ГЕОФІЗИКА

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GEO- AND HYDRO-ACOUSTIC COMPLEX AS A STUDY OF INTERCONNECTION BETWEEN PROCESSES IN WATERS AND BOTTOM SEDIMENTS

The modern native geo- and hydro-acoustic complex usinged as the study of interconnection between processes in waters and sediments as elements of the difficult geo- and hydrodynamic system is proposed. This previous sentence is totally vague and unclear, after reading it several times over several days I do not know its meaning or intent. Please, what is connected? What is proposed? The relevance of sub-bottom profiling is noticed and it is considered the item of joint presentation for results in bottom survey and its ground maps as three-dimensional (3 D) images. It solved the problem in obtaining unknown information about the state of bottom sediments aside from the carrier of the sonar profiler using the spatial interpolation method. There are the results of complex research of the structure in the upper layers of the bottom sediments and relief of the bottom surface using the designed complex based on the project entitled "Development of the observation system of influence of the economic activity on natural systems and operational control of negative changes in their structure". There is a specified direction of work that combines geophysical and geochemical research methods of the water areas from the Dnipro river, with its contact in the upper layer of sediments. Herewith contact survey provided divisional analysis and deposition of heavy metals as well as control and conformation of remote survey results. The previous results of analyses found that the presence of distribution regularities in certain lithological types of sediments because silted areas fit with the areas with the minimum hydrodynamic activity as well as dynamic economic activity. Problems of geophysical monitoring, necessity to conduct long-term observations, and complexity of hydro-acoustic research on the shelf set tasks not only to collect and save the information, but to predict the complex data processing with a view to remove the regularities and knowledge creating conditions for the different specialists' collaboration. The developed geo- and hydro-acoustic complex can solve these problems. 2 times in this above paragraph is used the word "regularities" maybe this word should be "irregularities" but not sure of intent.

Key words: bottom relief, sediment, side-scan sonar, sonar profiler, echo-sounder, hydro-acoustic parameters of sediments

Introduction

The structure of sediments and geo-dynamic processes have an influence on the state of the water column interacting with the bottom surface, providing a continuous process of energy and mass exchange at the interface of two mediums. The bottom relief influences on the parameters of currents affecting the process of the sedimentation. It is necessary to consider the geological structure factor of underlying sediments in determining the lateral variability of the relief forms and intensity of the geo-dynamic processes within explored waters [Lobkovskii L., 2005, 2013].

Studying the interrelation of the water column and bottom sediments as elements of the difficult geo- and hydro-dynamic system needs the simultaneous study of them in a monitoring mode. Monitoring of the medium state is assumed to be the creation of the single mathematical model of the discussed processes and simultaneous observations in time [Ambrosimov A., 2010; Arkhipov V, 2006].

Purpose

Thereby, there is a need to create an equipment complex and methods to measure and process the data that give a joint study of hydro- and physical parameter variability in the water column, the geo- and physic characteristics of natural layer, and the structure of the underlying geological bodies.

It is an important experience of multipurpose use as a means panoramic in hydro acoustics, namely using a profiler for acoustic sensing in the upper layer of bottom sediments in a simultaneous mode [Kaevitser V., 2008] and exploring aqueous medium with the use of the side-scan sonar (ГБО) [Ananov O., 2014]. Given results have shown the prospects of using such equipment not only for its intended purpose (such as exploring the bottom), but for studying the properties of the bottom sediments [Korjakin Y., 2004]. In other countries there are designed complexes [Rimsky-Korsakov H., 2007; Liss A 2012; Stewart Robert H., 2008;

Kraeutner P. H. 1998] used for exploring the interconnection of water column and bottom sediments. They are, however, very expensive and that is why they are not obtainable for this research.

Therefore, the purpose of this article is a creation of native automated multi-purpose geo- and hydro-acoustic complex [Gonchar A, 2009] for exploring upper layer structure of bottom sediments and water area. This previous sentence should be inserted in the very 1st paragraph of this article in the area of confusion within the 1st or 2nd sentence of the introduction.

Methods

This complex was designed in the Science and Technology Center of Panoramic Acoustic Systems in the National Academy of Sciences in Ukraine. See Fig. 1 which connects the coordinates and time implements following items:

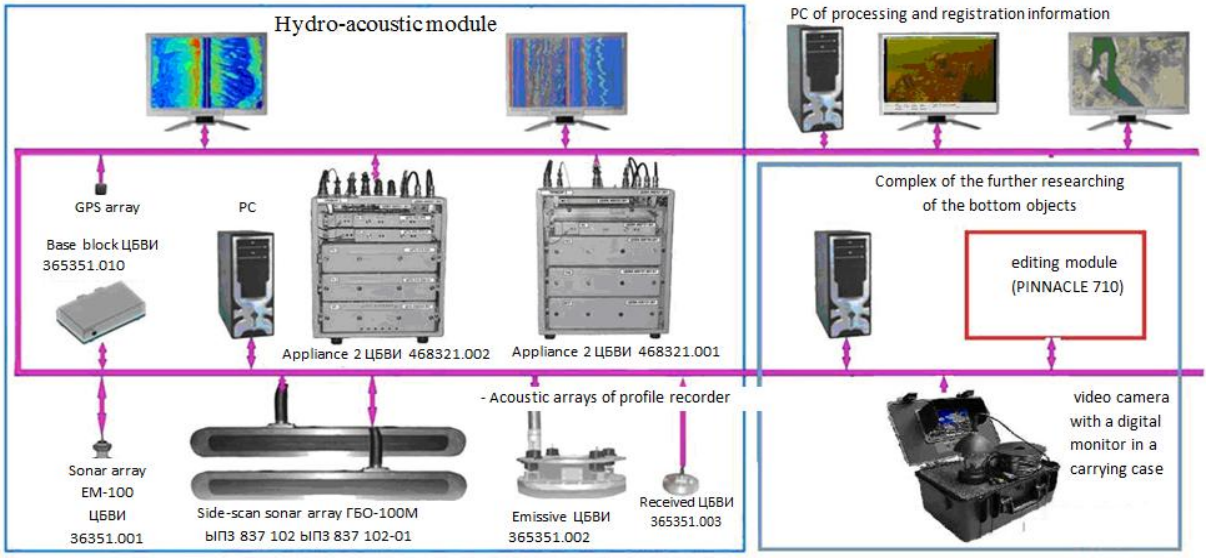

Fig. 1. *The structure of geo- and hydro- acoustic automated modular and block information and measuring complex*

