-1 Minato-machi, Hakodate, Hokkaido, Japan. 041

As part of research program to evaluate zooplankton production in the southern Japan Sea, a series of vertical samplings (500 m to the surface) with twin-type Norpac nets (0.10 and 0.35 mm mesh) were made every two weeks from February 1990 to January 1991 at an offshore station in

Toyama Bay, southern Japan Sea. Supplemental samples were also obtained using MTD horizontal closing nets, Fish-larva nets and IKMT. From the analysis of these field samples (combined with rearing experiments for some species), life history patterns of copepods (*Metridia pacifica*, *Pareuchaeta elongata*), amphipods (*Themisto japonica*, *Primno abyssalis*), a euphausiid (*Euphausia pacifica*), a mysid (*Meterythorops microphthalmus*), an ostracod (*Conchoecia pseudodiscophora*), a coelenterate (*Aglantha digitale*), a chaetognath (*Sagitta elegans*), and a sternoptychid fish (*Maurollicus muelleri*) have been evaluated successfully. All these results are reviewed, and data of some of these species are compared with their northern North Pacific counterparts on which the life history data are available (*M. pacifica*, *E. pacifica*, *A. digitale*). As a result from this comparison, it is suggested that the life history pattern of a given species is vulnerable depending on environmental characteristics of habitats.

5AM1996-POC18 oral
SHORT AND LONG TERM VARIATIONS OF PARTICULATE FLUXES AT THE CONTINENTAL MARGIN IN THE EAST CHINA SEA
Kazuo Iseki, Kazumaro Okamura and Yoko Kiyomoto, Seikai National Fisheries Research Institute, 49 Kokubu-machi, Nagasaki, Japan. 850

As part of the MASFLEX (Marginal Sea Flux Experiment in the West Pacific) program, multi- and time-series sediment traps were deployed at the shelf edge (bottom depth: 132 m), the upper slope (301 m), and the mid-slope (604 m) in the East China Sea for 9 days from Oct. 27 to Nov. 4, 1995. The fluxes increased generally with depth, reaching values as high as 360 mgCm⁻²d⁻¹ in the 592 trap (12 m above the bottom=12 mab) at the mid-slope. At the shelf edge, the fluxes rapidly increased from 35 mab (39 mgCm⁻²d⁻¹) to 12 mab (266 mgCm⁻²d⁻¹), probably due to resuspended bottom sediment. Further the time-series sediment traps moored at 102 mab and 30 mab on the mid-slope station showed a high flux event almost simultaneously occurred at the both depths during Oct. 29 and 30. A one year sediment trap studies at the deep Okinawa Trough Water also indicated the significant, high frequency variability of particle fluxes (Iseki et al., 1995), which are apparently linked to seasonal events in shelf waters such as a winter monsoon and summer typhoon. These evidences strongly showed resuspension and near-bottom transport may be key processes for cross-shelf transport of particles.

5AM1996-BIO08 oral
SHORT-PERIOD VARIABILITY OF PRIMARY PRODUCTION IN EARLY SUMMER IN THE OYASHIO REGION
Hiromi Kasai, Tokihiro Kono, Atsushi Tsuda and Hiroaki Saito, Hokkaido National Fisheries Research Institute Katsurakoi 116, Kushiro, Hokkaido, Japan. 085

We carried out a series of physical and biological observation tracking a drifting buoy in the Oyashio region, western subarctic Pacific off Hokkaido, Japan, in early summer of 1996. Primary production and nitrogen uptake during daytime were measured once a day by 13C and 15N tracer methods. During the observation nutrients were depleted and subsurface chlorophyll maximum was well developed. We will elucidate the characteristics of physiological status of phytoplankton in early summer and discuss the effects of solar radiation, water column stability, nutrient availability, and other factors on the variability of the primary production and nitrogen uptake.

5AM1996-BIO09

oral

THE COMMUNITY STRUCTURE OF MYCTOPHID FISHES AND WARM CORE RING IN THE TRANSITIONAL WATERS OF THE WESTERN NORTH PACIFIC

Koh Kawaguchi, H. Watanabe, M. Moku and A. Hayashi, *Ocean Research Institute, University of Tokyo*

Because of their universal abundance in the open sea, myctophid fishes have been thought an important component of the subarctic and transitional offshore ecosystem, as one of the main crustacean grazers and also as prey of commercially important fishes in the upper 100m layer at night. In this context we studied the spatiotemporal distribution patterns of the 11 myctophid species abundant in the transitional waters, based on the 131 day-night samples collected by commercial trawls in 6-8 discrete depth layers from 20m down to 700m in August 1994 and July 1995. In the transitional waters the community structure of myctophids proved to be greatly affected by the presence of warm core rings and related phenomenon like intrusion of Kuroshio waters. The response patterns of the various species to the warm core waters were well explained by their zoogeographic distributions, diel vertical migratory patterns and also their temperature ranges. Habitats of nonmigrants living below 300m down to 700m are not affected by the warm core rings, although their biomass is greatly decreased under the warm waters probably due to their low productivities. East-west and north-south expatriations will be discussed for both subarctic and subtropical species.

5AM1996-POC19

oral

DYNAMICS OF THE HYDROLOGICAL REGIONS ON THE WESTERN PART OF THE BERING SEA SHELF IN CONNECTION WITH MEANDERING OF THE KAMCHATKA CURRENT

Gennady V. Khen, S.A. Shershenkova and V.Y. Efimkin, *Pacific Research Fisheries Centre (TINRO-Centre), 4, Shevchenko Alley, Vladivostok, Russia. 690600*

In the shelf on the western part of the Bering Sea there are three hydrological regions: the coastal, transitional and oceanic. Vertical structure of the coastal and transitional regions consists of two layers: the warm surface and cold lower ones, but they are of differ by salinity of the warm surface layer. Coastal surface's salinity is < 31 psu and Brunt-Vaisala frequency is $> 0.015/c$ in the seasonal maximum of vertical density gradient layer (5-15 m). In the transitional region the frequency is $< 0.012/c$. In the oceanic region the vertical water structure has three layers: surface, a cold intermediate and warm lower layers.

The Kamchatka current plays an important role in the locations of the hydrological regions. When the Kamchatka current flows near the continental slope all the hydrological regions and frontal divisions shift toward the coast and over the outer shelf the structure is similar to the oceanic (1991,1993). When Kamchatka current moves off the continental slope, all natural complex shifts toward the outer shelf. In the shelf zone the hydrological structure has only two types: coastal and transitional (1992).

These data are proved by the results of hydrobiological researches. In summer of 1991, the species plankton composition of the epipelagical layer near-slope water corresponds to the composition of the deep-water zone plankton. Parasagitta elegans up to 60% of total zooplankton abundance and copepoda of oceanic complex Neocalanus cristatus and eucalanus bungii (8-11 %) dominate in every regions. In 1992 the composition of zooplankton in these regions significantly differs. In the deep-water zone as in 1991 saggita P.elegans (44%) and copepoda N.cristatus (30%) dominate, but in the near-slope shelf region copepoda E.bungii (27%), saggita P.elegans (26%) and larvae of euphausiids dominate.

5AM1996-BIO10

oral

INTERDECADAL ICE COVER VARIATIONS IN THE FAR EASTERN SEAS DURING CURRENT CENTURY AND OBSERVED RESPONSES IN ICHTHYOCENOSIS

Gennady V. Khen, V.A. Snytko and E.P. Karedin, *Pacific Fisheries Research Centre (TINRO), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

"Global warming" in the Northern Hemisphere during the first half of XX century (Jones, 1988) in the Far Eastern seas is expressed by gradual decrease of the ice cover. An opposite tendency has occurred in the 1960's and 1970's became the most ice concentration years since the early century. In the mid 1980's there has come the second long-term warming period accompanying with analogous decrease of sea's ice cover area that is continuing up to now. The decrease rate is appreciably higher in comparison with the early century and the first half of 1990's had the lowest level of ice cover in the current century. During this "warming period" the deep changes in hydrosphere of the Far Eastern seas have happened: sharply expressed relation of ice cover occurrence and 11 year cycle of sun activity has disturbed, range of two year fluctuations has decreased, opposition between the Okhotsk and the Bering Seas has disappeared, the volume transport of the main currents has appreciably decreased, the Okhotsk Sea polynia has often closed and so on. The changes of thermal regime in some "natural areas" of the Northern Pacific are different. So, evident "cooling" is observed in the South Kuril area located in subarctic zone.

Marine biota reacted on the mentioned changes in seas by changes of biomass and structures of plankton and nekton communities (Shuntov, 1993). There have been observed different changes in abundance of the main commercial species that caused the decrease of some targets' catch (sardine, walleye pollock....) especially at the edge of their area and increase of another ones (some herring stocks). Pacific saury abundance has increased, size structure and stock density have changed on the background of summer "cooling" in the South Kuril area.

5AM1996-POC20

oral

HYDROLOGICAL AND ACOUSTIC CHARACTERISTICS THE COLD CURRENTS IN THE NORTHWEST PACIFIC AND ATLANTIC OCEANS

Feodor F. Khrapchenkov, *Pacific Oceanological Institute, 43 Baltyiskaya Street, Vladivostok, Russia. 690041*

Hydrological and acoustic environment in the off-shore of Kamchatka Peninsula in Pacific and East-Greenland continental shelf in Atlantic are formed in complicated conditions. The determinative influence is that of East-Kamchatka Current in Pacific and Greenland Current streaming along the continental slope and transporting cold waters. Complexity consists in variety of interaction of this flux with different structure forming factors. These are both active interaction with cold and less salt shelf waters and the influence of more warm and cold waters of the adjacent areas of the Oceans. Significant role is plaid by interaction of the moving flux with the sinuous coast line and the continent slope as well as the climate influence. All this influences the spatial-temporal variability of hydrophysical characteristics of waters leading to origination of fronts on the boundaries of the current and the vortices, as well as to formation of intrusions of different types. The formation of the anticyclonic vortices, their transfer along the coast along with the specific peculiarities of the waters structure in the region lead to the significant changes in conditions of sound signals distribution both along the coast and in the off-shore direction. It takes place the uplift of the underwater sound signal up to the depth of 20-40 m, horizontal gradients of sound velocity being increased simultaneously. These areas are bound by sound velocity isotaches in the field of sound velocity and relief of the continental shelf comprising a closed three dimensional wave guide with sound velocity drops up to 40 m/s.

5AM1996-POC21

oral

SEASONAL VARIATION OF THE EAST KOREAN WARM CURRENT

Kuh Kim¹ and Yang-ki Cho²

¹ Department of Oceanography, Seoul National University, Seoul 151-742, Republic of Korea

² Department of Oceanography, Chonnam National University, Republic of Korea

Hydrographic data and satellite images indicate the East Korean Warm Current(EKWC) from April through late autumn, but its absence in February. The EKWC flows northward along the Korean coast in summer when the cold lower layer becomes thick enough in the Ulleung Basin. Generation of negative vorticity due to the intrusion of the cold water in the Korea Strait may be responsible for the formation of the EKWC rather than the planetary beta-effect.

5AM1996-FIS13

oral

DID CLIMATE REGIME SHIFT IN 1976 IN THE NORTH PACIFIC OCCUR IN KOREAN WATERS?

Suam Kim¹ and Sinjae Yoo²

¹ Polar Research Center, KORDI, Ansan P.O. Box 29, Seoul, Korea. 425-600

² Biological Oceanography Division, KORDI, Ansan P.O. Box 29, Seoul, Korea. 425-600

In the north Pacific, climate showed a decadal scale of abrupt change, called climate regime shift. Recent change happened in 1976, and it persisted over ten years until late 1980's, showing the intensified low pressure systems replaced the high in the north part of Pacific Ocean. Accordingly, primary production, species composition and its distribution in marine ecosystem were also changed due to the increased sea water temperature and storm intensity. In Korean waters, there might be some changes in sea water properties and ecosystem structure. Warm water temperatures appeared during 1975-1980 in the East Sea, and the catches of some fish species had a tendency of decrease or increase after mid 1970s, though catch records does not always indicate the stock condition. Pink salmon catches from the North Korea since 1920s are very similar to the patterns found in the Alaskan waters.

5AM1996-POC22

oral

INTERDECADAL VARIATIONS OF THE PACIFIC OCEAN AS AN IMPACT OF INTERDECADAL TROPICAL VARIABILITY IN AN MRI COUPLED GCM

Y. Kitamura, Masahiro Endoh, and S. Yukimoto, Meteorological Research Institute, Nagamine 1-1, Tsukuba, Japan. 305

Interdecadal variations of the Pacific climate and ocean are simulated in an MRI coupled GCM with 120 years integration. ENSO variations with a spectral peak in the 3-6 years period, affect the mid-latitude atmosphere and ocean, mostly via atmospheric signals propagating with a PNA pattern. Coupled variations of tropical Pacific climate and ocean in the time-scale longer than 12 years also induce pan-Pacific interdecadal variations both in the mid/high atmospheric system and the subtropical/subarctic ocean gyre system. Strengthening and southward shift of the Aleutian low pressure system are typical and similar to the observed 'climate shift in 1976'. Spatial pattern of associated cooling of the upper ocean temperature in the mid/high latitude is also similar to that of the observed change. Spin-up of the subtropical gyre (or increase of the gyre mass transport) driven by the associated increase of the wind stress curl over the subtropical gyre, is accompanied by increase of the northward heat transport in the subtropical gyre, which is estimated as 0.2 peta Watt along the 30N latitude.

5AM1996-SB12

poster

GLOBAL CLIMATE CYCLES AND PELAGIC FISH STOCK FLUCTUATIONS IN THE NORTHERN AND SOUTHERN PACIFIC

Leonid B. Klyashtorin, *Russian Federal Institute of Fisheries and Oceanography (VNIRO), 17v.Krasnoselskaya, Moscow, Russia. 107140*

Main Pacific commercial species: Peruvian, Japanese and Californian sardine, Anchovy, Pacific salmon, Walleye pollock, Chilean jack mackerel, Pacific cod, and some others are involved in long-term simultaneous oscillations. Northern Hemisphere surface air temperature anomaly (dT) and Aleutian Low Index (ALPI) trends being strongly smoothed, demonstrate general direction of climate changes, though without reliable predictive meaning for main commercial stock trends.

The climatic index most closely related with long-term fluctuations of main commercial stock trends (Corr.Coeff 0.82- 0.94) is so called Atmospheric Circulation Index (ACI) characterizing the principal direction of aerial mass transport (meridional or latitudinal). This index has been registering continuously in Northern Hemisphere since 1891 for more than 100 years.

ACI long-term dynamics are in phase with general smoothed dT and ALPI trend, and they both have been in tight correlation with the trend of a global geophysical characteristic: Earth Rotation Velocity Index (ERVI), for more than 100 years. Cyclic variations by period of 50-60 years were observed in stock dynamics of main commercial species, ACI and ERVI trends.

The fluctuations of main commercial species production in the Pacific over last century can be pictured as two sequential climate governed production cycles, with maxima in the late 1930s and in late 1980s-early 1990s. The latter cycle now comes to its final phase, similar to the phase of the 1940-1950s. The climatic (dT,ALPI,ACI) and geophysical (ERVI) indices are also close to their descending phase. The adaptation of long-term ACI (and ERVI) variations to elaborate a predictive "climate regime model" to forecast general trends of main Pacific commercial stocks for future 2-15 years and correct them timely if necessarily.

5AM1996-SB13

poster

PACIFIC SALMON: CLIMATE LINKED LONG TERM STOCK FLUCTUATIONS

Leonid B. Klyashtorin, *Russian Federal Institute of Fisheries and Oceanography (VNIRO), 17v.Krasnoselskaya, Moscow, Russia. 107140*

According to historical and statistical data, three maxima of salmon production have taken place over past 120 years: in 1870s, 1930s and 1990s. A careful correction of commercial statistics shows that total salmon harvest reached 1.1 million tons in the 1930s, declined to 0.4 million tons in the 1950-1960s and rose again to about one million tons in the early 1990s. Thus, carrying capacity of the North Pacific for salmon is not constant, and exhibits long-term fluctuations, with a period of about 60 years. An attempt has been undertaken to find out what climatic characteristics correlate reliably with long-term dynamics of the salmon stocks. Northern Hemisphere surface air temperature anomaly (dT) and Aleutian Low Pressure Index (ALPI) trends being strongly smoothed demonstrate general direction of Global Climate changes, though without reliable predictive meaning for Pacific salmon stock production. Atmospheric Circulation Index (ACI) trend that characterizes principal direction of air masses transport in the Northern Hemisphere is in phase with general trend of dT and global geophysical characteristic: the Earth Rotation Velocity Index (ERVI). The ACI and ERVI trends correlate tightly (Corr.Coeff. is 0.84-0.90) with Pacific salmon stock trend for 1920-1994. ACI and ERVI can be considered as predictive indices to forecast (and to correct, if necessary) the long-term dynamics of Pacific Salmon stock for 3-15 years based on "Climatic regime model". Variation of Pacific salmon population over last century can be pictured as two sequential climate-governed cycles observed in the 1920-1930s and 1980-1990s. The recent cycle is not completed yet, but in accordance with climatic trends it comes to its final phase similar to period of the 1940-1950s. The salmon harvest is at its top point now, but the salmon population will start to decline gradually in nearest

future. The long-term Pacific salmon fluctuations are in phase with fluctuations of main commercial species of the north Pacific.

5AM1996-BIO11 oral
INFLUENCE OF THE STRATIFICATION TO THE PRIMARY PRODUCTION OF THE OYASHIO REGION USING A ONE-DIMENSIONAL MODEL

Tokihiro Kono¹, Michio Kawamiya², Hiromi Kasai¹ and Hiroaki Saito¹

¹ Hokkaido National Fisheries Research Institute

² Center for Climate System Research, University of Tokyo

A vertical one-dimensional ecological-physical coupled model was developed. Calculated results were compared with results of the observation performed between 13 and 18 June 1996. A drifting buoy with a thermister chain was set in the Oyashio region southeast off Hokkaido Japan. We collected physical (CTD, micro-structure profiler, wind, irradiance), chemical (nutrients), and biological (chlorophyll, primary production, natural fluorescence, nitrogen uptake, zooplankton biomass, zooplankton ingestion) data while tracking the buoy. The ecosystem model was tuned and validated using the data obtained. Vertical diffusion coefficient was calculated using a mixed layer model coupled and was compared to temporal change of chlorophyll, primary production. The effects of vertical stratification to the primary production will be discussed in this paper.

5AM1996-BIO12 poster
DIEL RHYTHM OF OVULATION AND SPAWNING, AND SPAWNING FREQUENCY FOR THE PACIFIC SAURY, COLOLABIS SAIRA, IN THE NORTHWESTERN PACIFIC OCEAN

Yutaka Kurita, Y. Oozeki and Y. Takahashi, *Tohoku National Fisheries Research Institute, 3-27-5 Shinhama-cho, Shiogama, Miyagi, Japan. 985*

The Pacific saury is a key species of the food web in the northwestern Pacific Ocean. It is also the main target species of fisheries. This species spawn multiple times during late autumn and late spring. In order to reveal the mechanism of population dynamics, the knowledge of reproductive traits is required.

In this paper we examined the timing of ovulation and spawning based on histological conditions of the oocytes and postovulatory follicles. We also estimated spawning frequency from those examination. Ovaries from 240 females, collected at 4-h intervals during 3 days (29 June - 2 July, 1995), were sampled. Ovulation occurred mainly in the daytime, and spawning showed no pattern with time. Females were likely to spawn at 5 - 10 day intervals.

