

PICES XIV S9-2558 Poster
Informational system for “Marine ecological monitoring”

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Obtaining essential, true and up-to-date data is the key to making accurate decisions in our “information age”. The obligatory stage of processing and analysis of the information lies between the stages of obtaining the data and ultimately making decisions. The Informational System (IS) under discussion is based on the theses stated above. It is intended for data reliability check, as well as for the analysis with the use of traditional and non-traditional (heuristic) methods. It has functionality which is a feature of the DBMS (data base management software): data does not depend on the processing programs, data is stored safely, access to data is centralized and sanctioned, duplication and inconsistency of data is excluded. IS contains a customizable interrogator system; the interface is user-friendly, it helps to actualize the data, *etc.* This work has a goal to bring into focus the fact that systems of independent files (which by no means are provided with these features) are still used in the existing processing of marine expeditionary data. A peculiar feature of IS is the support of COM technology, which makes it possible to apply the power of models of spatial data (discrete and continuous) that are used in well-known geo-informational systems. The spatial component is important in hydro-biological research, as well as in granulometric, chemical and hydrological research. Some subsystems of IS can be used as automatization servers. The other peculiarity of IS is that it includes mathematical methods for simultaneous processing of all data, independent of their nature and type. It can increase the effectiveness of monitoring because in this case, the decisions are made not concerning each separate factor (biological, chemical *etc.*), but according to synergy effect – in combined accounting to all data obtained to date.

PICES XIV S9-2620 Oral
Progress in oil spill risk assessment for Sakhalin shelf conditions

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The complex study of oil spill risk and stochastic oil spill simulation allows estimates of potential environmental hazards that should be taken into account when deciding upon safe allocation of oil processing facilities and planning oil spill response measures. This technology has been developed based on VOS 4.0/REA model and applied to estimate oil spill risks for various Sakhalin shelf oil and gas exploration projects. This technology takes into account availability of sensitive shoreline (mouths of lagoons and rivers) and offshore (grey whale feeding areas and marine mammal gathering sites) areas. Statistical oil simulations that accommodate variable seasonal hydrometeorological conditions allows the determination of a comparative hazard index for different project options and deciding upon the most reasonable allocation of hazardous facilities and/or the most efficient oil spill response measures. Study results cover southern Sakhalin including probabilities of Sakhalin and Hokkaido Islands shoreline pollution. For the northeastern Sakhalin shelf it has been shown how oil spill risks and modeling have been used in research for choosing environmentally sound offshore pipeline routes. The study also describes application of oil simulation results in oil spill response planning.

PICES XIV S9-2437 Oral
The quantification of natural radioactive background levels of radioactivity in offshore bottom sediments of northeastern part of Sakhalin Island

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The aim of our work was the estimation of natural radioactivity of bottom sediments that is defined with natural radioactivity (NRN) of uranium and thorium series and K^{40} . The investigation was conducted in areas with gas and oil deposits, where the drilling operations had started during the *Sakhalin-2* project. The reason for the investigation was the initiation of the drilling process. The analysis of the data received showed that the average content of Ra_{226} and Th_{232} in bottom sediments, that consist of fine-grained sands, was 7.9 ± 3.3 and 5.6 ± 3.0

Bk/kg respectively. An admixture of ooze increased the activity of NRN by 1.5-2 times and reached 11.3 ± 4.0 Bk/kg for both radionuclides. The content of K^{40} varied from 470 ± 90 Bk/kg for sand up to 650 ± 120 Bk/kg for mixture of mud and sand. The comparison of this data with that of background studies that were conducted before the initiation of oil and gas development, showed that the level of NRN in bottom sediments associated with the *Sakhalin-2* project remained on the same level as in 1997. Thus the gas and oil development has not had a negative influence on the radiation situation in the area to date.