5AM1996-FIS14 oral
RECENT CHANGES IN POPULATION STRUCTURE OF YELLOW CROAKER, PSEUDOSCIAENA POLYACT BLEEKER, IN THE WEST COAST OF KOREA AND THE EAST CHINA SEA

Jang-Uk Lee and Cha-Soo Park, *National Fisheries Research and Development Agency, 408-1 Sirang-Ri, Kijang-Up, Kijang-Kun, Pusan, Republic of Korea. 619-900*

Population structure of yellow croaker, one of the most commercially important fin fishes in Korea not only in terms of marine production but also on economic viewpoint, was reviewed to understand historical changes in temporal-spatial distributions, size- and age compositions including sexual maturation during spawning season based on the fishery data and scientific information available for this fish species between 1970 and 1994.

Yellow croaker has been mainly used from both large pair trawl and offshore stow net fishery, accounting for about 75% of the total catch on the average per annum. Annual total catch showed much fluctuations between years with the peaks of 54,000 and 48,000 metric tons in 1974 and 1980, respectively. During 1983 to 1986, it decreased to less than 10,000 tons, a lowest record levels since commence of fishing for this fish resource. From 1987 onward, however, annual catch increased year after year and in 1992 it was about 40,000 tons.

A reduction of fishing areas off the west coast of Korea and an expansion to the areas in the East China Sea during the study periods between 1974 and 1990-1992 existed obviously: geographical dense distribution regions of yellow croaker in 1974 were placed in the area off the southwest coast of the Korean peninsula, 35°N to 36°N and 125°E to 126°E, from May to August known as spawning season. In recent years, the dense area located in 1974 no longer appeared during the period of 1990-1992 but fishing was mainly concentrated in a wide area of the East China Sea, 31°N to 33°N and 123°E to 125°E, throughout the whole year except several months.

In recent years' data, there has been a decrease in percentage of large fish (more than 30 cm TL) from historical length compositions. Average lengths have not varied much between years, ranging between 15.9 cm and 17.8 cm TL. From the second half of 1980s, the average values were estimated to be over 17.0 cm TL, indicating an increase of about 1.0 cm in average size compared with the 1970s' values. In the age compositions estimated from the age-length key data, the percentage of old fish (over 5 years old) showed a tendency decreasing over that of the 1970s and 1980s. The age range of this fish species shrunk from 0-10 years old in the past two decades to 0-7 years old in 1994. The average ages remained unchanged between 1.1 and 1.3 years of age. According to recent determination on sexual maturation of this fish species, small yellow croaker less than 19.0 cm female which was reported as an average size at first maturity from previous study showed its high gonado-somatic index in May that might reveal to be related to spawning activities.

Even though this analysis was very restricted to comparison of some ecological aspects, there existed changes in population structure of this fish species. It was required from this analysis that core attention should be paid to reproductive potential of the spawning stocks as well as long-term effects in the fishery for yellow croaker.

5AM1996-MEQ07 oral
DISTRIBUTION OF TRIBUTYL TIN IN SEDIMENTS, MUSSELS AND OYSTERS FROM
CHINHAE BAY, KOREA

Kwang Woo Lee¹, Hyun Min Hwang¹, Jae Ryoung Oh² and Sung Hyun Kahng²

¹ Department of Earth and Marine Sciences, Hanyang University, Ansan, Kyunggido, Republic of Korea. 425-791

² Chemical Oceanography Division, Korea Ocean Research & Development Institute (KORDI), P.O. Box 29, Ansan, Seoul, Republic of Korea. 425-600

To study the historical and current status of the environmental levels of organotin compounds in Chinhae Bay in the southeast Korea, sediment cores, mussels (*Mytilus edulis galloprovincialis*) and oyster (*Crassostrea gigas*) were analyzed for tributyltin compounds. The concentration and percentages of TBTs in sediment cores decreased with depth as result of debutylation. Half-lives of TBT and DBT in sediments were 6.9 and 11.6 years, respectively. TBT concentrations were little higher in oysters (mean : 0.61 $\mu\text{gTBT/g d.w.}$) than in mussels (mean : 0.48 $\mu\text{gTBT/g d.w.}$). The TBT concentrations in mussels were higher than those in sediments by a factor of 4 to 7. The major sources of TBT were in the inner Bay, and the highest TBT concentrations of 1.21 $\mu\text{g/g}$ (mussels) and 1.80 $\mu\text{g/g}$ (oysters) were observed at St. 2, adjacent to the port. Concentration of TBTs decreased sharply with the distance from the inner bay toward the outer bay, and there was almost no significant levels of TBTs in the outer bay. Significant correlation was observed between the distance and the tissue TBT levels in oysters and mussels.

5AM1996-MEQ08 oral
PRELIMINARY ANALYSES OF BIOTA IN BALLAST WATER COLLECTED IN SHIPS
ARRIVING AT BRITISH COLUMBIA PORTS FROM THE WESTERN NORTH PACIFIC
Colin D. Levings, Department of Fisheries & Oceans, Science Branch, 4160 Marine Drive, West
Vancouver, BC, Canada. V7V 1N6

Numerous invertebrate and plant species have been transferred from the western North Pacific to the eastern North Pacific through a variety of mechanisms including oysters shipments, ship hull fouling, and intentional introductions. In this paper, preliminary results of an Investigation of transfer via ship ballast water will be presented. Biological samples of ballast water obtained in ships arriving in four British Columbia harbours from ports in the western North Pacific were obtained on a monthly basis beginning in December 1995. Temperature and salinity data of the ballast water were also obtained. Calanoid, cyclopoid, and harpacticoid copepods were the dominant organisms but a wide variety of taxa were also encountered including decapod zoea larvae, polychaetes, and cumaceans. Detailed identification of these species is proceeding but collaborators from the western North Pacific could assist this taxonomic work. Our results indicate that significant amounts of water must be disposed of before the ships arrive in port since many ships were encountered with only partially filled ballast tanks. In addition numerous vessels also exchange ballast water in mid-Pacific, judging from salinity information and interviews with the ships' Masters. Implications of the findings for natural ecosystems and aquaculture operations will be discussed.

5AM1996-POC23 oral
ZONALITY OF NEAR-CONTINENTAL SEDIMENTARY PROCESS AND AZONATE
MATTER FLUXES THROUGH SHELF

F.R. Likht¹ and Arkady V. Alekseev²

¹ Pacific Oceanological Institute, Far East Branch, Russian Academy of Sciences, 43 Baltiyskaya Street, Vladivostok, Russia. 690041

² Far East Branch, Russian Academy of Sciences, 50 Svetlanskaya Street, Vladivostok, Russia. 690600

The zonality is the main singularity for the near-continental sedimentary process. The zonality is reflected in a regular distribution of sediments on seafloor of marginal seas according to structure-matter properties and, in main, to the accumulation velocities. The regularity is determined by the terrigen composition of sediment material and processes of its mechanical differentiation in the sedimentary process in accordance with the hydraulic sizing of particles.

The zonality of sediment formation into seas with deep-water basins is reflected by that the intensive sedimentation of material observed near by the coast line and internal shelf in a part. The next zone of active accumulation is observed on the low part of continent slope and it's foot. It is need to remark the boards of zones are parallel for the coastal line approximately. These accumulation zones is separated by the external shelf and upper part of continent slope. The terrigen suspended matter is not practically sedimented and the most ancient (relict) sediments can be observed at here.

The very zones with the absence (null sedimentation) of sedimentation have considerable areas on wide shelves. The fluxes of fine sediment material have been during last years determined in these zones (as a rule it was black muds) guttering from the coast to the slope through the shelf and to the deep water seafloor in the next. They have the name "transit near-bottom fluxes of matter" and connected with the ancient river set submersible on the shelf. Valleys of these ancient rivers have a different morphological structure into the bottom relief. The very structure may be presented by good conserved cuts into surface as on the shelf of the East-Korean Bay in the Sea of Japan or by light observed linear lows as near by paleo-Mekong on the shelf of the South-China Sea.

The very transit fluxes are not so well investigated at the present time, but at the same time they are very perspective for applied investigations. They can be used for effective natural removing of low-toxic wastes generated by urban coasts. The structure of transit fluxes can give the information about the system of ancient submersible rivers. The last information is very important for the

estimation of the shelf resources such as springs of underground fresh waters and alluvial deposits. The reconstruction of their evolution can be also done.

5AM1996-FIS15 oral
FISHERIES AND STOCK BIOMASS OF FILEFISH NAVODON SEPTENTRIONALIS AND VARIATIONS OF PHYSICAL ENVIRONMENT IN THE EAST CHINA SEA
Chuanlan Lin, Bingrong Xu and Shanhua Li, *Second Institute of Oceanography, State Oceanic Administration, Hangzhou, Zhejiang, People's Republic of China. 310012*

In the East China Sea, the filefish *Navodon septentrionalis* is one of main catch objective in winter/spring fisheries produce since 1974. In winter/spring, they feed, spawn and migrate along the left flank of front of the Kuroshio Current and its branch in the East China Sea, forming the fishing ground. Using the monthly commercial fisheries catch statistics of filefish *Navodon septentrionalis* and the stock biomass by estimation, temporal variations (1974-1992) of the catch, the stock biomass,, their relationship to variations of physical environment in the East China Sea were investigated. During 1974-1992 stock biomass of filefish *Navodon septentrionalis* had three period of variation with 7-9 yr. Highly production generations maybe lasted 3-5 yr., lower productive generations lasted 3-4 yr. However, the yearly total and monthly catch has a 2-3 yr. Oscillation. Highly productive generation (1983) does not mean the appearance of high catch. Contrary, in lowest productive generation (1989) among all investigated years, have got highest catch. Interannual variations of the central fishing ground distribution were also evident. It suggested that the hydrometeorological processes in the East China Sea influence on the stock biomass, catch and central fishing ground distribution. In this paper, it will be described in detail.

5AM1996-MEQ09 oral
CHINESE MARINE AND COASTAL CONSERVATION AND MANAGEMENT
Hongbin Liu, *Institute of Marine Economics, 8 Gold Lake Road, Qingdao, Shandong, People's Republic of China.*

Chinese coastal philosophy seeks to preserve the most scenic coasts and islands, at the same time recognizing multiple forms of use to which coastal zone and ocean environments are subjected. To date a total of 68 national and local marine and coastal nature reserves have been established. This represents only a very small percentage (less than 3%) of Chinese coastline and islands to be declared natural conservation sites compared with developed countries, for example, England and Wales, UK, where 33% of the coast has been defined as Heritage Coasts alone.

To protect the coastal and marine environment, especially to protect and rescue coastal and marine ecosystems and species. Laws and regulations were enacted, making protection and management of coastal conservation necessary. Some suggestions to the Chinese government to protect the finest coast and marine areas are proposed.

5AM1996-MEQ10 oral
CONNECTION HIGH PHYTOPLANKTON PRODUCTIVITY ON THE OKHOTSK SEA SHELF WITH ANOMALIES OF MERCURY
Luydmila N. Luchsheva, *Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

Coastal zones have great importance in formation of high bioproductivity of the Okhotsk Sea waters. They are characterized intensive change of currents, formation of whirlwinds and upwellings, high volcanic activities.

The biosubstances delivered of upwellings and volcanic activity products create in these zones favorable conditions for high phytoplankton productivity.

The raised contents of mercury were found in bottom layer of water in Kuril and Sakhalin shelf zones and in the source of Shelikhov Bay. These researches are spent in 1993 during 24th cruise of the R/V "Academic Alexander Nesmeyanov".

The raised concentrations of mercury changed in bottom layer of water from 0.122 up to 1.760 mkg/l (at background meaning 0.025 mkg/l). The contents of mercury in the upper microlayer of water was also raised (up to 0.061 mkg/l) in comparison with background (0.025 mkg/l). The concentration of mercury in surface 1-m layer of water did not exceed usually background meaning (0.020 mkg/l). Sakhalin shelf is the exception, because there high mercury concentration were marked in surface layer of water, which were observed on the stations with a sharply varied direction of the current.

As is known, the mercury is the indicator of volcanic activity and can to accompany with nutritious substances, which cause rough phytoplankton "blooms".

The phytoplankton bioproductivity has appeared raised in places of display of mercury, where it is caused same genus of Diatomea. The sizes of bioweight exceeded here productivity of typical upwelling zones on the average in 5.5 times, and background zones almost in 30 times.

The heaviest phytoplankton bioweights (up to 550 862 mg/m sq.) were observed in those zones, where together with displays of mercury were observed the upwellings and high dynamic activity of the waters. However, size of bioweight were significant lesser (up to 81 580 mg/m sq.) there, where were marked intensive display of mercury, but the upwelling was weak. This phenomenon is caused, probably, the poisonous properties of mercury.

These zones are possible to consider as activators of high bioproductivities, because they are characterized steady more by high its level in comparison with other regions of the Okhotsk Sea.

The active hydrodynamics of these zones creates the conditions for formation of whirlwinds with high phyto- and zooplankton bioweights, which then are moved in low productive water of the nearby ocean. These dynamic structures are capable to transfer high plankton bioweights and by that to promote expansion of feeding area of trade kinds of fishes.

5AM1996-FIS16 oral
ACCELERATED NATURAL MORTALITY RATES CAN CAUSE ERRORS IN FISHERY STOCK ASSESSMENT AND MANAGEMENT
Alec D. MacCall, NMFS/SWFSC Tiburon Laboratory, 3150 Paradise Drive, Tiburon, CA 94920. USA

Contrary to the widespread fisheries assumption that the natural mortality rate is invariant with age, the natural mortality rate may increase with age (i.e., the natural mortality rate is accelerated) for many species and stocks. This leads to a natural truncation of age distributions relative to those that would be expected under the constant mortality rate assumption, and is a potential source of systematic errors in fishery analyses.

Some examples follow:

--Average natural mortality rates may be overestimated, especially if estimates are based on the oldest known age, leading to overestimated MSY.

--VPA stock assessments may be affected due to violation of assumptions linking estimated mortality rates of older age groups.

--Stock synthesis assessments may produce erroneous dome-shaped selectivity curves, falsely indicating that old fish are less vulnerable to fishing gear.

--Erroneous dome-shaped selectivity curves may imply existence of "uncatchable" old fish that do not actually exist, leading to errors in the estimated stock-recruitment relationship, and increasing risk of overfishing.

--Simulations indicate that the average natural mortality rate of an exploited stock may be 5 to 20% lower than the rate for an otherwise identical unexploited stock.

The consequences of an unrecognized acceleration of the natural mortality rate depend on many factors, including the life history characteristics of the fish, the history of exploitation, and the methodology use to assess the stock. Sensitivity analysis provides a means of evaluating the severity of this potential error.

5AM1996-POC24

oral

HORIZONTAL EXCHANGE OF PLANKTON AND NUTRIENTS BETWEEN THE VANCOUVER ISLAND CONTINENTAL SHELF AND THE ADJOINING DEEP NORTH PACIFIC

David L. Mackas, D.R. Yelland, Kenneth L. Denman, J.R. Forbes and D.F. Moore

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

The British Columbia continental margin forms the upstream end of the California Current system. Most of the flow of water is alongshore. But eddies, meanders and "filaments" along the shelf break and slope cause strong and spatially-localized cross-shore exchange of water, nutrients, and biota. As part of the Canadian JGOFS program, we examined this exchange by mapping alongshore distributions of current velocity, water properties (including nutrients), phytoplankton and zooplankton on several occasions between 1986 and 1995.

Narrow (20-30 km) tongues of shelf water often extend seaward order 100 km beyond the shelf break. These contain elevated nutrient, chlorophyll, and shelf zooplankton (copepod, larval euphausiid) concentrations. Measured seaward velocities were sometimes greater than 0.5 m s^{-1} , but more commonly circa 0.1 m s^{-1} . Satellite images show two to three recurrent locations roughly evenly spaced along Vancouver Island: circa 50°N (off Brooks Peninsula), circa 48°N (off the mouth of Juan de Fuca Strait), and less often circa 49°N (off Hesquiat Peninsula/Estevan Point). Occurrence and magnitude of the upwelling filaments covaried with seasonally-averaged Bakun upwelling index anomalies.

5AM1996-SB14

oral

A PACIFIC DECADEAL CLIMATE OSCILLATION WITH IMPACTS ON SALMON

Nathan Mantua, Steven Hare, Yuan Zhang, John Wallace and Robert Francis

University of Washington, JISAO, Box 354235, Seattle, WA USA 98195-4235

Evidence gleaned from the instrumental record of climate data identifies a robust, recurring pattern of ocean-atmosphere climate variability centered over the mid-latitude Pacific basin. Over the past century, this oscillation in Pacific basin climate has varied irregularly at interannual-to-decadal time scales. There is compelling support for reversals in the prevailing polarity of the oscillation occurring around 1925, 1947, and 1977; the last two reversals correspond with dramatic shifts in salmon production regimes in the North Pacific Ocean. This pattern of climate variability also affects coastal sea and continental surface air temperatures, as well as streamflow in major west coast river systems, from Alaska to California.

5AM1996-BIO13

oral

HOW DO EGGS AND LARVAE COME TO NURSERY BEYOND FRONT?

Katsumi Matsushita, *Department of Fisheries, University of Tokyo*

Most pelagic fish spawn their eggs at offshore area but the nursery is usually coastal area. We sometimes detected the patches of eggs and larvae at the frontal area as like they were induced to stay at the front. How do the eggs and larvae enter and/or entrainment nursery beyond the front?

I suspected that the recruitment success of white bait fishery may be influenced by physical entrainment from offshore spawning area beyond the front. Because the catch of white bait fishery was very fluctuate though the spawning potential was constant. I evaluated the entrainment by using 3 methods.

1. Distribution and abundance of eggs at frontal and offshore area by CPSs,
2. Daily population index of white bait fishery by otolith analysis,
3. Physical entrainment ration to the nursery area by drift card.

The CPS grid survey lines were arranged to cross the front, then I could detect the front and anchovy eggs patches accumulated along frontal area. At the same time, the drift cards were thrown at each continuous sampling station. The survey of offshore distribution of eggs were also carried out by another CPS. Furthermore, I collected anchovy larvae of white bait fishery and the data of catch per haul each 7 days between 10-30 days period after eggs distribution survey. The larvae were analyzed the otolith and estimated that birth date. Then, I could estimate the daily population index of the eggs distribution survey day.

The daily population index is not directly correlated to the abundance of eggs at frontal area. The drift card return ration to the nursery area is more important to predict the daily population index. Then, I supposed the recruitment success of white bait fishery was influenced by the physical phenomenon.

5AM1996-MEQ11

oral

TEMPORAL TRENDS IN CONCENTRATIONS OF CHLORINATED AND AROMATIC HYDROCARBONS IN FISH AND SEDIMENT FROM SELECTED SITES ALONG THE PACIFIC COAST OF THE U.S.

Bruce B. McCain, D.W. Brown, S.-L. Chan, J.T. Landahl, B. Horness, M.M. Krahn, C.A. Sloan, K.L. Tilbury, S.M. Pierce, D. Burrows

Environmental Conservation Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 2725 Montlake Boulevard East, Seattle, WA 98112, U.S.A.