PICES XIV S9-2469 Poster

Petroleum hydrocarbon pollution of Ussuriyskiy Bay (Japan Sea) in 2003 – 2004

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Development of the oil and gas industry in the Russian Far East has had a negative influence on the state of marine ecosystems. It is connected not only with direct mining, but also with transportation of oil and products associated with its processing. There is a tendency toward increasing concentrations of petroleum hydrocarbons (PH) in Ussuriyskiy Bay water (up to $70 \mu\text{g/l}$) for last decade. PH determination in sea water and sediments was carried out by IR-spectroscopy. In the autumn of 2003, high heterogeneity in the distribution of PH in seawater was observed. The lowest concentration was observed in the inner part of the bay ($65 \mu\text{g/l}$) and the highest levels in Sukhodol Bay ($1120 \mu\text{g/l}$). The presence of high PH concentrations in some areas, for example, near Cape Telyakovskogo ($120 \mu\text{g/l}$), is possibly explained by the local input. PH concentrations in the sediments of this area were low – about 90 mg/kg . However, in Sukhodol Bay, high PH concentrations have been found out in sediments (1230 mg/kg) as well as the seawater, that testifies to chronically pollution here. In the autumn of 2004, the situation did not change. The average PH concentration in seawater in inner part of Ussuriyskiy Bay was $77 \mu\text{g/l}$, in the central part - $53 \mu\text{g/l}$, and in the area of Cape Telyakovskogo - $108 \mu\text{g/l}$. The highest concentration ($248 \mu\text{g/l}$) was found out in the area of salt barriers where there is a sharp change of physical and chemical properties of seawater.

PICES XIV S9-2287 Oral

Ichthyoplankton as an indicator of the state of coastal ecosystems in the areas of oil and gas deposits on Sakhalin shelf

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The state of ichthyoplankton on the eastern Sakhalin Island shelf was investigated in summer 2002. Eggs of walleye pollock *Theragra chalcogramma* and yellow-fin sole *Limanda aspera* were selected as bioindicators for estimation of coastal ecosystem quality because the eggs of these species were characterized as widely distribution and having a high number in samples. The minimum number of normally developing eggs of pollock and yellow-fin sole was observed over the oil and gas deposits in coastal zone of the northeastern Sakhalin shelf. The coincidence of stations (83%) with a high proportion of the dead eggs of both species testifies on similar unfavorable influence of environmental factors on the embryogenesis in deposits areas. The share of normally developing eggs caught in these areas was 2.8% for pollock and 3.7% for flounder whereas on the average these values for the whole surveyed region were about 10 times higher (29 and 30.2% accordingly). Evidently, pollutants acting together with other environmental changes caused the observed eggs mortality.

PICES XIV S9-2300 Oral

Study on damage and recovery of coastlines for three years after the Nakhodka oil spill

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The damage and recovery of the Japanese coastline from Suzu, Ishikawa Prefecture to Mikuni, Fukui Prefecture was investigated visually over three years after a C-heavy oil spill from the Russian tanker “Nakhodka” in the

Sea of Japan on January 2, 1997. The beached C-heavy oil tended to remain for a long time on coasts of bedrock and boulder/cobble/pebble but it was removed rapidly from coasts of gravel/sand and man-made structures. On the coasts of the latter type, wave energy appeared to be the main force for removing the oil. One year after the spill, C-heavy oil tended to remain strongly on the sheltered coasts of bedrock and boulder/cobble/pebble. Even on the coasts of this type, the contamination was remarkably removed by 2 years after the oil spill. The concentration levels of polycyclic aromatic hydrocarbons (PAHs) in oil lumps, sand and seawater were monitored over 3 years after the oil spill. The concentrations of PAHs having 2 or 3 rings decreased more quickly than did those of PAHs having 4 or more rings, suggesting volatilization as the main factor for the decrease. On the other hand, the concentrations of PAHs having 4 to 6 rings did not start to decrease until 7 months after the spill. The main factor for the decrease seemed to be photolysis. The concentration of benzo[a]pyrene (BaP) in seawater off the polluted coasts was high 1 month after the spill and then decreased. Three years after the spill, the level fell to the sub ng/L level, which was as low as those in seawater at unpolluted clean coasts in Japan. The concentration of BaP in greenling was higher than the normal level only during the first 2 months after the spill. These results suggest that the coastlines in Ishikawa and Fukui Prefectures that were polluted with C-heavy oil recovered in 3 years.