Concentrations of organic contaminants were monitored in sediment and bottomfish from 49 sites along the coastlines of Alaska, Washington, Oregon, and California during the years 1984-1990. Temporal trends of concentrations of contaminants in sediment and fish were evaluated by first performing Spearman rank correlations on concentrations of each of six classes of contaminants in sediment and in stomach contents and tissue for each fish species at each site. Only sites for which analyses had been conducted for at least four years were used ---14 sites met this criterion. The results showed statistically significant ($p \leq 0.05$) increasing trends, based on meta-analysis of correlations found for both sediment and fish, for polycyclic aromatic hydrocarbons (PAHs) at eight of the sites, for dieldrin at four sites, for chlordanes at three sites, and for DDTs and PCBs at two sites. Among the decreasing trends, concentrations of chlordanes, PCBs and DDTs were each decreasing at three sites, and concentrations of dieldrin and PAHs were each decreasing at two sites. All three of the nonurban, reference sites and five of the urban sites in San Francisco Bay (two sites) and San Pedro Bay (two sites) (CA), and Commencement Bay (WA) had significant increases in PAHs. These results suggest that, since the mid-1980s, concentrations of persistent chlorinated hydrocarbons, such as

PCBs and DDTs, show no consistent temporal trends, whereas levels of PAHs, which are non-point source contaminants, are more consistently showing increases at both nonurban and urban near-coastal sites.

5AM1996-Fis17

oral

THE IMPORTANCE OF LONGEVITY IN THE LIFE HISTORY OF SABLEFISH (*ANOPLOPOMA FIMBRIA*)

Gordon A. McFarlane and Richard J. Beamish, *Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, B.C., Canada. V9R 5K6*

Sablefish have been reported to live to ages greater than 70 years. Growth is rapid to age 5 at which time most fish mature. Growth slows after maturity and is greatly reduced after age 10. Both males and females continue to live for long periods during which little growth occurs. We propose that the longevity and pattern of growth is an adaptation to occupying a deep spawning habitat which is suitable for reproduction provided the appropriate environmental and biological conditions exist. The length of life of sablefish may correspond to the maximum period (over evolutionary time) that unsuitable conditions have occurred. In an unfished population long life would ensure that the habitat is occupied. Fishing reduces the number of occupants of the habitat but in a favorable environment (and under appropriate management strategies) the occupants are replaced through recruitment. However, fishing strategies that consider longevity only in relation to mortality have a tendency to reduce the number of older fish in a population. In an unproductive regime recruitment may be very low and the fishery needs to be regulated so that suitable adult spawning and rearing habitat is occupied for the duration of the unfavorable regime. This requires an understanding of the impacts of fishing and changes in the longevity and growth of the population.

5AM1996-SB15

invited

AN OSCILLATION OF PERIOD 50-60 YEARS OVER THE NORTH PACIFIC

Shoshiro Minobe, *Division of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University, Sapporo, Japan. 060*

The interdecadal variability over the North Pacific and the vicinity of the basin were analyzed. The climate changes (regime shifts) that have similar spatial distributions as the change in the 1970s are detected in the 1920s and 1940s, with alternative signs. These three changes exhibit coherent signals in sea-level pressure in the North Pacific, air-temperature over the North America, and SST at the Japan coast. Corresponding SST changes in the tropical Indian Ocean suggest that these changes originate in the tropics.

The multi-taper spectrum analysis reveals that the interdecadal signals have a period of 50-60 years. The 50-60 year variability also exist in the 19th century in dendroclimate records over the United States, implying that the variability is natural one and not due to the anthropogenic forcing. Interestingly, the global temperature rise in the present century occurred roughly in the regimes of deepened Aleutian low and warmer SST in the Indian Ocean-maritime continent region, implying that the natural 50-60 variability modulates the evolution of the global warming.

The water characteristics in the western North Pacific near Japan and in the Japan /East Sea were analyzed from the 1920s. The analysis reveals that all the three regime shifts affect the sub-polar circulation of the North Pacific. In the Japan / East Sea, however, the 1940s change caused much more significant influence than the change in the 1970s, resulting in the reduction of the formation rate of the deep water after the late 1940s to the present.

5AM1996-POC25

oral

NUMERICAL SIMULATION OF THE CIRCULATION IN PRINCE WILLIAM SOUND

Christopher N.K. Mooers and Jia Wang, *Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, USA*

As a follow-up to the EXXON VALDEZ oil spill of 1989, the Sound Ecosystem Analysis (SEA) Program is conducting a multi-year, multi-trophic level ecosystem study in Prince William Sound (PWS), Alaska. In support of the SEA Program, the Princeton Ocean Model (POM) is being utilized to simulate numerically the circulation, and this implementation is referred to as PWS-POM.

PWS-POM has been implemented with 1.2 km horizontal resolution and 15 sigma (terrain-following) levels. It is presently forced by (1) inflow from the Alaskan Coastal Current, (2) winds, and (3) tides. Later, PWS-POM will also be forced with (4) heating/cooling, (5) evaporation/precipitation, and (6) freshwater runoff. Over the next few years, it will be evolved into a nowcast/forecast system driven by synoptic (operational) atmospheric forcing.

The initial simulations indicate the strong (cyclonically bending) throughflow, development of mesoscale eddies, strong residual circulation from tidal flow nonlinearities due to topographic interactions, and a typical response time of ten days to changes in forcing. Passive tracer calculations give insight into advection and diffusion patterns, the complex "residence time" topic, and identification of potential retention zones. In the future, such calculations will be utilized to investigate the transport and dispersal of herring larvae, and to test hypotheses about wintering-over strategies of zooplankton and local versus offshore sources of zooplankton populations.

5AM1996-POC26

oral

NUMERICAL SIMULATION OF THE JAPAN SEA (EAST SEA) CIRCULATION

Christopher N.K. Mooers and HeeSook Kang, *RSMAS/University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, USA*

The Princeton Ocean Model (POM) is used to simulate and understand the circulation of the Japan Sea (East Sea). (SOJ-POM has been implemented with ca. 10 km horizontal resolution, 15 sigma (terrain-following) levels, and 10 sec for external and 5 min for internal time steps.) To investigate the importance of the windstress, and of the amount of inflow through the Korean Strait, for forcing the model circulation, several sensitivity experiments are described. All cases were initialized with the annual mean Levitus climatology and use relaxation to surface climatology (with a relaxation time of 100 days) for surface thermohaline forcing.

First, comparison of the results from two different windstress data sets [Hellerman and Rosenstein (1983) and Na (1992)], indicate that, due to major differences between the two windstress curl distributions along the east coast of Korea and the Primorski coast of Russia, the East Korean Warm Current (EKWC) separates from the coast at 38N (as expected) for the Na windstress case but EKWC overshoots to 42N for the Hellerman and Rosenstein case.

Second, comparison of the results from seasonal inflows (for the wintertime case, 1.4 Sv; for the summertime case, 4.2 Sv) through the Korean Strait, indicates much more vigorous mesoscale variability in the upper layer in the southern region, and that the EKWC separation point is displaced northward, during summer.

Third, some time series from the longest experiment, which uses annual mean Hellerman-Rosenstein windstress and annual mean (2.8 Sv) inflow, indicate the model evolution throughout the water column. For example, with steady forcing, strong current fluctuations (10 to 20 cms⁻¹) on a few month time scale extend from surface to bottom.

The intention, over the next few years, is to compare SOJ-POM with recent observations and other models, and to help evolve a nowcast/forecast system for Japan Sea (East Sea).

5AM1996-BIO14

poster

POPULATION STRUCTURE AND GROWTH OF THE NEON FLYING SQUID (OMMASTREPHES BARTRAMI) IN THE NORTH PACIFIC OCEAN

Junta Mori, Kazuya Nagasawa, Akihiko Yatsu, Hiroyuki Tanaka and Hiroshi Okamura, *National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, Japan. 424*

The North Pacific neon flying squid is known to consist of the autumn cohort and the winter-spring cohort, based on the hatch date distribution. The purposes of the present study are to identify geographic populations in the winter-spring cohort by parasites as biological tags and to examine the growth variability of this species from different areas. A total of 1,516 squid (118 - 571 mm in mantle length [ML]) from a wide area of the North Pacific (24 - 47N, 147E - 135W) during 1991-1995 were examined for endoparasites.

The ages of 229 squid were also estimated by reading number of increments in the statoliths and their growth rates were compared between areas.

Squid from the central-eastern North Pacific (east of 170E) had significantly higher infection level of *Lappetascaris* sp. (Nematoda) than those from the western North Pacific (west of 170E). The individual overall growth rates (ML in mm divided by age in days) were positively correlated with their estimated hatch dates during January 1 - May 31 for both areas and sexes. Adjusted means of the overall growth rates were significantly higher (1.71 for females, 1.69 for males) for the western Pacific squid than those for the central-eastern squid (1.45 for females, 1.56 for males). These results suggest that the winter-spring cohort is composed of two geographic populations in the North Pacific.

5AM1996-BIO15

poster

LATITUDINAL CHANGES IN BIOMASS OF MACROZOOPLANKTON AND PHYTOPLANKTON IN THE NORTHERN NORTH PACIFIC AND BERING SEA IN EARLY SUMMER

Kazuya Nagasawa¹, Akihiro Shiimoto¹, Kazuaki Takokoro² and Yukimasa Ishida¹

¹ *National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, Japan. 424*

² *Ocean Research Institute, University of Tokyo, Nakano, Tokyo, Japan. 164*

Latitudinal changes in biomass of macrozooplankton and phytoplankton were surveyed along a transect at 179° 30'W from 38° 30'-58° 30'N in the northern North Pacific and Bering Sea in the early summer, 1992-1993. The most interesting results of this study is that there was a reverse relationship between macrozooplankton biomass and phytoplankton abundance. In the Bering Sea (52° 00'-58° 30'N), macrozooplankton biomass was low but phytoplankton abundance was high. Macrozooplankton biomass conversely high in the transition domain (42° 00'/43° 00'-46° 00'N) where phytoplankton stock was at a low level. In the subarctic domain (46° 00'-52° 00'N), macrozooplankton biomass varied between years, but phytoplankton abundance declined with increased macrozooplankton biomass. These latitudinal changes may have been caused by factors other than environmental elements, such as sea-surface temperature and macronutrients.

5AM1996-POC27

oral

ORIGIN OF WATER IN THE COLD WATER BELT APPEARING OFFSHORE SIDE OF THE SOYA WARM CURRENT NEAR LA PEROUSE STRAIT (THE SOYA STRAIT)

Akifumi Nakata¹, Iori Tanaka¹, Hiroki Yagi¹, Gennady Kantakov² and Andrew Samatov²

¹ Hokkaido Central Fisheries Experimental Station, 238 Hamanaka-cho, Yoichi-cho, Yoichi-gun, Hokkaido, Japan. 046

² Sakhalin Research Institute of Fisheries & Oceanography (SakhNIRO), 196 Komsomolskaya Street, Yuzhno-Sakhalinsk, Russia. 693010

Perouse Straits (the Soya Strait) and adjacent seas in August 1995 to obtain basic data for estimating the biological productivity in the area. In this observation, we had a chance to observe near center of the Cold Water Belt, which was formed offshore side of the Soya Warm Current near La Perouse Strait (the Soya Strait).

CTD data showed the water mass in the Cold Water Belt was well mixed vertically and has homogeneous properties in temperature and salinity (7.35°C, 34.098 PSU) from top to bottom except for just surface water.

From analysis of T-S relationships, the water mass of the Cold Water Belt was shown not to be made by lateral or vertical mixing with adjacent water masses in the Okhotsk Sea and Aniva Bay.

The distributions of temperature, salinity and the result of the current measurement show the water mass of the Cold Water Belt originates from the shallow area of the western shelf of Sakhalin through the lower layer in Sakhalin side of La Perouse Strait.

5AM1996-BIO16

oral

LONG-TERM FLUCTUATIONS IN THE FOOD AVAILABILITY FOR JAPANESE SARDINE LARVAE ON THE COASTAL SIDE OF THE KUROSHIO

Kaoru Nakata, National Research Institute of Fisheries Science, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Japan. 236

Stock size of Japanese sardine had started to increase in the first half of 1970's, when the main spawning ground was formed on the coastal side of the Kuroshio off Tokai and Kanto districts, the central parts of Japan. In order to examine the year to year fluctuation of food availability for sardine larvae on the coastal side of the Kuroshio, chlorophyll *a* concentration and biomass density of small copepods were examined during the main spawning season of sardine. Chlorophyll *a* concentration, which increased with decreasing in the mean wind speed and increasing in the mean global solar radiation in March, was probably high in 1972-1982. The small copepod community was often dominated by a neritic species, *Paracalanus* sp.. The biomass density of *Paracalanus* sp. was low in 1977-1980 when the Kuroshio continued to meander largely (A-type meandering period). During the A-type meandering, the Kuroshio counter current developed near the coast, which probably prevented the expansion of neritic small copepods on the coastal side of the Kuroshio. While, in the first half of 1970's, the neritic small copepods expanded their distribution to the waters on the coastal side of the Kuroshio and their biomass density was relatively high. The high biomass density of small copepods and the probable high chlorophyll *a* concentration coincided to the starting of increasing in the sardine stock.

5AM1996-BIO17 oral
ADAPTATIONS OF SPRING-SPAWNING WALLEYE POLLOCK, *THERAGRA CHALCOGRAMMA*, TO THE INHERENT ENVIRONMENTAL VARIABILITY OF THREE REGIONS

Jeff M. Napp, K.M. Bailey and M.K. Cohen, NOAA/Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115, USA

The walleye pollock, *Theragra chalcogramma*, is a key ecosystem species in the northern Gulf of Alaska and eastern Bering Sea. Distinct spawning populations persist despite regional differences in spring bloom dynamics and inherent susceptibility of larvae to environmental variability. In the northern Gulf of Alaska, there are several local populations, but the largest spawns with a single spawning pulse; if conditions are not favorable for early production of copepod nauplii, then larval survival is poor. Variability in cessation of winter storms, sunlight, and water column stratification (freshwater runoff in the Alaska Coastal Current) strongly influence the spring production cycle. Over the continental slope of the eastern Bering Sea, a single spawning pulse occurs. Larval prey concentrations are relatively low (< 10 nauplii liter⁻¹); energy for larval maintenance may be obtained from microprotozoa. Mesoscale variability dominates in this region; factors that influence eddy production variability are important. Production cycles over the southeastern Bering Sea shelf are strongly influenced by large variations in temperature and wind mixing. Pollock exhibit at least two spawning pulses over the shelf. First spawning pulse larvae are most vulnerable to starvation. In 1995, shelf temperatures were uniformly low ($< 0 - 2.5^{\circ}\text{C}$), and April prey concentrations were only 1.3 to 5.5 nauplii liter⁻¹ compared to 2.2 to 9.2 liter⁻¹ during the previous year ($2 - 4^{\circ}\text{C}$). In the cold year, May prey concentrations were < 1 to 13 liter⁻¹. In this system, temperature variability and its effects deserve further investigation -- they affect prey production and larval metabolism.

5AM1996-FIS18 oral
A STOCHASTIC MODEL FOR EXPLOITED FISH COMMUNITY

Vyacheslav V. Navrotsky, Leninsky prospect, 85, 2, Kaliningrad, Russia. 236039

A stochastic description of a system of N interacting fish populations under conditions of fishery is given. The evolution of the system is described by means of Ito's stochastic differential equations, which are the natural stochastic generalization of the Lotka-Volterra deterministic differential equations. Recurrence properties, stability, existence of the equilibrium probability distribution, and extinction probabilities are considered with regard to random both environmental and internal (in growth, generations, deaths, competition coefficients) fluctuations. The effect of fishing (in particular, the age structure altering) is analyzed. As the result of this analysis some conclusions important for the evaluation of alternative fishery management strategies are made.

5AM1996-BIO18 oral
INFLUENCE OF CLIMATE AND OCEANOLOGICAL FACTORS ON YIELD OF GREENLAND TURBOT BROOD OF THE OKHOTSK SEA

Larisa P. Nikolenko, Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko, Alley, Vladivostok, Russia. 690600

Greenland turbot biomass on the continental slope of the Okhotsk sea in 1977-1989 varied from 200 to 330 thousand tons. During this period the influence of fishery on population was insignificant. The natural change of broad abundance was the main reason of its stocks fluctuation. Comparison number of generations Greenland turbot with parameters, describing thermal mode of year to has shown that generation of higher number to occur in warm years, and low - in cold. So, during decrease of yield with 1967-71 years and with 1977 till 1982 basically fast process ice development occurred, by March the ice was covered more than 80 % of the sea, and the spring destruction of a ice went slowly - in April under ice still there were not less than 60 % of sea (Plotnikov, 1990). In these years the area of a nucleus of a cold of the north-Okhotsk shelf made not less than 130 thousand

square miles (Chernyavskiy, 1992), and on Avachinsk hydrological section was marked negative anomalies of temperature of a water in a cold intermediate layer (Davidov, 1984). At occurrence of the tendency to warming of the waters yield of it species began to grow. Generation of highest number (1975-1977) appeared when ice cover of the sea below 80 %, area of a nucleus of a cold consisted less than 120 thousand sq. miles, and on Avachinsk hydrological section took place positive deviations of temperature of a water of a cold intermediate layer.

Greenland turbot is cold boreal a kind and difficulty to admit, that just temperature of a water plays a mainly role in formation of generations number. Probably, the success of development eggs and larvae in a greater degree depends on a direction and speeds of currents, which are essentially distinguished in warm and cold years and are in turn stipulated by changes in atmospheric circulation. In warm years at the southern coast Kamchatka prevail southern winds, which result in strengthening of inflow concerning warm ocean waters in the Okhotsk Sea. Flow directed on north West-Kamchatka current in these years at western coast of Kamchatka form. Its bears larvae to Shelikhov Bay - main region of their development. Strengthening of inflow of pacific waters strengthening and other currents - Middle and East-Sakhalin, which transfer larvae to the bays of southern Sakhalin - region second of their development. In cold years winds northern quarters prevail, they reduce Inflow of pacific waters and intensity West-Kamchatka current. Its flow separated on some eddies (Davidov, 1989). Therefore the larvae a long time can remain in local regions and not to be born in the main regions of growth, that results in decrease of survival.

5AM1996-BIO19 poster
BIOLOGICAL CHARACTERISTICS OF NORTHERN LAMPFISH, STENOBRACHIUS LEUCOPSARUS, CAUGHT IN THE NEAR-SURFACE LAYER IN THE BERING SEA
Akira Nishimura, T. Yanagimoto and K. Nagasawa, *National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 7-1, 5-chome, Orido, Shimizu, Shizuoka, Japan.* 424

Trawl surveys were conducted to examine the distribution of fish micronecton in the Bering Sea in the summers of 1989-1991 and 1994. A netliner of 4 mm mesh size was attached inside the codend of mid-water trawl net and samplings were carried out within a few hours after sunset by trawling in the near-surface layer at depths of 20-40 m. In the basin area (>800 m in depth), catches were mostly northern lampfish (*Stenobrachius leucopsarus*) followed by northern smoothtongue and squids. Northern lampfish collected in 1994 were examined for their length and age by area (eastern, western and northern Bering Sea). Age was determined by otolith reading. Size ranges (20-105 mm) were similar in all areas, however, the major mode was different between areas (59 mm in eastern area, 43 mm in northern area and 71 mm in western area). Growth was expressed by the von Bertalanffy's equation as

$$L_t = 108.167 \cdot (1 - \exp[-0.2507 \cdot (t - 0.4374)]) ,$$

where L_t is fork length in mm and t is age in years. The growth patterns were similar in all areas.