PICES XIV S9-2245 Invited

Oil spills - Risk, preparedness and response in the Northwest Pacific

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In today's world, oil spills are a major environmental problem. In total, millions of tonnes of oil have been spilled into the world's oceans, resulting in enormous impacts on fisheries, wildlife and their habitats, coastal industries and tourism, and even on political and social aspects, etc. The sea area of the far-eastern Asian countries was regarded as the area facing the highest risk of oil spill in the world. In fact, 16 major oil spills (greater than 1,000 tons), 115 intermediate spills (50 ~ 1,000 tons), and innumerable small spills (less than 50 tons) have been occurred in the area from 1990-2002. The four countries bordering the Northwest Pacific have developed effective measures for regional cooperation in marine pollution preparedness and response within the framework of the Northwest Pacific Action Plan (NOWPAP), agreed in 1994 by the governments of China, Japan, R. Korea and Russia. They have developed the NOWPAP Regional Oil Spill Contingency Plan and its Memorandum of Understanding, which will be a firm foundation in our strong partnership among NOWPAP Members in the relevant field. The present paper also introduces current activities of MERRAC as a new regional initiative on marine pollution preparedness and response in the NOWPAP region, together with analysis of oil spill risk in the region and regional preparedness and response system to oil spill.

PICES XIV S9-2294 Oral

Ecological investigations on the Sakhalin Island shelf, including Molikpaq platform monitoring: A review of FERHRI studies

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Complex ecological investigations on the Sakhalin Island shelf were expanded at the end of the last century. In the 1990s, experts of FERHRI executed a number of expeditions at the Piltun-Astokh and Lunscoe oil and gas fields. The monitoring studies of the Molikpaq platform (Piltun-Astokh field) in 1998-2003, and the investigations along the prospective lines of underwater pipeline and at some other regions of the Sakhalin-2 project infrastructure development in 2001 were made. Background characteristics of the granulometric composition of bottom sediments, of the contents and distributions of various classes of contaminants in sea water and sediments (petroleum, alkanes, and polycyclic aromatic hydrocarbons, metals, phenols, detergents), of the status of pelagic and benthic communities, and also of birds and sea mammals were obtained. Results of the monitoring studies at Piltun-Astokh field showed the absence of significant influence of the oil and gas extraction works on the ecosystem of this area.

PICES XIV S9-2552 Oral

Monitoring chemical substances in surface sea water in North Pacific Area

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Pollutants are brought to sea from various paths: atmospheric deposition, discharge from rivers, and ships. Various substances such as heavy metals, nutrients, organic chemicals including PAHs, POPs, oil spillage, are considered to be threats to marine environment. The sea is the final sink of anthropogenic and natural pollutants and thus monitoring of surface seawater is essential for the preservation of the marine environment. We are developing a seawater monitoring system using commercial and scientific vessels. Concentrating sampling systems, together with several automated sensors were loaded onto vessels and chemical substances and water quality data were collected during the voyages. Poly-urethane and activated carbon fiber (ACF) adsorbents were used as the concentrating media for chemical substances. About 200 liters of seawater was pumped and brought to the adsorbents at a constant flow rate. Concentrating media was frozen at minus 20 degrees centigrade, brought to laboratory, and then chemical substances were extracted by the Soxhlet method and served for chemical analysis. It turned out that this system for useful for monitoring organic substances including POPs. In this report, we will present some results of seasurface water monitoring and also a plan for investigation of concentration of organic chemicals in Northwest Pacific Region Sea.