5AM1996-FIS19 poster
FIELD TESTING OF JUVENILE FLATFISH HABITAT MODELS
Brenda L. Norcross, Brenda A. Holladay and Amy Blanchard
Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, AK 99775-7220, USA

Based on field collections in 1991 and 1992 around the island of Kodiak, Alaska, habitat models were developed for the four most abundant species of flatfishes collected: rock sole (*Pleuronectes bilineatus*), Pacific halibut (*Hippoglossus stenolepis*), flathead sole (*Hippoglossoides elassodon*) and yellowfin sole (*Pleuronectes asper*). In 1995, collections were made in bays of the Alaska peninsula, a location separated from Kodiak Island by 45 km of Shelikof Strait, an area previously unsampled for juvenile flatfishes. Sample locations were designated by sediment type as sand, mud or mixed sand and mud and by depth strata of 0-20 m, 20-40 m, 40-90 m and >90 m, corresponding to prior model increments. In concordance with the models, 96% of rock sole were

collected in water <40 m and 98% were collected on sand or sand/mud. The agreement with the model for halibut was even greater with 95% collected <40 m and 99% collected on sand and sand/mud substrate. Although captured in smaller numbers than at Kodiak Island, the distribution of flathead sole was in agreement with the model. For flathead sole, 86% were collected in waters >40 m and 84% were captured on mud bottoms. Yellowfin sole, also captured in relatively small numbers, agreed with the model in that 99% were captured <40 m and 74% were captured on sand/mud mix. The ability to predict the use of an area as a nursery for certain species of flatfishes, based on the physical characteristics for that area, will be beneficial in defining critical habitat in areas where baseline data have never been collected.

5AM1996-MEQ12 oral
ANOMAL CONTENTS OF MERCURY AND METHANE AND THEIR POSSIBLE CORRELATION WITH PHYTOPLANKTON ON THE OKHOTSK SEA SHELF

A.I. Obzhirov¹, Luydmila N. Luchsheva² and G.I. Mishukova¹

¹ Pacific Oceanological Institute, FEB RAS, 43 Baltiyskaya Street, Vladivostok, Russia. 690041

² Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600

Distribution of gases, mercury and phytoplankton in water of the Okhotsk Sea shelf has been studied since the 1980s. In the result of investigations anomal fields of methane and heavy hydrocarbon concentrations have been found. They are associated with oil-gas deposits and fracture zones. Anomal methane concentrations in bottom water come to 5000-15000 nl/l, that exceeds background ones 1000 times.

In bottom water high mercury concentrations have been found as well. They are associated with anomal methane fields. Mercury contents come to 600-1700 ng/l, that exceeds background concentrations 10-100 times.

In the same regions of the sea high phytoplankton productivity and violent blossoming of diatoms have been observed. Phytoplankton and other microorganisms are the base of rich feed for fish and accumulation of organic matter in bottom sediments.

Analysis mercury containing in the samples of phytoplankton and bottom sediments showed increasing of mercury concentrations to 200 and 80 mkg/g correspondingly. It is result of mercury sorption by phytoplankton and mercury accumulation in the bottom sediments during diagenetic transformation of organic matter.

Thus, there are a cycle of the interdependent processes on the shelf of the Sea of Okhotsk, such as: 1) formation of anomal methane and mercury fields in water over oil-gas deposits; 2) high phytoplankton productivity; 3) accumulation of organic matter and mercury in the bottom sediments. Thanks to such circulation mercury migrates from deep sedimentary layers to the surface and accumulates there. These processes are faster in fracture zones during geological activation. Material and gases go from the interior in water and increase methane and mercury concentrations there. Necessarily to take it into consideration when making conclusion about environmental contamination.

5AM1996-BIO20 oral
SUBPOLAR COPEPODS OF THE PACIFIC -- A TALE OF TWO HEMISPHERES

Mark D. Ohman, Marine Life Research Group, Scripps Institution of Oceanography, La Jolla, CA 92093-0227, U.S.A.

The distinctive life history characteristics of the Neocalanus species that dominate macrocopepod biomass in the oceanic Subarctic Pacific include non-feeding adults, obligate deep-water reproduction, and univoltine population cycles. Although there are regional and perhaps interannual differences in the timing of population growth, the 3 Neocalanus species that occur in the subpolar

latitudes of the northern hemisphere appear to be fixed with respect to these characteristics. An evolutionarily similar species, *Neocalanus tonsus*, inhabits the oceanic Subantarctic Pacific. The life history of this southern hemisphere congener includes feeding adult females, reproduction in both deep water and the surface mixed layer, and bivoltine population growth. Understanding the selective forces that generated and maintain these differences between closely related species should aid in the prediction of responses of the Subarctic Pacific zooplankton to a changing oceanic climate.

According to Gillian's rule, life history traits should minimize the quotient of μ/g , where μ is mortality rate and g is growth rate. A conventional perspective would interpret the differences in life history traits between northern and southern subpolar congeners in terms of processes and constraints acting on g . This paper will explore the suitability and consistency of hypotheses based on growth-related constraints in life history traits and contrast them with those that act principally on μ .

5AM1996-BIO21 oral
HEAT-LOVING FISHES IN PACIFIC WATERS OFF THE NORTH KURIL ISLANDS AND SOUTHEAST KAMCHATKA
Alexei M. Orlov, *Federal Research Institute of Fisheries and Oceanography (VNIRO), 17 Krasnoselskaya, Moscow, Russia. 107140*

Episodic invasions of heat-loving fishes in temperate and cold waters of the northwest Pacific associated mainly with warm climate periods may serve as indicators of certain oceanological processes in investigated area. In 1992-1995 investigations of ichthyofauna in Pacific waters off the North Kurils and Southeast Kamchatka were carried out on board of three Japanese trawlers. A number of heat-loving pelagic and bottom fishes were found during the period of investigations.

Pelagic fishes were presented by epipelagic species, Pacific saury (*Cololabis saira*) and salmon shark (*Lamna ditropis*). This species spawning near the Japanese coast, feed in the more northern regions, penetrating into the Bering Sea during the warmest years.

Among the mesopelagic heat-loving fishes species spawning in the warm waters and then carried by currents into the more northern areas were registered. They include angle mouth (*Gonostoma gracile*), bigeye lanternfish (*Protomyctophum thompsoni*) and warty dory (*Allocytus verrucosus*). Another group of heat-loving mesopelagic fishes includes daggertooth (*Anotopterus pharao*), long-nose lancet fish (*Alepisaurus ferox*) and *Scopelosaurus harryi*. Their spawning grounds are located in warm waters, but being the typical predators, these fishes actively migrate for feeding in temperate and cold waters.

Among bottom fishes we found species treadfin bakeling (*Laemonema longipes*) which spawn in warm waters and only their juveniles migrate for feeding into the region under consideration. Only adults of spiny dogfish (*Squalus acanthias*) and *Notacanthus chemnitzii* are able to the active migration to the north during the warm climatic period. Occurrence of other bottom heat-loving fishes (*Glyptocephalus stelleri*, *Microstomus achne*, *Aphanopus arigato*, *Erilepis zonifer* and others) are possibly explained by advection of their pelagic juveniles into the area of investigations.

5AM1996-BIO22

poster

RARE BOTTOM FISHES IN PACIFIC WATERS OFF THE NORTH KURIL ISLANDS AND SOUTHEAST KAMCHATKA

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

Investigations of bottom ichthyofauna in the Pacific waters off North Kurils and Southeast Kamchatka conducted in 1992-1995 on board of three Japanese trawlers allowed to discover a number of rare even new for this area fish species.

Until now liparid fish *Polypera simushirae* was registered only in waters off Simushir Island. Obviously, its catching near Hokkaido coast (Ueno, 1971) is exceptional. Our investigations showed that the northern limit of its area in waters of the Kurils reached the central part of the 4th Kuril strait. This species was commonly caught during bottom trawlings in the area of underwater plateau located near 48°N at depth of 166-833 m.

A rather species for region under consideration is deepsea sole (*Embassichthys bathybius*). This species is common near the northeastern coast of North America, while it was caught only once in waters off Hokkaido (Amaoka et al., 1981). Deepsea sole is rather rare in the Bering Sea (Fedorov, 1967). During our investigations it was noted at depth range from of 447 to 792 m, and most commonly in the 500-600 m layer.

Until recent time, liparid fish *Careproctus zachirus* was considered as very rare fish. This species was described only by few individuals caught near the Aleutian Islands (Kido, 1984). However, it was registered rather often in the area of underwater plateau located near 48°N at depth range of 285-567 m, and more frequently in the 400-500 m layer.

Catchings of giant skilfish *Erilepis zonifer* were very rare. This species is common in waters of the Northeast Pacific and in the Russian waters for the first time it was registered by Andriyashev (1955). Two specimens in area under consideration were caught at 48°09'N in the depth range of 282-374 m.

Catchings of trichiurid fish *Aphanopus arigato* is very interesting. Its species status was determined only recently (Parin, 1994). All previous catchings of this fish in the area from Japanese coast to Paramushir Island were only single. Catching of this species near the southern tip of Kamchatka during our investigations is the most northern one by now.

5AM1996-POC28

oral

NUMERICAL MODELS OF CREEPING FLOW INTO SEDIMENTAL COVER AT MARGINAL PARTS OF OKHOTSK SEA'S BASINS

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

The origin of certain morphostrucures into sedimental cover discovered by geophysical investigations at marginal parts of Okhotsk Sea's basins haven't been determined yet. According to data of seismical and geophysical observations these structures are correlated with zones of main faults of underlying basement (ledges, cracks, etc.) and also marked by more high values of heat flow and other anomalies of geophysical fields. Therefore it may be supposed the injection of viscous fluid into sedimental cover through basement's faults.

The numerical model is designed to investigate the creeping flows in sedimental cover subjected by this process. The cover is treated as a thin viscous layer increased by sedimentation on upper boundary and fluid's injection. The model based on equations of creeping flow of inhomogenic viscous fluid. Quasi-linear parabolic system for cover's boundaries is obtained.

The numerical modelling natural morphostructures recognized by seismic observations at Macarov's basin, Derugin's basin, Cashevarov's elevation support the supposition that the injection of fluid may be one of main factor to forming these structures.

5AM1996-FIS20 oral
**INDETERMINATE SPAWNING, CLIMATIC FLUCTUATIONS, STOCK STRUCTURE
AND RECRUITMENT**

Richard H. Parrish, *Pacific Fisheries Environmental Group, National Marine Fisheries Service, 1352 Lighthouse Avenue, Pacific Grove, CA U.S.A.*

During the last decade two highly intractable problems, stock structure and recruitment, have seriously limited our knowledge of the population dynamics of marine fishes. It is now obvious that two other highly intractable problems, indeterminate spawning in subtropical and tropical pelagic fishes and decadal scale environmental fluctuations in sub-tropical and sub-Arctic regions, are the apparent norm.

The annual reproductive output of nearly all of the fishes with indeterminate spawning is unknown; but, where studied, it is apparent that older/larger fish have an order of magnitude greater fecundity than younger/smaller fish. Inter-year variation in the fecundity of indeterminate spawners is likely to be highly dependent upon available forage and recent studies on decadal scale climatic forcing suggest that forage variations at the longer time scales are undoubtedly much larger than previously thought possible. Knowledge of the stock structure of most of the widespread indeterminate spawning fishes is poorly understood and confounded by their often highly migratory behavior and age/size dependent geographical distributions.

The change in the age/size structure of fish populations resulting from exploitation has the potential to seriously alter the synergistic relationship between indeterminate spawning, decadal climatic forcing, stock structure and recruitment which has maintained the populations of many dominate marine fishes. The purpose of this paper is to more fully develop this concept.

5AM1996-BIO23 poster
**INTERANNUAL FLUCTUATIONS OF HIDROLOGICAL CONDITIONS IN THE
REGIONS OF INHABITATION OF THE KUROSHIO COMMERCIAL FISHES**

V.P. Pavlychev, I.A. Zhigalov and E.I. Ustinova, *Pacific Fisheries Research Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

As known, last years there are essential changes in the pelagic ichthyocenosis of the Kuroshio system. This process was observed on the background of significant changes of hydrological conditions in the whole areal of its spreading.

On the one hand, in the middle of 1980's there was marked a noticeable water cooling on the considerable aquatorium of the North Western Pacific, including the neighbouring regions of the Japan and Okhotsk Seas. So, on the most northern plots of feeding areal of sardine (south-western coast of Sakhalin, southern part of the Okhotsk Sea) there were predominated the negative anomalies of water temperature in the upper 200-m layer. In some years of this period the values of anomalies reached the level, which was not marked from the beginning of observations in indicated regions. In these years the subarctic waters received a wade spreading eastward from Honsyu. The Kuroshio current occupied the most southern position (35-36 N).

On the other hand, on the boundary of 1980-1990's there was a abrupt transition of water regime to the warming. Under that the indicated phenomenon embraced also the extensive areas of the North Western Pacific with the neighbouring Far Eastern Seas (Pavlychev et al.,1990). The area of subarctic waters in zone of subarctic front was reduced. Heat storage in the layer of 0-100 m was the

maximum eastward from Japan Islands in 1989 beginning from 1981. The warm Kuroshio eddies occupied the northern position.

From the end of the 1980's there was the beginning of transitional period from the large-scale Kuroshio meandering southward from Honsyu to the period of shelf paths.

Moreover, in the end of the 1980's - the beginning of the 1990's, according to the Pyatin O.G. data, the duration of the cold period (with negative heat balance of sea surface) was noticeably increased relative to norm. This is the evidence of delay of spring-summer processes in the reproductive areas and of formation, in ecological meaning, of unfavorable conditions for life of fisher eggs and larva.

5AM1996-SB16 invited
THE SPIN-DOWN OF THE SUBARCTIC AND SUBTROPICAL GYRES IN THE NORTH PACIFIC, 1987 TO 1995, OBSERVED WITH THE PARALLEL OCEAN CLIMATE MODEL. A RESPONSE TO GLOBAL WARMING OR A 20-YEAR CYCLE?
Jeffrey J. Polovina, *Honolulu Laboratory, SWFSC, NMFS, NOAA, 2570 Dole Street, Honolulu, HI 96822-2396, USA*

Empirical Orthogonal Function analyses are used to examine interannual variation of the North Pacific annual sea surface height and current velocity fields from the Parallel Ocean Climate Model over the period 1987-95. The results show circulation of both the subarctic and subtropical gyres rapidly weakened from 1987 to 1991 and subsequently remained at a relatively weak state through 1995. The weakening of circulation in both gyres appears coherent with the weakening of the Aleutian Low Pressure System since 1987.

Evidence from a variety of long-term time series suggest that the gyres may strengthen and weaken on a 20-year cycle. For example, sea level height from tide gauges, sea level pressure, temperature, and Japanese coastal pelagic fisheries data over the past 100 years exhibit a 20-year cycle consistent with a strengthening and weakening of the gyres. However, a weakening of mid-latitude winds has also been suggested as a response to global warming and the 1987-95 weakening of the gyres could also be due to global warming.

5AM1996-SB17 poster
THE RECENT CLIMATE CHANGES IN THE SEA OF JAPAN (EAST SEA)
V.I. Ponomarev and A.N. Salyuk, *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, Russia. 690041*

Basis for this study was formed by the Japan / East Sea oceanographic and hydrochemical data collected from 1950 to 1995 years. The main goal is to trace the recent regime shifts in certain regions and layers of the Japan Sea. To obtain the changes in the seasonal and main pycnocline, intermediate, deep and bottom waters we use averaged vertically values of potential temperature, dissolved oxygen, phosphate and silicate concentrations in the fixed layers. Besides we use depth of some isotherms and oxygen minimum. The climate regime shifts are mainly analyzed in the northwestern Japan / East Sea and certain regions adjacent to areas of the different layers ventilation.

We show that the long-term climate changes are particularly pronounced in deep and bottom layers in hydrochemical parameters especially. Moreover its are conditioned by changes of water characteristics and physical processes in underlying layers which have high frequency variability. The substantial positive anomalies of potential temperature and silicate concentration side by side with negative anomaly of dissolved oxygen are clearly revealed in the deep and bottom layers during last decade. Such anomaly of potential temperature in the lowerlying layer displays later than that in underlying one.

It is the Japan Sea where climate changes of deep and bottom waters are relatively quick in comparison with another seas and regions of the ocean. So, the future climate regime shifts might be successful trace in that sea.

5AM1996-POC29

oral

LAGRANGIAN MEASUREMENTS OF DIURNAL TIDAL CURRENTS NEAR THE KURIL ISLANDS

Alexander B. Rabinovich^{1,2}, Richard E. Thomson², Paul H. LeBlond³

¹ P.P. Shirshov Institute of Oceanology, Mosco, Russia. 117218

² Institute of Ocean Sciences, P.O. Box 6000, Sidney B.C., Canada. V8L 4B2

³ Department of Oceanography, University of British Columbia, Vancouver, B.C., Canada. V6T 2Z2

Three standard WOCE surface drifters with holey-sock drogues centered at 15 m depth were deployed on September 4, 1993 about 200-300 km offshore of the Kuril Islands. One drifter (15374) stayed in the region of the Kuril-Kamchatka Trench (KKT) for 72 days and then failed at sea. Another (15372) went in the direction of the Kuril Islands and ran aground on the shelf of Iturup Island after 17 days. The third drifter (15371) made a few circuits in a quasi-permanent anticyclonic eddy centered over the axis of the KKT, then traveled over the continental shelf of Urup Island, moved through Friz Strait into the Sea of Okhotsk, where it made a few cyclonic loops, and then returned through Bussol' Strait back into the Pacific Ocean. Rotary spectral analysis of the currents reconstructed from the drifter data showed that drifter 15374 motions in the deep sea were dominated by inertial oscillations in the deep sea. Diurnal or semidiurnal tidal currents were not observed. On the contrary, drifters 15371 and 15372, traveling mainly over the shelf, had strongly dominant spectral peaks corresponding to diurnal (K_1 , O_1) currents. The "rotary multiple filter technique" was used to examine clockwise and counterclockwise drifter motions in frequency and time (space). Strong diurnal currents (0.5-0.7 m/s) were detected on the Pacific shelf of Urup and Iturup islands, with maximum diurnal currents (up to 1.8 m/s) associated with Friz Strait between these islands. However, on the Okhotsk shelf of Iturup diurnal currents were insignificant. The theory of coastal trapped waves is used to describe the behaviour of diurnal currents in the examined region. Good agreement was found between theoretical and observational results. First mode quasigeostrophic shelf waves were responsible for strong diurnal currents on the Pacific shelf but did not influence the Okhotsk shelf currents.

5AM1996-BIO24

oral

INTERANNUAL VARIABILITY OF DOLLY VARDEN SALVELINUS MALMA (WALBAUM) DISTRIBUTION IN THE DEEP-WATER ZONE OF THE BERING SEA IN RELATION WITH OCEANOLOGICAL CONDITIONS

Vladimir I. Radchenko, Pacific Research Fisheries Center (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600

It was hitherto considered that Dolly varden does not leave inner shelf during its sea life and occur not far than 7-9 km from coast. Dolly varden also did not occur in catches of complex expeditions covering during 1986-1990 the whole warm season in the western Bering Sea. In June of 1991 first occurrence of abundant Dolly varden offshore migration was fixed by us in the deep waters of the western Bering Sea. Char's catches were appeared in the distance up to 150 miles from coast. In 1991-1993 the Dolly varden calculated numbers and biomass were increased in the south-western Bering Sea from year to year: in 1991 - 8.5 million fish (4.4 thousand tons), in 1992 - 11.44 (2.91), in 1993 - 22.83 (11.34). In 1995 numbers slightly decreased up to 9.0 million fish (3.0 thousand tons). However, in this year the Dolly varden schools tended to the south-western Aleutian Basin and some part of char could remain beyond survey area. On the whole, main char aggregations tended to the surface water of western slope modification (Zuenko, 1991). This water usually spreads on distance up to 200-220 miles from coast, especially over the Shirshov Ridge. The Atka mackerel juveniles replace chars in the catches in waters of deep-water basin modification (i.e., slightly modified Pacific waters).