PICES XIV S9-2569 Poster

Effects of oils and chemical dispersants on the growth of the phytoplankton, *Cochlodinium polykrikoides*

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This study was conducted to understand the effects of oil spill accidents and the use of dispersants on the growth of *Cochlodinium polykrikoides*. Kuwait oil, United Arab Emirates oil, Bunker-C, kerosene and diesel oil, and two types of oil spill dispersants, Hi-Clean and Seagreen 805A were added with a series of 10 ppb to 300 ppm in the f/2-Si medium at 20 deg C under a photon flux from cool white fluorescent tubes of 100 $\mu\text{mol m}^{-2} \text{s}^{-1}$ in a 14: 10 h L:D cycle for the culture of *C. polykrikoides*. In low concentrations of ≤ 1 ppm of examined oils no impact on the growth of *C. polykrikoides* was recorded, while in high concentration of ≥ 10 ppm cell density, it was significantly decreased with the range of 10 to 80% in comparison with the control. The growth of *C. polykrikoides* after the addition of the dispersants ≥ 10 ppm appeared to decrease by 70% in comparison with the control after 14 days, whereas the growth of *C. polykrikoides* exposed to $\leq 5,000$ ppb showed little serious impact. The toxicity of a mixture of three types of oils and two types of dispersants appeared to have similar variations with dispersants. However, almost all the *C. polykrikoides* cells died regardless of types of dispersants and combined mixtures within a few days after the addition of high concentrations.

PICES XIV S9-2237 Poster

The distribution of petroleum hydrocarbons and biota assessment in Amursky Bay (Japan Sea)

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The distribution of petroleum hydrocarbon (PH) was determined in Amursky Bay (Japan Sea) near Vladivostok in summer, 2004. Samples of seawater and bottom sediments were collected at 45 stations. The total content of PH was analyzed with an IR spectrometer. Concentrations of PH in seawater varied from 0.03 to 0.92 mg dm^{-3} , and in bottom sediments – from 5.3 to 441 mg kg^{-1} . The areas with maximal and minimal levels of oil pollution were marked. There was no correlation between the total biomass of macrozoobenthos and the concentration of PH in bottom sediments, but biological effects were determined by the impact on organismal and molecular levels. The use of bioindicators has shown the influence of pollution by decreasing species numbers and also

displayed by changes in the population structure of mysids (*Crustacea*). The distribution and abundance of indicator species were the most informative indexes of coastal ecosystems. Activity of glutathione-S-transferase (the key enzyme of biotransformation) was higher in mussels *Crenomytilus grayanus* in sites with increased PH level in bottom sediments. Glutathione concentration was higher in mussels from the sites with moderate levels of pollution and depressed in mollusks from the chronically polluted site. The results showed us that the ecological situation in the inner areas of Amursky Bay is unfavorable.

PICES XIV S9-2250 Oral

Alterations of biotopical conditions and variations of benthos distribution near Molikpaq platform (North-East Sakhalin Island shelf)

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Effects of sediment grain size, petroleum hydrocarbons and metal contents in bottom sediments on composition and structure of benthos were investigated near Molikpaq platform from 1998-2001. Factor analysis showed that alterations of the fraction composition explain the notable part of the variations of benthos abundance and diversity characteristics. Increased species diversity and richness of benthos accompanied a decrease of sediment sorting and, accordingly, the growth of biotope diversity. Partial replacement of sediments after the platform installation, when gravel grounds were exchanged for sandy ones, resulted in a spatial re-distribution of the associations of benthic animals. Any negative effects of the contents of petroleum hydrocarbons and metals on the composition and abundance of benthic communities were not found.

PICES XIV S9-2260 Oral

Changes of granulometric composition of bottom sediments near Molikpaq platform (North-East Sakhalin Island shelf)

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Grain-size composition of the sediments near Molikpaq oil-extracting platform (Piltun-Astokh field) was studied before and after its installation in 1998-2001. Application of factor analysis to the data obtained revealed two kinds of consequences of technology sediment replacement. First, the relatively short-term effects, which affected a significant part of the area and were expressed as the growth of the content of fine particle association (<0.25 mm). Evidence of these effects almost completely disappeared by October 1999, a year after the platform installation. Second, the longer-term local effects, basically within a 250-m radius of the platform, were reflected in a reduction of the area occupied by the psephitic particle association (>1 mm). Traces of these effects remained until September-October 2001. Only within 125 m from the platform were the consequences of sediment replacement not statistically significant. These two kinds of effects occurred against a background of high natural spatial and temporal variability in deposits almost over the whole area and were expressed, first of all, in variations of sand fraction content. On the whole, high hydro- and lithodynamics do not make conditions for contaminant accumulation.