Before 1990s surface current pattern in the Bering Sea (Ohtani, 1973) was considered almost invariable on the whole in long-term aspect. According to complex TINRO expeditions' data, in 1990-1995 the surface geostrophic circulation was significantly changed in comparison with 1986-1989. The north-westward flow from the Near Strait to the Kamchatkan Strait appeared as a one feature of this circulation anomaly since 1990 fall (Verkhunov, Tkachenko, 1992). Interannual variability of this flow location and Pacific water inflow intensity determined the features of Dolly varden distribution during its feeding migration route.

5AM1996-BIO25 oral
SPATIAL PATTERNS OF SALMON PREY, FEEDING AND GROWTH IN THE NORTHEAST PACIFIC OCEAN

Peter S. Rand and Scott G. Hinch, *Westwater Research Unit, Institute for Resources and Environment, University of British Columbia, Vancouver, BC, Canada*

We describe results from analyses of data sets on zooplankton biomass and salmon diets and describe the development of a spatially-explicit model to represent feeding and growth processes of Pacific salmon in the Northeast Pacific Ocean. Our research objective was to define the effective prey patch size for salmon (over scales from 100 km to >2000 km) and describe how salmon feeding and growth is influenced by patterns of sea surface temperature (SST) and prey resources among years. We compiled data on sea surface temperature (SST), zooplankton biomass, and salmon diets in the Northeast Pacific during the 1960's and 1980's and found evidence of spatial-, temperature- and prey-dependence on salmon feeding. We found evidence of meso (<500 km) and gyre-(>1000 km) scale patch structures in prey (zooplankton) biomass and predator (salmon) feeding. Algorithms were developed to simulate feeding and growth of salmon on the high seas; preliminary results suggest that growth rate potential declines sharply within the southern zone of salmon distribution, at approximately the latitude where salmon abundance has been observed to decline by one to two orders of magnitude. This suggests that bioenergetic mechanisms may give rise to this apparent "zone of intolerance" for salmon. We describe potential future applications of the model to better understand effects of oceanographic regime shifts and broad scale climate change on salmon growth and mortality processes.

5AM1996-FIS20 oral
WHAT DOES FISHING REALLY DO TO A FISH COMMUNITY?

Jake Rice, *Pacific Biological Station, Department of Fisheries and Oceans, 3190 Hammond Bay Road, Nanaimo, BC, Canada. V9R 5K6*

Because fishing mortality (F) is an additional contribution to total mortality (Z), it must necessarily change the age composition of the stock being fished. These direct effects have been captured in fisheries models back at least to Baranov. Even early fisheries models also included single-species population dynamics responses of a fish population to increases in Z. If F is high enough to alter an age composition so that there are significant life history ramifications, then F can be shown to be high enough to violate one of the traditional benchmarks of recruitment overfishing or growth overfishing. The interrelationship of these benchmarks can be shown analytically. The conclusion is that first-order effects of fishing on age structure can be handled in existing fisheries models.

Recently the ICES Ecosystem Effects of Fishing Working Group has been investigating the broader questions of how assemblages respond to fishing. Survey data for assemblages of interacting fish species, individually subjected to a range of fishing pressures from incidental bycatch to intensive directed exploitation, have been analyzed. Multispecies models have also been used to explore how assemblage-level attributes respond to different levels of fishing and natural mortality.

These approaches and models can be used to explore the community-level effects of altering age composition of fish stocks through fishing. Although fisheries models do not address how

assemblages respond to fishing of constituent species, the responses appear lawful. Effects of fishing on both abundance and diversity of size and age classes will be reviewed in the assemblage context. Because fishing is generally size selective rather than age selective, community level effects of fishing show up more on size scales than age scales. Fishing actually increases diversity for the sizes or ages being targeted. Numbers accumulate just below the targeted size or age. Implications of these results receive the usual amount of speculation.

5AM1996-SB18

oral

DETECTION OF REGIME SHIFT IN CLIMATE CHANGE BASED ON ANNUAL VARIABILITY IN DISTRIBUTION AND CATCH RATES OF STAGNANT AND MIGRANT FISHES IN NORTHERN JAPAN

Yasunori Sakurai, Faculty of Fisheries, Hokkaido University, Minato-cho 3-1-1, Hakodate, Hokkaido, Japan. 041

Many commercially important fishes occur in northern Japan, including around Hokkaido Island and the Tohoku area of Honshu. The distribution and catch rates of migrant species such as herring, sardine, Japanese common squid and mackerel, have changed dramatically during the 20th century. Recently, an interdecadal regime shift from annual catch rates of subarctic species such as walleye pollock and Pacific cod has been observed. We held a symposium related to the retrospective analysis of catch data at Hakodate on 25 and 26 January 1996. The objective of the symposium was to discuss the regime shift in climate change based on the annual variability of distribution and catch rates of stagnant and migrant fishes in northern Japan during the 20th century. In this presentation, I will review the keypoints and discussion from the symposium.

5AM1996-BIO26

poster

A NEW APPROACH TO THE MODERN ECOLOGICAL CONDITIONS OF THE SEA OF OKHOTSK

Victor V. Sapozhnikov, Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), 17 V.Krasnoselskaya, Moscow. 107140

Detailed biochemical surveys of the Sea of Okhotsk conducted in 1990-1994 allowed to distinguish mesoscale eddies and estimate their effect on the nutrient vertical fluxes and also the rates of production-destruction processes. Comparing of the locations of the vortexes revealed during this four years studies showed that some of the anticyclonic eddies are quasistationary.

Quasistationary mesoscale eddies are located on the outer border of the continental slope of Sakhalin island and Kamchatka peninsula, in Aniva Bay, in the outer Shelekhov's Bay and in the southern part of the Sea of Okhotsk over the Kuril basin.

The localization of the anticyclonic eddy over the shoals in the shelf in Aniva bay showed a radical increase of shrimps catches up to 20 kg/30 min of trawling and crab catches up to 300 sp/30 min of trawling in the center of the vortex.

Considering the effect of mesoscale eddies and particularly the conjugate vortex structures makes it possible to get a new look of on the processes of primary productivity and its total value.

First of all one can notice the upwelling off the Sakhalin coast and flux of nutrients to the euphotic layer epizodically results to new production (0.5-0.9 g C/m² day) in summer when winter stocks of phosphates, nitrates and silicates are utilized during photosynthesis.

The all year round powerful upwelling over the Kasherova bank where vertical velocities are up to 1/10 cm/s is of great importance.

The volume of nutrients upwelled by this stream could be compared with that of winter convection. By the way this upwelling is also the source of new production. At the same time the total depletion of phosphates, nitrates and silicates is observed in summer in the surface layer of the open sea that results in transition the ecosystem to recycling.

Taking into account all these factors allows to estimate the total primary production in the Sea of Okhotsk as 4.9 10 000 000 g C/year.

5AM1996-FIS22

poster

SEX-SPECIFIC EGG CANNIBALISM IN SPAWNING WALLEYE POLLOCK (*Theragra chalcogramma*)

Robert Schabetsberger and Richard D. Brodeur, *Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, WA 98115-0070 U.S.A.*

Spawning adult pollock apparently ingest their own eggs during normal gill ventilation. This inadvertent egg cannibalism has been studied extensively in Shelikof Strait, Gulf of Alaska (Brodeur et al., 1996 and references therein) but until recently no data were available for the large pollock spawning stock near Bogoslof Island in the southeast Bering Sea. Stomach contents of 260 adult pollock collected during the 1995 spawning survey in the Bering Sea were compared to 266 stomachs collected in the previous year in the Gulf of Alaska. In both areas male pollock had on average 6-7 times more eggs in their stomachs than females. The average number of eggs per stomach of male and female were 33.5 versus 5.4 in the Bering Sea and 34.1 versus 4.9 in the Gulf of Alaska. These findings also correspond to data collected between 1990-1993 in the Gulf of Alaska. Most eggs were fertilized and spawned 0-48 h prior to ingestion. No major differences between the distributions of developmental stages of eggs ingested by males and females were found. It has been shown previously that during the spawning period the two sexes aggregate in several well-defined horizontal strata. Differences in sex-specific egg ingestion rates may reflect different times spent in layers of high egg densities, but more data will have to be collected before final conclusions can be drawn.

5AM1996-SB19

oral

BALEEN ISOTOPE RATIOS PROVIDE A DECADEAL RECORD OF CHANGES IN PRIMARY PRODUCTIVITY IN THE BERING SEA

Donald M. Schell, *Institute of Marine Science & Water Research Center, University of Alaska Fairbanks, Fairbanks, AK 99775, USA*

Isotope ratios of carbon and nitrogen offer an alternate means of assessing relative rates of primary productivity in the marine environment. In the Bering Sea, there is a pronounced gradient of carbon and nitrogen isotope ratios between the deep pelagic waters of the Bering Basin and the shelf waters. After ten years of repetitive sampling of herbivorous zooplankton, data have been acquired to show a consistent gradient in isotope ratios indicative of a distinct on-shelf progressive uptake of free carbon dioxide and nitrogenous nutrients. To get a multi-year record, we used the isotope ratios in bowhead whale (*Balaena mysticetus*) baleen laid down in the Bering-Chukchi seas as a proxy for the temporal record of isotope ratios in the zooplankton. By using baleen plates from 26 whales archived at the Los Angeles County Museum and recently taken by natives, we have assembled a record of average carbon and nitrogen isotope ratios back to the 1940s. From this record we infer that primary productivity in the Bering Sea was at a higher rate over the period 1948-1976 and then declined until 1985 when it leveled off at a lower rate that continues to at least 1991. Attempts to correlate these changes with long-term temperature records and cross-shelf advection have provided tantalizing but inconclusive results to date. Nitrogen isotope ratios also declined for over thirty years and show oscillations on a two-four year periodicity that may be in response to changes in trophic structure in the zooplankton community. Analysis of these data continues.

5AM1996-POC30

oral

SOME PECULIARITIES OF ATMOSPHERIC PROCESSES OVER THE SEA OF OKHOTSK AND THE ADJOINING PACIFIC PART IN 1970-1996

Tatyana A. Shatilina, *Pacific Research Fisheries Institute (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

There are some main peculiarities of atmospheric processes taking place over the Sea of Okhotsk and the adjoining Pacific part last decades (1970-1996).

It is shown the winter processes of the seventies are notable for a lot of reiteration of atmospheric circulation zonal forms according to O.K.Ilyinskiy typification; high - altitude depressions were mainly over the Sea of Okhotsk.

In the first half of the eighties the high-altitude depressions centers were over the Sea of Okhotsk, and since the second part of the eighties they have moved to the Primorye and the Sea of Japan (East Sea).

In the nineties AT 500 surface structure is characterized by huge strengthening of the Pacific ridge moving to the west Kamchatka, and the high-altitude depressions moved to the west. There is abnormal redistribution of heat in the atmosphere and hydrosphere.

These differences in cold hollows and heat ridges over the Sea of Okhotsk and the adjoining Pacific part have influence on intensity of heat branches development of Kuroshio - Oyashio and it changes ocean circulation.

In the period of ice-field increasing in the Sea of Okhotsk the water temperature near Kuroshio rises too, and in the period of decreasing it the temperature lowers.

On the base of data analysis for 1961-1987 period there was anti-phase between water temperatures anomalies by the south and north Kurils, and there is a warm oceanic waters inflow through Kurils north straits into the east part of the Sea of Okhotsk, and there is a cold water flow through Kurils north straits into the ocean. Interaction between currents systems of the Sea of Okhotsk and the adjoining Pacific part goes through atmospheric processes.

5AM1996-FIS23

poster

STOCK DYNAMICS OF SAKHALIN-KURILES PINK SALMON IN RELATION WITH HYDROMETEOROLOGICAL PROCESS OVER THE FAR EAST

Tatyana A. Shatilina, V.I. Radchenko, *Pacific Research Fisheries Institute (TINRO-Centre), 4, Shevchenko Alley, Vladivostok, Russia. 690600*

Stock dynamics of Sakhalin-Kuriles pink salmon shows periods of ups and downs as well as a long-term trend of catch increase in the 1990s.

The comparison of these periods of ups and downs with atmospherical processes over the Far East (120-160 E, 30-60 N) has indicated the following.

In a period of the pink salmon stock decrease in the 1960s, the Siberian pressure maximum was intensively developed. An index of that was high reiteration of meridionnal forms of atmospherical circulation over the Far East (by O.K.Ilyinsky typification).

After 1963, the Siberian pressure maximum decreased, the reiteration of zonal and eastern FACs (forms of atmospherical circulation) being more frequent.

The tempos of growth, ripening and surviving of the pink salmon depend much on the conditions of its winter fattening in the ocean.

For January, the periods of higher and lower reiteration have been indicated: the first period - 1954-1963 (negative anomalies) and the second period - 1964-up to now (prevalence of positive anomalies).

The processes of decreasing (increasing) of the Siberian pressure maximum intensity determine the development and location of a cold Far Eastern hollow in the middle troposphere (AT500 mb surface), being fixed with help of H500 geopotential anomalies. Extremely high values of the H500 were observed in January 1989 (the peak catch of the pink salmon near the Eastern Sakhalin) and in February 1990.

The location and development of the Siberian pressure maximum in its turn, is connected with the location of high-altitude ridges over the Atlantic that is, with the types of atmospheric circulation by Vanguame-Girs. Forms of atmospheric circulation depend on solar activity, the changeability showing long-term cycles.

This enables to use the indexes of the cycle recurrence of global physical processes to make up catches forecasts of various foresight (40-60 years to 1-2 years) for Sakhalin-Kuriles pink salmon.

5AM1996-SB20

oral

CORALS AS CLIMATE RECORDING SYSTEMS

Glen T. Shen, *School of Oceanography, University of Washington, Box 357940, Seattle, WA 98195-7940, U.S.A.*

The tropical surface ocean is home to one of nature's most versatile climate recording systems. When interpreted properly, the coral record may rival instrumental measurements in accuracy and time resolution. At least seven geochemical properties in coral aragonite ($d_{18}O$, Sr/Ca, U/Ca, Mg/Ca, $d_{13}C$, Ba/Ca, Mn/Ca) relate to environmental changes in temperature, precipitation, insolation, and ocean mixing. The key is to isolate which environmental parameters influence each geochemical marker in a specific location.

The geographic range of applicability for coral based methods is wide -- roughly 25° on either side of the equator. Massive colonies spanning 400 years of continuous growth have been sampled, though 100-200 year old specimens more commonly represent the upper limit in many reef settings. Dating by x-radiographic band counting is often precise to the year, with radiometric thorium dating capable of defining the absolute age of a modern sample to within 13 years when a known age horizon is unavailable. The latter dating technique opens the door to drilling of deceased reef platforms and drowned terraces to examine climate changes as far back as the Pleistocene. Highest temporal resolution is easily seasonal as coral extension rates commonly reach 1 cm/yr. Debate continues over the legitimacy (and usefulness) of reconstructing changes over shorter (i.e. daily to weekly) time frames.

Progress in the last few years has been rapid, but questions remain and painstakingly long time series slow to emerge. I will present a summary of principal methods, findings, and retrospective strategies targeted by researchers for upcoming years.

5AM1996-BIO27

poster

THE TRANSITION OF PRODUCTIVITY IN ISE BAY FROM WINTER TO SPRING

Toru Shimoda¹, Katsuyuki Sasaki¹, Kaoru Nakata¹, Minoru Tomiyama² and Hirokatu Yamada³

¹ *National Research Institute of Fisheries Science*

² *Fisheries Research Institute of Mie*

³ *Aichi Fisheries Research Institute*

Lower trophic level productivity was investigated in order to develop fishery productivity model of Sandlance as key species in Ise Bay, a weekly mixed estuary, from winter to spring. Temperature, salinity, nutrients(NH₄, NO₃, NO₂, PO₄ and SiO₂) and chlorophyll a concentrations, primary productivity measured by 13C method, copepod biomass and productivity by Ikeda-Motoda(1979) were examined about every ten days from December to March and once a month from April to June. Chlorophyll a concentration and copepod biomass fluctuated largely during the investigated period. Primary productivity which was high in December, decreased with water temperature in January and increased again in April. A positive correlation was found between temperature and primary productivity. During the low temperature period, the variations of the primary productivity were coincident with the copepod productivity. In presentation, we will consider about these mechanism.

5AM1996-BIO28

oral

EAST AND WEST CHANGES OF STANDING STOCK AND SIZE COMPOSITION OF PHYTOPLANKTON CHLOROPHYLL a IN THE TRANSITION DOMAIN IN THE NORTH PACIFIC, SPRING AND SUMMER

Akihiro Shiomoto, *National Research Institute of Far Seas Fisheries, 7-1, Orido 5-chome, Shimizu, Shizuoka, Japan. 424*

The Transition Domain lies just north of the Subarctic Boundary around 40°N in the North Pacific Ocean. Little is known about east and west changes of standing stock and size composition of phytoplankton assemblages in the domain. Size-fractionated (<0.2, 2-10 and >10µm) phytoplankton chlorophyll a above 150 m was measured in spring and summer for elucidating the changes.

Total chlorophyll a standing stock integrated from surface to 150 m depth, tended to decrease from west to east in the domain; on the contrary, percentage contribution of small phytoplankton (<2µm) to the phytoplankton standing stock tended to increase eastward. The results were due to decrease of standing stock of larger planktons (2-10 and >10µm) and roughly constant standing stock of small ones (<2µm).

I will discuss the factors causing the reduced standing stock of the larger planktons and constant standing stock of the small ones.

5AM1996-BIO29

poster

GEOPHYSICAL FIELD VARIATIONS ON BORDERS OF CONVERGING TECTONIC PLATES AS A POSSIBLE FACTOR OF ENVIRONMENTAL CHANGES IN THE NORTH PACIFIC

Evgeny N. Shumilin, *Interdisciplinary Marine Science Center (CICIMAR), Playa El Conchalito, Apdo Postal 592, La Paz, Baja California Sur, 23000, Mexico*

Spacio-terrestrial and especially solar-terrestrial electromagnetic and gravitational interactions may be leading factors of temporal changes of matter and energy fluxes between the continent, sea floor, and ocean compartments of the Earth.

It is conceivable that borders of converging tectonic plates may be sites of increased environmental impact and intensive energetic exchange in the Northern Pacific Ocean (e.g. Japan trench, Kuril- Kamchatka trench, Aleutian trench, Middle-America trench and adjacent areas of the marine and terrestrial environment).

These impacts can be of different nature (seismic, electromagnetic, acoustic etc.). They may discharge excess of energy in the deep and shallow North Pacific Ocean, especially during strong geophysical events like magnetic storms, sun flares, hurricanes, earthquakes, terrestrial tides and tidal motions of magma beneath the earth crust.

As a consequence of piezoelectric, piezomagnetic, electrokinetic and other geophysical effects below the surface of the sea floor in the zones of plate interactions, these areas of elevated tectonic activity can be more subjected to strong environmental and climatic changes, including changes in the chemical and biological composition of marine and terrestrial ecosystems. Electromagnetic waves and low frequency magnetic field variations may be physiologically responsible for advanced transformations of marine and terrestrial organisms and of their communities here. Integrated geobiophysical surveys are strongly needed in these impact regions for obtaining experimental data necessary for the construction of global and regional models of environmental changes in the North Pacific Ocean.