PICES XIV S9-2253 Oral

Interrelation of the contents of petroleum hydrocarbons, metals and granulometric composition of sediments near Molikpaq platform (North-East Sakhalin Island shelf)

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The content of petroleum hydrocarbons (PHCs), metals, and grain-size composition of bottom sediments were studied near Molikpaq oil-extracting platform (Piltun-Astokh field) in 1998-2001. During the whole period of investigation, the concentrations of PHCs and trace metals in sediments of the study area were low and matched those of non-polluted areas of World Ocean. Application of factor analysis showed that PHCs and metals deposited in the area occurred from different sources. Factor analysis did not detect the accumulation of PHCs in the sediment fine particle association. As a whole during studied period, a stable decrease of average content of PHCs was observed. The total metals concentrations were 1.5-2 times below the minimum threshold concentrations causing negative biological effects.

PICES XIV S9-2271 Oral

Review of monitoring results in the area of Moliqpak platform (north-eastern shelf of Sakhalin)

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Sakhalin Energy has carried out annual monitoring of the marine environment and benthic communities since 1998 when the platform was installed. The programme includes the collection of water samples in close vicinity of the platform and sediment samples in the area of 3-5 km around the platform. Reference zone stations are located 10 km south of the platform. Industrial environmental monitoring revealed the changes in content and volume of waste waters.

A high level of hydrodynamic activity in this area results in water mixing and soil grading diversity, thus providing a low level of water layer and bottom sediment pollution. The research of 1998 – 2004 prove that all controllable features of soil and water (oil hydrocarbons, metals, phenols, synthetic surfactants, biological oxygen demand, nitrites, nitrates, ammonia nitrogen, phosphates, silicates, suspended matter) complied with background levels for the Sakhalin's northeastern shelf. Neither the environment nor the biota have proven to have clearly defined tendencies in variability caused by industrial impact, including variability of the plankton and benthic community features (season and annual variability, rearrangements of soils due to hydrodynamic activity in the platform area).

PICES XIV S9-2388 Oral

Concentrations and compositions of aliphatic and polycyclic hydrocarbons in bottom sediments off Sakhalin Island

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Concentrations and compositions of the aliphatic hydrocarbons (AHC) and polycyclic aromatic hydrocarbons (PAH) in surface sediments of the Sakhalin Island shelf were studied in 1994 and 2002. Higher AHC and PAH concentration found in offshore sediments in 2002, as compared with those in 1994, are most likely related to the different lithological types of analyzed sediments. The presence of transformed anthropogenic petroleum alkanes, which were not detected previously, implies the increased pollution related to the intensified economic activity in the area of the oil and gas development. The composition of hydrocarbons in bottom sediments reflects their differentiation during sedimentation, *i.e.*, sorption and biotransformation rather than genesis of

initial organic matter. Therefore, the composition of alkanes in bottom sediments and that of the spilled oil differ from each other. In conclusion, it should be noted that the lithological type of sediments and natural geochemical background of hydrocarbons (concentration of hydrocarbons and their composition) should be taken into consideration when interpreting data on oil pollution in bottom sediments. This is of principal importance when estimating the results of ecological monitoring in areas of marine oil and gas deposits where petroleum hydrocarbons of both natural and anthropogenic origin can occur.