The basic principles of newly oriented methodology have to be developed urgently for North Pacific ocean ecosystems of these meteorologically and tectonically active areas. Some proposals for future international cooperation related to "GLOBEC" project of IGBP and "Climate Change and Carrying Capacity program" of PICES will be suggested in the report.

5AM1996-MEQ13

oral

TRACE ELEMENTS IN COASTAL SEDIMENTS OF THE GULF OF CALIFORNIA ALONG THE SOUTHEASTERN PART OF BAJA CALIFORNIA PENINSULA

Evgeny N. Shumilin¹, Enrique Nava-Sanchez¹, Lucio Godinez-Orta¹, Sergio Troyo Dieguez¹, Dmitry Yu. Sapozhnikov², Yuri A. Sapozhnikov³

¹ *Interdisciplinary Marine Science Center (CICIMAR), Playa El Conchalito, Apdo Postal 592, La Paz, Baja California Sur, 23000, Mexico*

² *V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry, 19 Kosygin Street, Moscow, Russia*

³ *Radiochemistry Department, Chemical Faculty, M.V. Lomonosov University, Moscow, Russia. 117234*

Trace elements in sediments of inner bordeland basins are representative indicators of land-sea interaction processes in coastal marine environment.

Vertical distribution of 30 elements in four sediment cores taken on the shelf and slope of tectonically active southeastern Baja California peninsula (areas of Santa Rosalia, Loreto, El Coyote and San Juan de La Costa in the Gulf of California) near fan deltas were studied with the use of neutron activation analysis technique.

Shale normalized trace element data for all studied sediment cores show generally a depletion of sediments relative to crust indicating low contribution of the directly discharged terrigenous material in the composition of sediments off the coast of the peninsula as well as the absence of considerable anthropogenic enrichment of upper layers of sediments by light REE's found earlier for strongly contaminated zones (Olmez et al, 1991).

The rare earth element (REE's) patterns normalized to average shale for the sediment cores from the Santa Rosalia and Loreto areas show the possibility of the influence of sea-floor hydrothermal sources of Guaymas Basin (Mitra, 1991) on REE's biogeochemistry of these areas of the Gulf of California. Strong minima of shale-normalized ratio for Eu were recorded in several horizons of laminated sediment cores from El Coyote and San Juan de La Costa areas in the . Such minima can be caused by episodic avalanche inputs of terrigenous material impoverished in Eu during ancient

hydrothermal high temperature reductive leaching processes reflecting also periodic strong changes of depositional conditions of biogenic sedimentary material in the La Paz Bay.

5AM1996-FIS24

poster

ON THE FAR EASTERN TANNER CRABS

A.G. Slizkin and V.N. Koblikov, *Pacific Fisheries Research Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

One of the most abundant commercial crabs in the far eastern seas is the tanner crab *Chionoecetes opilio* (Fabricius). This species is common for low-arctic and high boreal habitats and is rather plastic. Large biomass of adult (harvested by fishery) specimens of the tanner crab is usually formed in restricted areas of the species broad geographic range. Maximum yield of the crab reached approximately 150 thousand tons in the north-eastern Bering Sea in 1993. It was assessed in 1988, that over 100 thousand tons of this species is removed from the stock annually by predator fish (cod, sculpins, halibut) in the north-western Bering Sea alone.

The tanner crab matures at 70 mm carapax width. Males spawn two to three times before recruiting into fishery (100 mm carapax width). That's why overfishing does not have such a negative influence on the species reproduction, as on lithodid crabs. Decrease of exploitation rate leads to relatively quick restoration of the tanner stocks.

Low abundance was registered for the species in 1995-1996 in the north-western Bering Sea, off eastern Sakhalin, and in the northern Japan Sea (East Sea), where relatively small populations live. All far eastern seas considered, increase of exploitation rate is possible on the northern Okhotsk Sea shelf, where the crab is underfished.

Another Tanner crab, *C. Bairdi* (Rathburn), is predominantly eastern-north Pacific species. It's widely distributed in the Bering Sea, while in the Okhotsk Sea it lives only off Western Kamchatka. This species shares habitat with other boreal crabs, such as King crab and Blue crab, and their ranges overlap. During the low abundance of two latter species, this tanner occupies their ecological hiscles. Such phenomenon was observed in the Bristol Bay in early 1970s. We registered the increase of the bairdi's abundance off the western Kamchatka, accompanied by decrease of the King crab stock in 1990s, and in the north-western Bering Sea, together with fall in abundance of the Blue crab.

Bairdi tanner crab dominates by the biomass among vagile benthos on the shelf in Olutorski, Khronozki and Avachinski Bays, where lithodid crabs are almost absent.

5AM1996-MEQ14

poster

CHEMICAL CONTAMINATION AND ASSOCIATED LIVER DISEASES IN TWO SPECIES OF FISH FROM SAN FRANCISCO BAY AND BODEGA BAY

Carla M. Stehr, M.S. Myers, D.G. Burrows, M.M. Krahn, J.P. Meador, B.B. McCain and U. Varanasi, *Environmental Conservation Division, Northwest Fisheries Science Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, U.S.A.*

Starry flounder (*Platichthys stellatus*), white croaker (*Genyonemus lineatus*) and sediments were collected annually from selected sites within San Francisco Bay, and a reference site in Bodega Bay between 1984-1991. Fish livers were examined for toxicopathic lesions and analyzed for selected chlorinated hydrocarbons (CHs); sediment and fish stomach contents were analyzed for polycyclic aromatic hydrocarbons (PAHs) and CHs; and bile was analyzed for PAH metabolites. Sediment concentrations of PAHs, PCBs and DDTs, bile concentrations of PAH metabolites; and liver concentrations of PCBs, dieldrin and chlordanes were generally significantly higher at all San Francisco Bay sites compared to the Bodega Bay reference site. For both species, hydropic vacuolation of biliary epithelial cells was the most prevalent liver lesion detected and was statistically associated

with sediment and tissue concentrations of PAHs or their metabolites, PCBs, DDTs, chlordanes and dieldrin. Temporal trends analyses showed that at Hunters Point, sediment PAHs and CHs increased between 1984 and 1991, while liver concentrations of CHs decreased.

5AM1996-FIS25

poster

INTERANNUAL VARIABILITY OF BEHAVIOR AND DISTRIBUTION OF EASTERN BERING SEA POPULATION POLLOCK AS ADAPTATION TO REDUCE OF ABUNDANCE

M.A. Stepanenko, *Pacific Fisheries Research Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600*

The abundance and biomass of eastern Bering Sea population pollock had stable trend of reduce by the end of 1980s and the first part of 1990s as a result of the absence of numerous year-classes. In the first part of 1990s the interannual change of pollock biomass and exploitation rate have opposite trends, appeared signs of overfishing some year-classes which have significant influence on age composition and distribution of different age groups.

In 1993 pollock of most numerous for the last ten years 1989 year-class predominated among spawners in Pribilof Islands area, in 1994 in Unimak Island area and its biomass was high.

In 1995 appeared clear signs of overfishing of 1989 year-class. At the same time in 1995 a lot number of pollock 1989 year-class began spawn in the southeastern part of Aleutian Basin (Bogoslof Islands area) and it was connected with declining biomass of old age pollock there (older than 10 years old) in 1994 to 350-400 thousand m.t. Quite obviously that middle age pollock (6-8 years old) prefer to spawn in the southeastern part of the Aleutian Basin (Bogoslof Islands area) but scale of spawning is significant of biomass of old age pollock lower than 0.5 million m.t. there.

Percentage of 1989 year-class in exploitable part of population on shelf area in 1995 and in Bogoslof Islands area in 1996 sharply decreased from 40-43% to 18-20% by abundance. In 1996 among spawning pollock on shelf area as well in off Aleutian Islands predominated fish of not numerous 1990 year-class and CPUE during winter-spring season decreased for 40-45% compared with previous year.

In spite of sharp declining of most numerous in exploitable part of population 1989-1990 year classes in 1995-1996 a scale of its migration to southeastern part of Aleutian Basin (Bogoslof Islands area) and to central Aleutian Islands significantly increased in spawning and postspawning period. The 1989-1990 year-classes of pollock formed in Bogoslof Islands spawning ground in 1995 about 25 and 18% and in 1996 about 21 and 24% consequently. In new found in 1995 pollock spawning ground in central Aleutian Islands area (Kanaga Sound) the 1989-1990 year-classes formed in 1995 about 8 and 3% and in 1996 about 18 and 12% consequently. At the same time in the eastern Bering Sea shelf a pollock of 1989 year-class in 1996 formed significant number spawners (20-22%) just in Unimak Island spawning ground but in Pribilof Islands spawning ground percentage has decreased to 12-13%.

In spite of declining abundance eastern Bering Sea population of pollock, in 1990s trend of habit middle age mature pollock in inshore water of Bering Sea side Aleutian Islands in spawning period as well in postspawning has increased. At the same time postspawning pollock migration to Aleutian Basin practically has stopped.

5AM1996-SB21

poster

REGIONAL DIFFERENCE IN INTERDECADAL VARIATIONS IN ZOOPLANKTON BIOMASS, CHLOROPHYLL CONCENTRATION AND PHYSICAL ENVIRONMENT IN THE SUBARCTIC PACIFIC

Takashige Sugimoto and Kazuaki Tadokoro, *Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakanoku, Tokyo, Japan.* 164

Interdecadal variations in zooplankton biomass and chlorophyll concentration in the summer during 1956-92 in the central and western subarctic Pacific and eastern Bering Sea were compared with each other and with those in the climatic and oceanic conditions. The zooplankton biomass and chlorophyll concentration during mid 1960s - mid 1970s in the central and western subarctic were a few times higher than in its preceding and following decades. The values in the eastern Bering Sea and at station P in the eastern subarctic have also increased after mid 1960s, and kept higher level than those in early 1960s with a short peak of chlorophyll concentration in the end of 1970s and a peak of zooplankton biomass in later 1960s. The decade of relatively higher plankton biomass in the whole subarctic Pacific during mid 1960s - mid 1970s corresponds to a period of relatively warmer and shorter winter followed by relatively cooler summer in the central and western subarctic, which corresponds to the period of smaller amplitude of meander of westerly jet in winter.

5AM1996-BIO30

oral

ROLE OF TOP-DOWN AND BOTTOM-UP CONTROL ON VARIATIONS IN PLANKTON BIOMASS IN THE SUBARCTIC PACIFIC

Kazuaki Tadokoro and Takashige Suimoto, *Ocean Research Institute, University of Tokyo, Minamidai 1-15-1, Nakano-ku, Tokyo, Japan.* 164

Local crustacean zooplankton biomass (wet weight; mg/m³) had significant negative correlation with the CPUE of salmonids (Tadokoro et al, 1996). The relationship suggested that salmonid feeding controls crustacean biomass.

Then we investigated relationship between macro-zooplankton biomass and index of chlorophyll *a* concentration, and relationship between chlorophyll *a* concentration index and surface nutrient concentration using data collected in same location and time in summer. Macro-zooplankton biomass had negative correlation with index of chlorophyll *a* concentration. Index of chlorophyll *a* concentration also had negative correlation with nutrient concentration. These negative correlations suggested that grazing of macro zooplankton controls the phytoplankton biomass, and phytoplankton controls nutrient concentration in short and local scales.

Stratification index in the upper layer had a tendency that nutrient concentration increase as stratification be weak. The "Ridge Domain" which have rich nutrient exist under the surface layer in the northern part of the subarctic current system, and flows upward. The Ridge Domain may supply nutrient to the surface layer and, sustain high nutrient surface layer in the subarctic north Pacific in summer.

5AM1996-POC31

poster

SEASONAL VARIATION IN THE TRANSPORT OF SUSPENDED MATTER IN THE EAST CHINA SEA

Satoru Takahashi¹, Tetsuo Yanagi², Akira Hoshika¹ and Terumi Tanimoto¹

¹ *Chugoku National Industrial Research Institute, Hiro-Suehiro, Kure, Japan.* 737-01

² *Department of Civil and Ocean Engineering, Ehime University, Matsuyama, Japan.* 790

Seasonal variation in the transport of suspended matter across the East China Sea is investigated with the use of results of field observations and diagnostic numerical experiments.

Field observations were carried out along the PN line (from the northern off-shore of Okinawa, Japan to the mouth of Changjiang River of China). Vertical distributions of water temperature and salinity were measured with use of the CTD (Sea-Bird 911) and turbidity by the nephelometer(ALEC ASTB-1000M) at each station in four seasons. Using these observed data, diagnostic numerical experiments are carried out to estimate the current field and the horizontal flux of suspended matter in the East China Sea. As a result, it is revealed that the suspended matter is transported from the shelf edge to the inner shelf in summer and from the inner shelf to the shelf edge in other seasons due to the vertical circulation mainly induced by the monsoon wind. The maximum transport of suspended matter from the inner shelf to the shelf edge occurs in autumn.

5AM1996-BIO31 oral
DISTRIBUTION OF *EUPHAUSIA PACIFICA* IN THE NORTHWESTERN PACIFIC OCEAN IN SUMMER

Kenji Taki and Takashi Ogishima, Tokhoku National Fisheries Research Institute, 3-27-5 Shinbama-cho, Shiogama, Miyagi, Japan. 985

We investigate horizontal distribution of each developmental stage of *Euphausia pacifica* based on the 98 vertical haul (0-150m) samples collected with Norpac net, on the occasion of multi-vessels survey of Pacific saury population, widely in the Northwestern Pacific Ocean ($38^{\circ} 06' - 47^{\circ} 30'N$, $140^{\circ} 38' - 156^{\circ} 53'E$) in August 1994, and vertical distribution of that based on the six stratified (0-50m, 50-150m, 150-250m, 250-500m, 500-1,000m) samples collected with MOCNESS net at 14 stations ($39^{\circ} 30'N$, $142^{\circ} 10' - 147^{\circ} 00'E$).

The results of Norpac nets indicate that stages from eggs to immatures tended to distribute in the transition area between Oyashio and Kuroshio, but adults not only in the transition area but also in Oyashio area. The results of MOCNESS nets indicate that early stages from eggs to calyptopis larvae tended to stay mainly in 0-50m layer both at day and night, while stages from furcilia larvae to adults showed the diel vertical migration within the range of 0-500m. But, in the marginal area of warm-core ring, where warm water ($>20^{\circ}C$) covered thickly, adults distributed mainly in 50-150m layer and did not ascend near the surface at night., while in the Oyashio area where cold water ($<4^{\circ}C$) dominated below 50m depth, furcilia larvae stayed in 0-50m layer and did not descend below 50m depth at day.

From the results, it was suggested that suitable temperature of adults may be lower than that of larvae. But through the change of diel vertical migration pattern, adults seemed to be able to inhabit and even spawn at the warmer area.

5AM1996-POC32 oral
RESULT OF DIRECT CURRENT MEASUREMENTS IN LA PEROUSE STRAIT (THE SOYA STRAIT), 1995-1996

Iori Tanaka¹, Akifumi Nakata¹, Hiroki Yagi¹, Gennady Kantakov² and Andrew Samatov²
¹ Hokkaido Central Fisheries Experimental Station, 238 Hamanaka-cho, Yoichi-cho, Yoichi-gun, Hokkaido, Japan. 046

² Sakhalin Research Institute of Fisheries & Oceanography (SakhNIRO), 196 Komsomolskaya Street, Yuzhno-Sakhalinsk, Russia. 693010

Simultaneous joint current measurements in La Perouse Strait (the Soya Strait) were planned as a part of La Perouse Project by HCFES and SakhNIRO to investigate seasonal variation of the volume transport passing through the Strait with ship mounted ADCP (Acoustic Doppler Current Profiler) and mooring systems.

Although the joint current measurement was succeeded only once in August 1995, the volume transport passing through this Strait toward the Sea of Okhotsk was evaluated for the first time to be 0.88Sv by direct measurements.

This result combining with that obtained from the normal oceanographic observation by HCFES just before these measurements enable us to calculate the volume transport of current system in the Sea of Japan.

The transport flowing out from the Tsugaru Strait, flowing northward along the west coast of Hokkaido, and flowing northward along the west coast of Sakhalin which must recirculate southward as the Liman Current are calculated to be 1.34Sv, 1.51Sv, and 0.63Sv respectively.

Finally, the volume transport of the Tsushima Current flowing into the Sea of Japan through the Tsushima Strait is calculated to be 2.24Sv as the sum of the outflows from remaining two major Straits, and 2.87Sv is calculated for the current flowing northward along Honshu as the sum of the Tsushima Current and the recirculated Liman Current.

5AM1996-BIO32 poster
DIATOM ASSEMBLAGES IN AND AROUND A WARM CORE RING IN THE WESTERN NORTH PACIFIC POLAR FRONTAL ZONE EAST OF HOKKAIDO, JAPAN
Akira Taniguchi and Kuo-Ping Chiang, *Laboratory of Aquatic Ecology, Division of Environmental Bioremediation, Graduate School of Agriculture, Tohoku University, Sendai, Miyagi, Japan. 981*

Relationship in spatial distribution between diatom assemblages and water types was investigated in and around a two-year-old warm core ring in the western North Pacific polar frontal zone off Hokkaido, Japan. Five diatom assemblages were defined by the principal component analysis using data on species composition of diatoms. Among the assemblages Background Assemblage with small standing crop was found over entire study area especially in subsurface layers including the core water of the ring. This assemblage likely indicates the site where condition are not highly suitable for diatom growth. Cold assemblage was also found in subsurface probably following the submerging subarctic Oyashio Water. Its standing crop was intermediate. Three other assemblages with larger crops were distributed in the upper layers and indicated the site where a cold streamer or a warm streamer intruded. Some species found in the latter streamer appeared to grow actively during the warm streamer flowed along the outer edge of the warm core ring and consequently formed a new assemblage downstream. As a result, configuration of different water types can be diagrammatically illustrated.

5AM1996-BIO33 oral
LIFE HISTORY, DISTRIBUTION, SEASONAL VARIABILITY AND FEEDING OF THE PELAGIC CHAETOGNATHA, SAGITTA ELEGANS IN THE SUBARCTIC PACIFIC
Makoto Terazaki, *Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano, Tokyo, Japan. 164*

The diurnal vertical migration of *Sagitta elegans* was observed in various waters of the subarctic Pacific. The estimated distance of a diurnal migration was 10 m - 200 m. *S. elegans* is abundant in the epipelagic layer upper 200 m in the Pacific but is distributed as deep as 1000 m or more in the Japan / East Sea because of deep-sea adaptation. *S. elegans* had three spawning periods during the year and their generation lengths were 6 to 10 months at Ocean Station P. In Japan / East Sea, there are two principal spawning period and generation lengths were 10 to 12 months. Copepods were major prey of *S. elegans* inhabiting in the subarctic Pacific. The annual mean food-containing ratio (FCR) was 6.1 % in the Japan Sea. The FCR of *S. elegans* collected from the 0-300 m layer in the western subarctic gyre, ranged from 0 % to 13.5 % (mean=9.6 %) and the feeding activity was

high during the nighttime hours. *S. elegans* consumes 4 % of total secondary production daily at 45 N, 165-10E.