PICES XIV S9-2379 Oral

Possible influence of accidental oil spills on the Far Eastern Sea shelf biota

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Industrial activity intensification increases the probability of an accidental oil spill in the coastal area. Accidents happen mostly while vessels are approaching ports in sea shelf areas. Accidental spills affect the most productive marine areas, zones of active fisheries, hatcheries and recreation. Oil spills account for a total of 6% of all hydrocarbon intake, causing major damage to sea ecosystems. We examined accidental oil spill influence on biota in the littoral and sublittoral area. Oil products have a toxic influence on phytoplankton and animal plankton in pelagic layer. Emulsified oil causes ichthyoplankton and meroplankton mortality in the surface layer. Affected regions during coastal oil spills can spread up to 5.5 km of beach length and 10m wide. Oil spills coming in contact with the coastline have considerable negative influence on macrophytes at depths up to 10 m depth and more, and on slow-moving species living on bottom, algae, echinoderms, bivalves and other inhabitants. According to model estimates, damage to commercial bioresources from accidents in the littoral zone can exceed that in the pelagic zone of different seas by 100 times. Direct loss due to macrophyte mortality totals 99.4 % of the whole damage, and 0.14% due to commercial littoral benthos mortality. Indirect loss totals 0.18% of phytoplankton and animal plankton mortality, 5×10^{-5} % of ichthyoplankton mortality, and 0.24 % of food benthos.

PICES XIV S9-2538 Poster

The assessment of acoustic measurements' impact upon animal plankton of far eastern seas

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The impact on marine organisms and ecosystems starts with the geological exploration of the sea bottom. It continues after discovering potential oil and gas geological structures with the further estimation of the quantity of the hydrocarbons they may contain. The assessments of damage to zooplankton from acoustic measurements took place in the Japan Sea offshore, in Peter the Great Bay, in the Samarginsky area, and on the Magadan offshore areas in the Okhotsk Sea. We used mathematical models to calculate the coefficient of death-rate for different groups of zooplankton, typical for the investigated area, within the range of the influence of the acoustic transducer. Our damage estimates used coefficients that were based on the attributes and quantitative characteristics of an ecosystem's functioning and productivity rate, determined from long-term complex studies. We also provide a specific analysis of the peculiarities of the impact upon biota in the Magadan offshore and Peter the Great Bay regions. The acoustic measurements are a necessary stage of oil and gas exploration in the sea, and thus it will be used in all parts of the Far Eastern offshore. Therefore, it is seen to be essential to have a sufficient assessment of the damage to the sea organisms.

PICES XIV S9-2511 Poster

Determining bottom sediments distribution by hydroacoustic monitoring

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A new technology of determining bottom sediments distribution using a hydroacoustic method is presented. During 2003-2005, shellfish inhabitation and influence of dumping on the bottom sediments distribution were observed by QTC technology. The results demonstrate that it is an effective tool for monitoring, decision-making, and for research of the ecological effects of offshore oil and gas developments arising from ongoing and future projects off Sakhalin Island

PICES XIV S9-2548 Oral

Geo-chemical monitoring of oil and gas complex at Sakhalin shelf

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Expeditionary surveys were carried out on the eastern part of Sakhalin shelf (in water areas of Piltun-Astokhskoye and Lunskeye oil fields) and in Aniva Bay onboard the R/V *Akademic M.A. Lavrentiev* in June-July 2003 and from the R/V *Professor Gagarinskiy* in June-July and October 2004. The surveys carried out as part of a program of ecological monitoring by "Sakhalin Energy Investment Company Ltd" with the goal to maintain an unbiased control over influence upon environment caused by construction and use of the objects of marine oil and gas complex. The level and character of anthropogenic influence upon marine environment was rated according to the results of the research of chemical composition of upper layer of marine bottom deposits, as bottom deposits are the final stage of migration of contaminants. The ecological condition of a water area was rated according to indices under control which are common indicators in assessment of anthropogenic influence upon the condition of marine environment. These indices characterize the basic processes of contamination and autoregulation of the hydro-ecosystem. Bottom deposit samples were analyzed for metal content, total petroleum, and polyaromatic hydrocarbons. A feature of the areas under study is the high heterogeneity of the distribution of physical-chemical characteristics of bottom deposits. That is why information obtained for each area under study and for each index under control was presented as statistical rating of a sequence of data which contained the results of chemical analyses. This approach makes it possible to compare the areas under study according to background characteristics and to reveal patterns of areal and temporal changes.