5AM1996-FIS26

oral

ENVIRONMENTAL INDICES FOR PREDICTING FRASER RIVER SOCKEYE SALMON RETURN TIMES

Keith A. Thomson¹, and David J. Blackbourn²

¹ Fisheries Centre, University of British Columbia, Vancouver, BC, Canada. V6T 1Z4

² Department of Fisheries and Oceans, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, BC, Canada. V9R 5K6

Sockeye salmon (*Oncorhynchus nerka*) return to their natal streams to spawn in the Fraser River basin after completing a remarkable migration of thousands of kilometres from their foraging grounds in the northeast Pacific Ocean. The harvest of these fish in the coastal fisheries, are managed by stock group. Pre-season abundance estimates are adjusted in-season, using commercial catch data, test-fishing data, and predictions of return times. The principal stock groups return to the mouth of the Fraser at different times: the early Stuart stock arrives first, the Horsefly and Chilko stocks are mid-summer runs, and the Adams stocks are late summer runs. The return times of a given stock may vary by as much as three weeks between years. We have undertaken an extensive examination of hypotheses which attempt to explain this variability and developed several new environmental and biological indices for possible use in multiple linear regression models for return time forecasts.

The indices examined (all of which are available in near real-time for pre-season or in-season forecasts) were: 1) for the temperature displacement hypothesis, sea surface temperatures and thermal limits (i.e. the latitudes of surface isotherms along specified meridians and the distances of isotherms from Vancouver Island); 2) for the surface advection hypothesis, eastward and northward currents imputed by the Ocean Surface Current Simulation (OSCURS) model of J. Ingraham (NMFS, Seattle, USA); 3) for the fish length hypothesis, female length of each stock; 4) for the fish abundance hypothesis, return abundances of BC sockeye and total Alaska salmon catch; 5) for the return time hypothesis, stock-specific return times; and 6) for the full moon hypothesis, the day-of-year of the first full moon of the year and the full moons in June and July. For hypotheses numbers 3 to 5, the variables were lagged by one year, lagged by four years, averaged over the last four years to obtain useful forecast variables (rather than having to use a forecasted variable within a forecast model), which also accounted for the time history of these quantities. The full moon hypothesis was suggested by Bill Proctor, a very experienced sockeye salmon fisherman, who stated that he has been predicting return times by the timing of the full moons.

We identified candidate predictor variables for each hypothesis and stock using correlation coefficients and Bonferroni probabilities. Alternative multiple linear regression models were compared to obtain the forecast models that would be the least likely to fail due to changes in the marine climate.

Our presentation will review the above hypotheses and potential forecast indices, discuss our forecast models in light of these hypothesis, and suggest that several of the new indices we used would also be of value for studying climatic effects on salmon.

5AM1996-MEQ15

poster

CHEMICAL CONTAMINANTS IN GRAY WHALES (*ESCHRICHTIUS ROBUSTUS*) STRANDED ALONG EASTERN PACIFIC COASTS AND FROM OFF THEIR WESTERN BERING SEA ARCTIC FEEDING GROUNDS

Karen L. Tilbury¹, J.E. Stein¹, S.A. Blokhin², R.L. Brownell, Jr.³, J. Bolton¹, W. Dyer¹, and D. Ernest¹

¹ Northwest Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE, Seattle, WA U.S.A.

² Pacific Research Institute of Fisheries and Oceanography (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600

³ Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92038, U.S.A.

The gray whale is a coastal migratory mysticete with a benthic feeding strategy and a long period of fasting during its southbound migration and their residence on the breeding grounds. Gray whales have been observed feeding in coastal waters which may present a higher risk of exposure to toxic chemicals. The prolonged fasting may also alter the disposition of toxic chemicals within the animal. We have recently measured the concentrations of organochlorines (OCs) and trace elements in tissues and stomach contents collected from gray whales that were stranded along the US west coast and from gray whales that were taken off their Arctic feeding grounds in the western Bering Sea during a Russian subsistence harvest. The subsistence animals were all juveniles (mean length \pm standard error, 860 \pm 81 cm; 7 males, 17 females), whereas the stranded whales were significantly ($p \leq 0.05$) longer (1,117 \pm 170 cm; 14 males, 6 females) and included juveniles and adults. The differences in sex ration and developmental stage did not have a marked effect on the concentrations (based on wet weight of tissue) of contaminants in the two groups of animals (e.g., Σ PCBs in blubber of the stranded whales and the subsistence whales were 640 \pm 82 and 920 \pm 220 ng/g wet weight, respectively). The lipid content (6 \pm 2%) of blubber for the stranded whales, which were on their northward bound migration, however, was low and significantly different than the lipid content (48 \pm 5%) of blubber for animals from the feeding grounds. The concentrations on a lipid basis, for example, of Σ PCBs in five juvenile stranded whales and the juvenile subsistence whales were significantly different (19,000 \pm 14,000 and 680 \pm 67 ng/g lipid, respectively). We hypothesize that the higher concentration of Σ PCBs in the stranded animals may be predominantly due to the retention of OCs in blubber during fasting rather than to markedly increased exposure. The concentrations of certain trace elements (e.g., cadmium) in some tissues (e.g., kidney) were also elevated in the stranded animals. Moreover, aluminum in stomach contents and tissues was high compared to other marine mammal species, which is consistent with the ingestion of sediment during feeding. Overall, the results for trace elements showed that 1) the concentrations in tissues were relatively low and less than levels considered to be of toxicological concern and 2) the profile of elements was influenced by the feeding strategy of the gray whale.

5AM1996-MEQ16

oral

POLLUTANT ACCUMULATION IN THE JAPAN SEA COASTAL BOTTOM SEDIMENTS

A.V. Tkalin¹ and B.J. Presley²

¹ Far Eastern Regional Hydrometeorological Research Institute (FERHRI), Vladivostok, Russia

² Texas A & M University (TAMU), College Station, USA

Extensive sampling of bottom sediments from Peter the Great Bay (Sea of Japan) for priority pollutant analysis was performed in September-October 1994 using FERHRI research vessels "Akademik Shokalsky" and "Hydrobiologist". Heavy metals were analyzed at the Trace Element Research Laboratory, TAMU, organic pollutants were measured in FERHRI. Sediment core dating using Pb-210 technique was implemented by G.H. Hong (Korea Ocean Research and Development Institute).

Elevated concentrations of trace metals in surface bottom sediments were detected within the local zones (3-5 miles) around main pollution sources (industrial effluents, city landfill, etc.). High concentrations of petroleum and chlorinated hydrocarbons were observed also within the local areas close to land-based pollution sources. According to vertical profiles of some metals, anthropogenic increase of their concentrations began approximately in 1940-1950. Outside these zones contents of heavy metals are regulated by grain size and mineralogy of bottom sediments, no anthropogenic changes in vertical distribution of trace metals were observed.

Average concentrations of trace metals and organic pollutants in bottom sediments of some bays around Vladivostok and Nakhodka (Golden Horn, Amursky, Ussuriysky, etc.) are different mainly because of uneven distribution of wastewater inputs to these areas. In the most polluted areas (Golden Horn Bay, the inner harbour of Vladivostok) concentrations of zink, lead and mercury were higher than those reported to be harmful to marine organisms (Long and Morgan, 1990).

Sedimentation fluxes of trace metals in Peter the Great Bay are less than, for example, in the Strait of Georgia or Puget Sound. Unlike some coastal areas of the U.S., no decreasing trends were observed in vertical distribution of metals in Peter the Great Bay. Therefore, strict regulations of wastewater inputs to coastal zone are necessary.

5AM1996-BIO34 poster
DILEMMA BETWEEN APPETITE AND FEAR OF PREDATOR

Atsushi Tsuda¹, Hiroaki Saito¹ and Taro Hirose²

¹ Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, Hokkaido, Japan. 085

² Ocean Research Institute, University of Tokyo

Nocturnal feeding is a widely observed phenomenon both for marine and freshwater zooplankton. Although nocturnal feeding behavior usually associate with diel vertical migration, there have been some observations that showed active feeding during night without detectable shift of the vertical distribution. Thus, feeding and migration thought to be independent behaviors controlled separately. Diel vertical migration is strongly suggested to be a visual predator avoidance behavior. On the other hand, the same cause is predicted for nocturnal feeding, bur poorly substantiated. We carried out a feeding experiment with copepods (*Acartia* and *Pseudocalanus*) and their visual predator (herring larvae and salmon fly) to confirm whether feeding copepods under a light is more vulnerable than non-feeding copepods. The results showed that the fishes fed on feeding copepod at significantly higher rate. The fact suggests that nocturnal feeding without migration is a possible strategy, making a trade-off between the metabolic disadvantages by starvation during a day and the decreased mortality.

5AM1996-BIO35 invited
CHARACTERISTICS OF THE LIFE HISTORY OF KEY COPEPOD SPECIES ALONG A EUTROPHIC-MESOTROPHIC-OLIGOTROPHIC TRANSECT IN JAPANESE COASTAL WATERS

Shin-ichi Uye, Faculty of Applied Biological Science, Hiroshima University, Higashi-Hiroshima, Japan. 739

Regional variations in trophic structure of plankton communities have been noted along a eutrophic-mesotrophic-oligotrophic transect, like that found from the innermost part of Osaka Bay to the oceanic waters off Kii Channel, Japan. Total carbon biomass of bacteria (BA), heterotrophic nanoflagellates (HNF) and microzooplankton (MZ) decreases steadily offshore, while the biomass of net-zooplankton, >86% of which is attributed to copepods, fluctuates greatly among sampling stations. Relative biomass of copepods is higher in mesotrophic regions than in oligotrophic and eutrophic regions, where BA, HNF and MZ are relatively more important. *Calanus sinicus* is the dominant species in the study area, particularly in the mesotrophic regions. As one moves to inshore, dominant species shift, in order, to *Paracalanus* sp., *Acartia omorii* and *oithona davisae*. Biogeochemical characteristics which define life history patterns, e.g. egg type (i.e. subitaneous/resting eggs), egg production rate,

recruitment rate, development time, egg to adult mortality, sex ratio, and ontogenetic changes in patterns of diel vertical migration underlie the temporal/spatial variations in population size at sea. I compare these biological attributes among the above-mentioned species and relate them to regional differences in biotic and abiotic factors in order to assess the importance of various factors in regulating copepod life history.

5AM1996-POC33

oral

EVIDENCE OF ON-SHELF FLOW AT THE BERING SEA SHELF BREAK

Pim van Meurs and Phyllis J. Stabeno, NOAA, Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115-0070, USA

The northward flow through Bering Strait (0.85 Sv) requires a net flux onto the eastern Bering Sea shelf. This on-shelf flux is an important source of nutrients and salt for the shelf. Satellite-tracked drifter trajectories, Acoustic Doppler Current Profiler data and a CTD survey for 1990 show the existence of episodal on-shelf flow at the Bering Sea shelf break. In May 1990, two sets of drifters were deployed at the slope (700 m depth). The first set of seven drifters followed the bathymetry northward, the second set of six drifters moved onto the shelf. CTD sections taken at the same time support the on-shelf flow evident in the drifter trajectories. Since the drifters are drogued at a specified depth, their use as an indicator of on-shelf flow is controversial. We explore theoretically under what conditions drifters can be used to measure on-shelf flow.

5AM1996-SB22

oral

CLIMATE-DEPENDENT LONG-TERM DYNAMICS OF SOME NORTH PACIFIC PINNIPED POPULATIONS

Valeriy Vladimirov, Marine Mammal Laboratory, Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), 17v.Krasnoselskaya, Moscow, Russia. 107140

Over the 2nd half of the current century trajectories of most northern fur seal (NFS), Steller sea lion (SSL) and some harbor seal (HS) populations of the huge Far Eastern - Alaskan region are practically identical and clearly correlate ($rr = 0.70-0.99$) with preceding changes of the Vangenheim's Atmospheric Circulation Index (ACI) which is the most reliable indicator of large-scale climatic changes.

Pinniped populations respond to secular climatic changes with a 20-28-yr lag as the latter mainly impact them indirectly - thru changes of oceanographic conditions and primary productivity, further - thru marine consumer chains and food availability, resulting in changes of juvenile seal survival and appropriate changes of age structure, reproductive potential of populations, etc. Naturally, this process takes decades before it is visibly reflected on seal abundance that explains observed time lags. There are as well significant correlations ($rr = 0.75-0.90$) of NFS, SSL and HS population trends with preceding changes of the North Pacific ichthyofauna (walleye pollock, herring, salmon, sardine stocks, etc.) whose oscillations (based on catches) also coincide very closely with ACI changes ($rr = 0.8-0.9$, - Klyashtorin, 1995). Great similarity of dynamic processes at different levels of the oceanic biota (including seabirds) suggests that climatic impact is the main triggering factor of natural long-term changes in the North Pacific ecosystem. Influence of human-related factors on NFS and SSL populations was wholly not too significant during last 30-40 years.

Obtained results create a basis for perspective environmentally-based forecasting of the dynamics of many North Pacific pinniped populations about 25 years ahead.

5AM1996-FIS27

oral

APPLICATION OF SPAWNING BIOMASS PER RECRUIT ANALYSIS IN FISHERIES MANAGEMENT FOR CHUB MACKEREL, SCOMBER JAPONICUS

Tokio Wada¹, Chikako Sato¹ and Yoshiharu Matsumiya²

¹ *National Research Institute of Fisheries Science, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Japan. 236*

² *Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo, Japan. 164*

For the persistence of a fish population, fishing should not reduce the spawning biomass per recruit (SPR) below a threshold level that is necessary for replacement. If we can adjust SPR as a reciprocal of the recruits per unit of spawning biomass (RPS) estimated from spawning-recruitment relationship, successive generations of the population will replace each other on average. The abundance of chub mackerel (*Scomber japonicus*) stock in the Pacific waters off northern Japan has decreased throughout the 1980's and in a low level at present without any fishing regulation. We simulated the changes in annual biomass and catch from 1980 to 1994 under 20 to 60% SPR conditions, and compared with those under actual fishing conditions. In the case of 40% SPR, the simulated biomass on 1994 was four times of actual value, and the average of annual catch was almost same as actual catch. 40% SPR would be appropriate as a conservative threshold level for replacement and also acceptable as a target of the fisheries management for the stock. Under 20% SPR condition, the stock almost collapsed by 1989. It was suggested that 20% SPR was not sufficient for replacement of the stock. On the other hand, 60% SPR was the most effective for maintaining the stock abundance. Under this condition, however, annual catch was controlled in a low level even in case that the stock abundance was high, 60% SPR would be inadequate as a target reference point for utilization of the stock.

5AM1996-FIS28

oral

ECOLOGICAL RISKS ASSOCIATED WITH DECLINING SPAWNER SIZE IN PUGET SOUND COHO SALMON (*ONCORHYNCHUS KISUTCH*)

Thomas C. Wainwright and Laurie A. Weitkamp, *Coastal Zone and Estuarine Studies Division, Northwest Fisheries Science Center, National Marine Fisheries Service, 2725 Montlake Boulevard East, Seattle, WA 98112 USA*

Adult coho salmon (*Oncorhynchus kisutch*) have been declining in body size throughout their range. Declines in body size have also been observed for Puget Sound coho salmon, with some population segments exhibiting the steepest declines of any west coast coho populations. The cause of these declines has not been determined, but potential causes include selective harvest, effects of hatchery practices, declining ocean productivity, and density-dependent growth reduction resulting from large hatchery releases. The decline in mean size appears to result from truncation of the upper tail of the size distribution. We examine the ecological consequences of loss of larger spawners from a population, particularly in terms of decreased average fecundity. We conclude that, regardless of the cause, decline in body size can substantially reduce stock productivity and increase risk to sustainability.

5AM1996-FIS29

oral

VARIATIONS IN SPAWNING GROUND AREA AND EGG DENSITY OF THE JAPANESE SARDINE IN THE PACIFIC COASTAL AND OCEANIC WATERS

Yoshiro Watanabe, Hiromu Zenitani and Ryo Kimura, *Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo. 164*

The spawning ground of the Japanese sardine *Sardinops melanostictus* was distributed over the oceanic waters as well as the coastal waters along the Pacific coasts of western and eastern Japan during 1978-1992. The area of the spawning ground in the coastal waters on the continental shelf has ranged from 95000 km² in 1992 to 143000 km² in 1988, constituting 44-77 % of the total area of the spawning ground. The area in the coastal spawning ground was relatively constant in spite of the large fluctuations in egg abundance from 88 (1987) to 668 trillion (1989) in the waters, i.e., size of the

spawning population. Spawning adults seemed to extend over the coastal waters irrespective of the size of the spawning population in these waters. In contrast to the coastal waters, the spawning area in the oceanic waters offshore of the continental shelf increased from 31000 km² in 1978 to 183000 km² in 1988 and then shrank to 83000 km² in 1992, as a function of the spawning population size. The egg distribution density in the coastal waters stayed less than 6000 m⁻²*mo⁻¹, but it reached as high as 27400 m⁻²*mo⁻¹ in the expanded spawning ground in the oceanic waters. The oceanic waters seemed to function as a reserve spawning ground for the sardine in the years of extremely high population.

5AM1996-SB23

oral

PATTERNS OF SCALE GROWTH IN BRITISH COLUMBIA PACIFIC SALMON, AND ITS RELAVANCE TO THE "CLIMATE CHANGE & CARRYING CAPACITY" PROGRAM

David Welch, High Seas Program, Ocean Sciences & Productivity Division, Pacific Biological Station, Department of Fisheries & Oceans, 3190 Hammond Bay Road, Nanaimo, BC Canada. V9R 5K6

Long-term changes in salmon growth were first recognized by Ricker, who noted that size at maturity decreased since the early 1950s for virtually all species in British Columbia. Recent studies have confirmed the trend towards slower rates of growth and its presence in Alaskan, Russian, and Japanese populations. Salmon growth can be complicated to interpret because size at maturity cumulative result of effects on growth occurring over several years in the ocean.

We review work completed over the last two years which indicates that archival scale holdings provide good evidence that measured patterns of scale growth reflect the overall growth of salmon, and describe patterns of growth covariation between stocks and species of salmon. The analysis indicates that the trend towards smaller size is generally evident only in the first and last years of life in the sea. The conclusion from these analysis is that growth during all periods of life in the ocean seems to be a sensitive indicator of changes in ocean climate but that density-dependent competition in B.C. salmon may be primarily occurring in the coastal zone, which most species of salmon only briefly transit on their way to the offshore. If correct, the result has significant implications for the design of studies on the carrying capacity of the north Pacific for salmon populations.

5AM1996-POC34

oral

RECENT CHANGES IN SURFACE WATER PROPERTIES ALONG LINE P IN THE NORTHEAST PACIFIC OCEAN

Frank Whitney and C.S. Wong, Institute of Ocean Sciences, P.O. Box 6000, Sidney, BC, Canada. V8L 4B2

Surface nutrients and salinity have been monitored along Line P (a section from the mouth of Juan de Fuca Strait to Station Papa at 50 N, 145 W) since 1989. Nitrate and silicate have been observed to decline steadily from 1989 to 1994 in conjunction with a wider distribution of low salinity water (less than 32.4 psu). One effect of this nutrient decline is that an area of nitrate depletion in late summer extended 1000 km offshore in 1994, about twice as far as was observed in 1989-90. Only a mild recovery in nutrient stocks has been seen since.

In the nitrate depleted region, phytoplankton biomass is concentrated at the base of the mixed layer, whereas further offshore, phytoplankton are uniformly distributed in the upper 40 m. Changes in the nutrient supply and possibly the ecologies of coastal and offshore waters are apparently having a dramatic effect on the vertical transport of particulate materials in winter. An incomplete sediment trap record through the late 1980s and mid 1990s shows that there has been a virtual cessation of transport to depth in winter at a variety of locations along Line P. Changes in fresh water and nutrient distribution may be the basis of a reported regime shift in ocean productivity in the northeast Pacific Ocean.