PICES XIV S9-2557 Poster

Research of the composition of petroleum products to identify petroleum contamination

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Petroleum products which got into the marine environment near the town of Holmsk (Sakhalin Island) in September 2004 as a result of the wreck of the Belgian oil tanker Christopher Colombo are the objects of the research conducted. Samples of oil film taken at the wreck site were examined by the following methods: chromato-mass-spectrometry (GS-MS); isotope mass-spectrometry (IRMS); mass-spectrometry with induction-coupled plasma (ICP-MS); infrared Fourier-spectrometry (IRS). The IRS method was used for preliminary identification of petroleum products. Data which makes it possible to identify the origin of petroleum with a high level of reliability and determine petroleum contamination was obtained with mass-spectrometry methods. The whole body of the results obtained will allow determination of the initiator of contamination (connection or absence of connection of the tanker wreck to possible petroleum contamination) in disputable (arbitrary) cases. It allows a well-defined expert conclusion in a wide range of climate conditions and in a long time interval after the incident. The experience gained by the surveys conducted showed that carrying out expert analysis at such a level is possible and that there is a necessity for serious work aimed at development and mastering of methods, and their certification.

Complex environmental impact assessment within marine seismic surveys

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One of the priorities of geological exploration of the oil and gas deposits is an estimation of the potential within the exploratory zone. There are two methods to obtain seismic data – two-dimensional and three-dimensional. A two-dimensional seismic survey is a simpler method that provides seismic data along survey transects. Two-dimensional surveys are mainly applied at the very beginning of subsoil exploration works. Three-dimensional seismic surveys registers the third dimension and produces seismic data by surfaces. The additional data provide a 3D chart of geological structures and ensures higher accuracy. Three-dimensional seismic surveys are characterized with higher densities of impulse points as compared to two-dimensional surveys, but the same energy level per impulse is used. Impulse sources have an adverse impact on the marine environment. We describe various seismic energy sources like dynamite, gas mixture, sparker, marine vibrator, and compressed air. We studied in detail the environmental impact that might be produced by the most widely used compressed air sources (airguns).

Benzene toxicity to the scallop, *Chlamys farreri*, and the shrimp, *Penaeus japonicus*

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Oil spills are a serious problem in world ocean shipping. Among the dissolved fractions of spilled petroleum and gasoline, benzene and its alkyl homologues that are collectively referred to as BTEX, are most toxic to aquatic species. However, we lack information on BTEX's toxic effects on marine animals in particular. Here we present the results of a preliminary study on benzene's toxic effect on two marine invertebrates that are cultured widely in China: the scallop, *Chlamys farreri*, and the shrimp, *Penaeus japonicus*. The results indicated that benzene was more toxic to the shrimp than to the scallop. Benzene was lethal to the shrimp (body length 88.6±4.8 mm) only when administered at doses above 20 mg/L and mortality occurred only within the first hour of the 24 hour exposure. Mortality of the shrimps was 40%, 70% and 100% to nominal concentration of benzene at 100 mg/L (dissolved 5.9 mg/L), 500 mg/L (dissolved 27.1 mg/L) and ≥1000 mg/L (dissolved ≥63.0 mg/L), respectively. Benzene was toxic to the scallops (shell height 30.4±1.7 mm) at nominal concentrations above 100 mg/L, but mortality (75%) occurred only in scallops exposed to 1000 mg/L nominal benzene concentration (dissolved <3.9 mg/L after 6 hr exposure) between 12 and 24 hr of exposure and all scallops died within 1 hr exposure to 2000 mg/L nominal concentration (dissolved 121.5 mg/L). The estimated 1-hr-LC50 of benzene was 13 and 40 mg/L for the shrimp *P. japonicus* and scallop *C. farreri*, respectively, and 24-hr-LC50 of benzene was 4 mg/L for the scallop, *C. farreri*. These values are lower than or similar to the predicted and empirical LC50 of benzene toxicity to marine organisms.