5AM1996-POC35 oral
SUBARCTIC MONITORING OF NUTRIENTS AND CHLOROPHYLL *a* IN THE SUBARCTIC NORTH PACIFIC

C.S. Wong¹, Y. Nojiri², T. Kimoto³ and J. Zeng²

¹ *Ocean Biogeochemistry, Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C., Canada. V8L 4B2*

² *National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan. 305*

³ *Research Institute of Ocean Chemistry, 5-19, Funahashi-cho, Tennoji-ku, Osaka, Japan. 310*

A bilateral cooperative program between Japan and Canada has been monitoring the subarctic Pacific Ocean using a lumber carrier, the M/V SKAUGRAN, between Vancouver and Japan, crossing the NE Pacific, the Bering Sea, Kamchatka waters and NW Pacific Ocean off the Kuril Islands and Japan and returning to Vancouver via a southern route. The results of one year of sampling showed the large-scale seasonal changes in the subarctic water masses for properties of nutrients (nitrate, silicate and phosphate) and chlorophyll *a*, total CO₂ and alkalinity. Nutrient depletion in the summer was related to intensified gyre circulation in the NE Pacific. The large-scale new production, estimated from changes in nitrate and carbon between summer and winter, was about 1 Gtc yr⁻¹.

5AM1996-MEQ17 oral
ON THE CHEMICAL CONTAMINANTS OF SURFACE SEDIMENTS IN THE SOUTHERN PART OF THE YELLOW SEA

Dong Beom Yang¹, J.R. Oh¹, K.T. Kim¹ and C.K. Park²

¹ *Korea Ocean Research and Development Institute (KORDI), Ansan P.O. Box 29, Seoul, Republic of Korea. 425-600*

² *National Pusan Fisheries University*

Surface sediments of the Yellow Sea were investigated for chemical contaminants in April 1994. Sediment COD ranged from 115 to 13.63 mg/kg dry wt. with higher values in the central part. High organic carbon and nitrogen contents were also found in the surface sediments of this region. Heavy metal (Cd, Pb, Zn, Ni, Co) contents, though close to naturally found level, showed geographic variation. PAH concentrations were generally low in the surface sediments of the Yellow Sea except naphthalene and phenanthrene which could be detected in the central part. Some organochlorine pesticides such as delta-BHC and dieldrin were found in the central part of the study area.

5AM1996-POC36 oral
SEASONAL CHANGES OF THE COLD WATER BELT IN THE SOYA STRAITS AND ADJACENT AREAS AND ITS CHEMICAL AND BIOLOGICAL PROPERTIES

Hiroki Yagi¹, Iori Tanaka¹, Akifumi Nakata¹, Tomomi Watanabe¹, Gennady Kantakov² and Andrew Samatov²

¹ *Hokkaido Central Fisheries Experimental Station, 238 Hamanaka-cho, Yoichi-cho, Yoichi-gun, Hokkaido, Japan. 046*

² *Sakhalin Research Institute of Fisheries & Oceanography (SakhNIRO), 196 Komsomolskaya Street, Yuzhno-Sakhalinsk, Russia. 693010*

For the southern part of the Okhotsk Sea, we have little information on the chemical and biological properties of the water masses which appear and disappear seasonally in spite of the high fisheries activity.

The Cold Water Belt (CWB) being indicated by a surface temperature less than 8°C in summer was found in the joint ocean observation of Japan and Russia in August 1995. The CWB was expanded from southwest coast of Sakhalin Island to the Russian Okhotsk Sea, crossing through the northern part of the Soya Strait. From analysis of temperature, salinity, nutrients and dissolved oxygen, the CWB seems to originate from a deep water upwelling along the continental shelf from approximately 100-200 m depth at the foot of Moneron Island situated off the southwestern part of the

Sakhalin main island. High densities of chlorophyll *a* and zooplankton biomass were found at the tip of the CWB.

The CWB was not recognized by winter cruise realized in March 1996, but found that the water originated from the Okhotsk Sea contrary flow out to the Tatar Sear passing through northern part of the Soya Strait.

The mechanism of the upwelling and the CWB formation as a nutrients supply pump in this area and its contribution to the productivities are discussed.

5AM1996-POC37 oral
THE FUZZY ANALYSIS OF THE RELATIONSHIP BETWEEN THE SEA SKIN-BULK TEMPERATURE DIFFERENCE AND WIND SPEED, AIR TEMPERATURE IN THE COASTAL AREA OF QINGDAO
Du Yong, *Ocean University of Qingdao, Qingdao, Shandong, People's Republic of China.*

The fuzzy analysis of the relationship between the sea skin-bulk temperature difference and wind speed, air temperature is made by using the two methods with the observational data collected by the underway auto-collect system in the coastal area of Qingdao for 5 days. It is shown that the complex relationship can not be described by the simple fuzzy distinguish of model correctly, but the method of the fuzzy inference is suitable for the prediction of the sea skin-bulk temperature difference. The correct rate of the main prediction is over 80%. It is believed that the accuracy of the prediction value of the sea skin-bulk temperature will be improved further with the accumulation of the observational data, and it will contribute to the improvement of the retrieval accuracy of the sea surface temperature from satellite.

5AM1996-POC38 oral
THE CIRCULATIONS EAST OF TAIWAN AND IN EAST CHINA SEA AND EAST OF THE RYUKYU ISLANDS FURING EARLY SUMMER 1985
Yaochu Yuan¹, Ziqin Pan¹, Cho-Teng Liu², Shi-pei Zheng²
¹ *Second Institute of Oceanography, State Oceanic Administration, Hangzhou, People's Republic of China. 310012*
² *Institute of Oceanography, National Taiwan University, Taipei, China*

A modified inverse method is used to compute the circulations east of Taiwan and in the East China Sea and east of the Ryukyu Islands with hydrographic data obtained during early summer of 1985. The computational region covers an area west of 129°E and from 21°45'N to 35°N. The computed results show that: 1) The net volume transport (VT) of Kuroshio through Section 21°45'N east of Taiwan and west of 123°E is about $45 \times 10^6 \text{ m}^3/\text{s}$ during early summer of 1985. The Kuroshio has two current cores. One is located near Taiwan, and its velocity is very large and its maximum velocity is 226 cm/s at the 100 m level, which is close to the maximum velocity of the beginning of the Kuroshio east of the Philippines. The other is located further to the east, and its maximum velocity is 159 cm/s at the 100 m level; 2) Through a transect northwest of Miyakojima Island and a transect southwest of Okinawa Island the volume transports of Kuroshio in the East China Sea both are about $25 \times 10^6 \text{ m}^3/\text{s}$. The maximum velocity of the Kuroshio at these two sections is 194 and 128 cm/s, respectively, and both are located on the shelf break; 3) Beneath and east of the Kuroshio both there are the counter current; 4) East of Okinawa Island there is a northeastward current, and its VT is about $12.6 \times 10^6 \text{ m}^3/\text{s}$, and it comes from a westward flow at 129°E Section and the recirculation, and do not originate from the Kuroshio east of Taiwan. There is a southwestward abyssal boundary current east of Okinawa Island; 5) There are several different scale eddies in this computational region. For example, there is a meso-scale cyclonic eddy east of Miyakojima Island.

5AM1996-MEQ18

oral

RELATION BETWEEN CHANGES OF THE MARINE ECOSYSTEM STRUCTURE AND CHEMICAL TOXICS OF COASTAL ENVIRONMENTS (SEA-WATER AND BOTTOM SEDIMENT ETC.) IN THE SETO INLAND SEA, JAPAN

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

In the PICES Third Annual Meeting, Nemuro, we had shown that number of species of coastal fauna has been reduce gradually in every monitoring station by observations of coastal fauna at the fixed points around Kure City, Hiroshima prefecture, Japan from FY1960 to FY1990 in every summer. The change of the marine ecosystem in the coastal sea does not correspond tot the change of organic materials, suggesting that the monitoring of organic matter can not seize the impact of pollutants on structure of the marine ecosystem.

Now we will show the environmental condition of each observation point and recent appearance of coastal fauna. Recently, several species, for instance *Coscinasterias acutispina*, *Pollicipes mitella*, has revived in several stations. In order to explain the cause of this phenomenon, we will show yearly changes of chemical toxics (PCB, Heavy metals and Petroleum oil etc.) of sea-water and bottom sediment. And we analyze the relation between changes of coastal fauna appearance and chemical toxics of coastal environment (sea-water and sediments) in the Seto Inland Sea.

5AM1996-POC40

oral

VARIATIONS OF THE AIR PRESSURE, AIR TEMPERATURE AND SEA LEVEL OF THE SYNODIC PERIODS OF MOON AND PLANETS

Chung Jong Yul¹, Katie V. Ivanova² and Vladimir V. Ivanov³

¹ *Department of Oceanography, College of Natural Sciences, Seoul National University, Sinlim-Dong, Gwanag-Gu, Seoul, Republic of Korea. 151*

² *Moscow State University, Moscow, Russia*

³ *Institute of Marine Geology and Geophysic, Nauka Street, Yuzhno-Sakhalinsk, Russia. 693002*

There are discovered the line structure of the power spectra of the time variations of the air pressure and air temperature, which are observed during the 19 years. The spectra look like the same as the spectra of the electromagnetic emission of the molecules. The frequencies of the separate lines can be juxtaposed with frequencies of the astronomical events and with the combinations of the frequencies of the different astronomical events and the frequency of the Earth rotation around the Sun.

5AM1996-POC39

oral

TIDAL CURRENTS IN THE KOREA STRAIT

Gennady I. Yurasov, *Pacific Oceanological Institute, 43 Baltiyskaya Street, Vladivostok, Russia. 690041*

Amplitude relationship between great bulk of diurnal and semidiurnal tidal waves obtained on data base of instrumental measurements and calculated by Franko's method show wrong semidiurnal pattern of tidal currents in the Korea Strait. Generally, wave M with maximal amplitude of 40-45 cm/s in the central part of the Strait forms regime peculiarities of tidal currents there.

Ellipses of summarized tidal currents in the narrow parts of the Strait are non-symmetric and considerably extended to the northeast. Horizontal tidal movements occur synchronically through the whole water column. Owing to diurnal inequality, tidal current maximal velocity vector extended to the East-China Sea exceeds 80-90 cm/s in average astronomical conditions and is almost two times more than ebb-tide velocity.

Typical peculiarities of horizontal movements of the Strait water masses made by some tidal waves are shown on tidal maps. Crest zone of stationary tidal oscillations is situated in the south part of the Korea Strait between Chechhudo and Tsushima Islands. It is clearly seen in the belt of 20-30 miles wide where condensation of isophase lines, lowering of tidal current velocity, abrupt orientation variations of semidiurnal wave tidal ellipses (up to 90°) and reverse coefficient increase up to 0.8 are observed.

Tidal current velocity vector rotates clockwise in the most part of the Strait and anti-clockwise in direction of wave M amphidromic system in the narrow parts of the Strait and there near the Sea of Japan / East Sea. During the period of phase inequality difference between flow speeds from syzygy to quadrature exceed 20-30 cm/s, and during the period of tropic inequality it exceeds 30-35 cm/s.

5AM1996-POC41 oral
ON THE PROPERTIES OF 3D CIRCULATION AT OCEANIC DENSITY FRONTS
O.G. Yurasov, *Pacific Oceanological Institute, 43 Baltiskaya Street, Vladivostok, Russia. 690600*

Theoretical model of 3D circulation at the front of density in open ocean is proposed. Variational method of local potential is used for approximate solution of the system of differential equations of ocean dynamics in Bussinesq approximation. This method is based on the principle of minimum entropy production in the stationary state of thermodynamics system by Prigogine.

On the example of the fronts of Gulf Stream and Kuroshio Extension an attempt is made to explain internal causes of stationary state of these items and its self-maintaining. An importance of influence of the horizontal (lateral) viscosity at the geostrophic flow at the front is supposed it was found the critical value of the ratio of Rossby number to horizontal Ekman number ($\epsilon\text{ps}/R/C$). The limits of the front of density existence are determined depending on ϵps .

The basic features of the along-frontal current structure are explored. It is demonstrated that axis of this current is shifted to the northern part of the front and that this asymmetry is necessary for this type of front. The countercurrent appeared at the southern part of the front for the about-critical values of ϵps . Cross-frontal circulation is characterized by two zones of convergence and divergence at the northern and southern parts of the front respectively. The horizontal scale of the front of density is defined. It is proportional to the Rossby radius of deformation. Horizontal turbulent viscosity leads to increase of horizontal scale of the front. For small values of the geostrophical flow this front is not stable and a "region of front destruction" is appeared.

5AM1996-FIS30 oral
CONSEQUENCES OF SIZE SELECTIVE FISHING ON TANNER CRAB POPULATIONS THAT EXHIBIT PERIODIC RECRUITMENT
Jie Zheng, Gordon H. Kruse and Margaret C. Murphy, *Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, P.O. Box 25526, Juneau, AK 99802-5526, USA*

Tanner crab fisheries in Alaska are managed through a size-sex-season approach, i.e., harvest of only large males and no fishing during spring molting and mating periods. In addition, commercial removals from assessed populations are based on a constant harvest rate strategy. Removal of large-size male crabs by fisheries truncates size-structures of crab populations and reduces abundance of large-size male crabs. As abundance declines, spatial distribution contracts thereby potentially affecting availability of large-size males for mating. Further truncation of size-structure may have deleterious effects on a crab population is natural buffer against periodic recruitment patterns. We examined consequences of size selective fishing on the Tanner crab (*Chionoecetes bairdi*) population in Bristol Bay, Alaska. A length-based model was constructed to examine the sensitivity of size-structure truncation to different harvest rates and recruitment patterns. We also investigated harvest strategies to reduce the negative effects of size-structure truncation on the population. With periodic

recruitment, higher harvest rates can be maintained during periods with strong recruitment than during periods with poor recruitment when lower harvest rates should be used to protect large-size crabs and reproductive potential.

5AM1996-POC42

oral

THE WATER MASS TRANSPORTATION IN THE OKHOTSK SEA

I.A. Zhigalov, Pacific Research Fisheries Center (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, Russia. 690600

The geostrophic currents and water transportation in the Okhotsk Sea were calculated on the base of oceanological observations, which were fulfilled in November-December of 1995 on RV "Prof. Levanidov". The water transportation was calculated for the layer 0-1000m or 0-bottom, when the depth was less than 1000m.

The north-eastern water transportation prevailed in south deep water part of the sea. The water transportation on the section between the south-eastern point of Sakhalin and Iturup in the northern direction was 2,4 Sv. The water transportation in the south direction on this section was absent with the probable exception of small area near the Iturup where unfortunately the observations were absent.

The northern direction of water currents also prevailed in the north-eastern part of the sea. The West-Kamchatka current (WKC) flowed as the wide current between the Kamchatka and 150 E. The deep stream of WKC was oriented approximately along the 154 E, after the passing of the southern part Tinro Basin WKC was divided into two branches: one of them flowed to the north and transferred 0,9 Sv; another of them deviated to the north-east and transferred 0,8 Sv. Then these waters were drawn into the general cyclonic circulation on the North-Okhotsk shelf and returned probably into the central part of the sea with waters entering from the Tatar strait.

On the section along the Kuril Islands from the northern point of Iturup to the south-western Kamchatka coast the water influx to the Okhotsk Sea accounted for 8,2 Sv, and the water flowing from the sea 11,8 Sv. The waters entering to the sea in the area of central and northern Kuril Islands flowed partially to the north (1,7 Sv), forming the WKC and partially returned to the islands with the branches of cyclonic and anticyclonic eddies. The most intensive water exchange was marked in the area of central Kurils. For example, in the area to the northwest of Simushir the water entering to the sea made up 5,6 Sv, the flow from the sea-5,5 Sv. The water entering to the Okhotsk Sea across the northern Kuril strait; 5;0 was insignificant (0,2 Sv).

Thus, in November-December, 1995 the summarized water influx across the Kuril strait and the south part of the sea was equal 10.6 Sv, and probably the water influx from the Tatar strait to the north-western part of the sea was equal 1.2 Sv. The summarized water flowing from the central part of the sea to Kuril Islands was equal 11,8 Sv, 3,0 Sv of them flowed out to the Pacific Ocean across the Friza strait.

5AM1996-POC44

oral

GEOGRAPHICAL VARIATION AND DEPOSITION OF ATMOSPHERIC TRACE ELEMENTS IN EAST CHINA SEA

Ming yu Zhou, Fanlan Qian, Chi Chen and Lirong Su

National Research Center for Marine Environmental Forecasts, 8 Dahuisi, Haidian District, Beijing, People's Republic of China. 100081

Using the aerosol samples collected during 1986-1992 in East China Sea, the trace elements were determined with neutron activation analyses. The analyses results showed that the concentrations of crustal elements Fe, Al and Co were higher along the coastal area and decreased

with distance from coast. In East China Sea the concentrations of pollution elements Sb and Se increased with increasing latitude.

In East China Sea there was distinct seasonal variation of crustal and pollution elements in aerosols. The concentrations of crustal and pollution elements had highest values in spring and lowest values in summer, the concentrations of these elements in fall were somewhat higher than those in winter.

The annual variation of depositions for crustal and pollution elements in East China Sea was discussed.

5AM1996-BIO36 oral
**EMPIRICAL PROGNOSTIC MODEL OF ENVIRONMENTS DEVELOPMENT AND SAURY
MIGRATION OFF SOUTHERN KURIL ISLANDS**

Yury I. Zuenko, Yury V. Novikov, Svetlana Y. Glebova, Larisa N. Bokhan, Alexey A. Batyaluk and Victor N. Filatov, *Pacific Fisheries Research Centre (TINRO), 4 Shevchenko Alley, Vladivostok, Russia.* 690600

Prognostic box model of seasonal development of vertical water structure, net plankton abundance and composition, pacific saury availability and concentration for July-October is presented. The model requires parameters of atmospheric circulation (Katz indices) and calculated the parameters of water structure (SST, temperature at 50 m horizon (T50), thermocline gradient), plankton (biomasses of the main species or groups in the upper 100 m layer), and saury catch per unit effort (CPUE) for next month in the six boxes which correspond to the main types of vertical water structure: subtropic, subarctic, warm Soya Current, cold Oyashio Current, the coldest Kuril type, and tidally-mixed one. Arrangement of the boxes and their contours are determined in the model by the patterns of atmospheric circulation.

All co-relations between model parameters were determined empirically by the methods of cluster analysis and multiple regression on the base of the data obtained in 1978-1988. The model realizes the following algorithm:

1. Katz indices - future boxes arrangement (by asynchronous cluster analysis);
2. Katz indices - future SST and T50 in a box (by asynchronous multiple regression);
3. SST or T50 (for certain boxes) - thermocline gradient (by synchronic linear regression);
4. SST, T50 and plankton species biomasses - future plankton species' biomasses (by synchronic multiple regression);
5. Plankton species' biomasses and thermocline gradient - saury availability in a box (by synchronic cluster analysis);
6. Plankton species' biomasses and thermocline gradient - mean CPUE in a box (by synchronic cluster analysis).

The model was tested in 1995 with satisfactory results (prognosis of phytoplankton abundance was not precise enough). All principal features of seasonal succession of plankton community and oceanographic conditions were reflected.

For the present the model is used for short-term (monthly) forecasting of saury fishing grounds location and fishing efficacy. The usage of the model for a study of climatic changes is possible.