– detailed investigation of the bottom relief in the waters (according to the area) using the side-scan sonar with the frequency from 29 to 470 kHz;

– stratification of sediment layers with the use of sonar profiler ПГ-100 with the frequency from 3 to 10 kHz;

– measuring depths up to 100 m with the echo-sounder EM-100 with the average instrumental error from 0,025 to 0,1 m;

– further researching the bottom for objects with the underwater camera.

See Fig. 2 for a piece of information in the geo- and hydro-acoustic complex (sonar profiler, side-scan sonar, echo-sounder).

Next primary information in Fig. 2 is mathematically processed [Gonchar A., 2012] to determine the physical mechanical properties of the upper layers in bottom sediments and the structure of the map-case with tacks (the trajectory of movement of the carrier) in exploring and plotting the detected objects and relief features (isobaths of depth).

Complex research with the hydro-acoustic properties of the structure in the upper layers of the bottom ground and bottom surface relief removes ambiguity in the interpretation of the acoustic image of sea (river) bottom comparing results obtained by measuring the sonar and sonar profiler).

Results

Thanks to the joint efforts of specialists from the Institute of Geological Sciences and Science and Technology Center of Panoramic Acoustic Systems of National Academy of Sciences in Ukraine in the project's boundaries “Development of the observation system of influence of the economic activity on natural systems and operational control of negative changes in their structure” introduced an observing system on the detection heavy metals in sedimentary flows in Dnipro waters and regularities in their deposition in the upper layer of bottom sediments. This previous sentence is over 10 lines long so you must make 2 or 3 sentences from this one very long sentence. There were designed items within the sediment monitoring of the atmospheric eolian flows and water reservoir, as well as the geo- and the ecological polygon to study the interaction of the bottom relief, the water column, and the upper layers of the bottom in the project’s boundaries.

One of the main tasks of this research carrying out in the experimental polygon territory is detecting season changes in the distribution of theupper sediment layer of lithological types. See figure 3 for illustration.

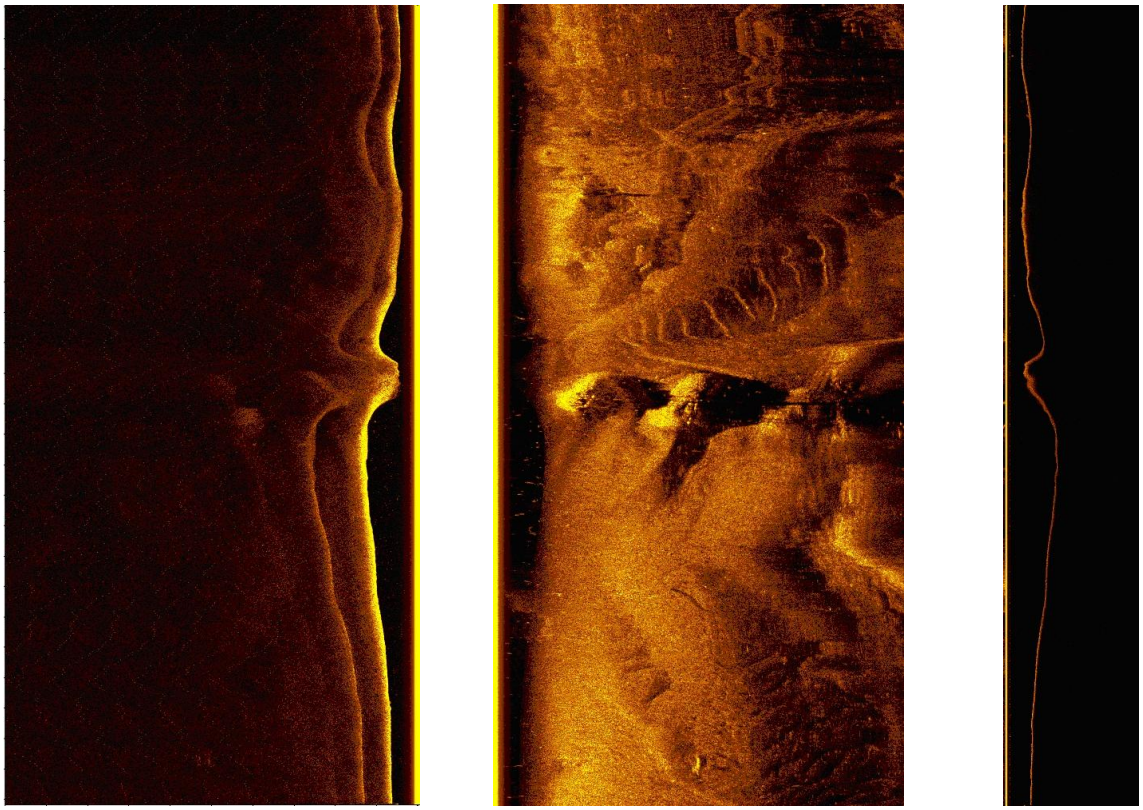

Fig. 2. *A piece of information of a hydro-acoustic module*

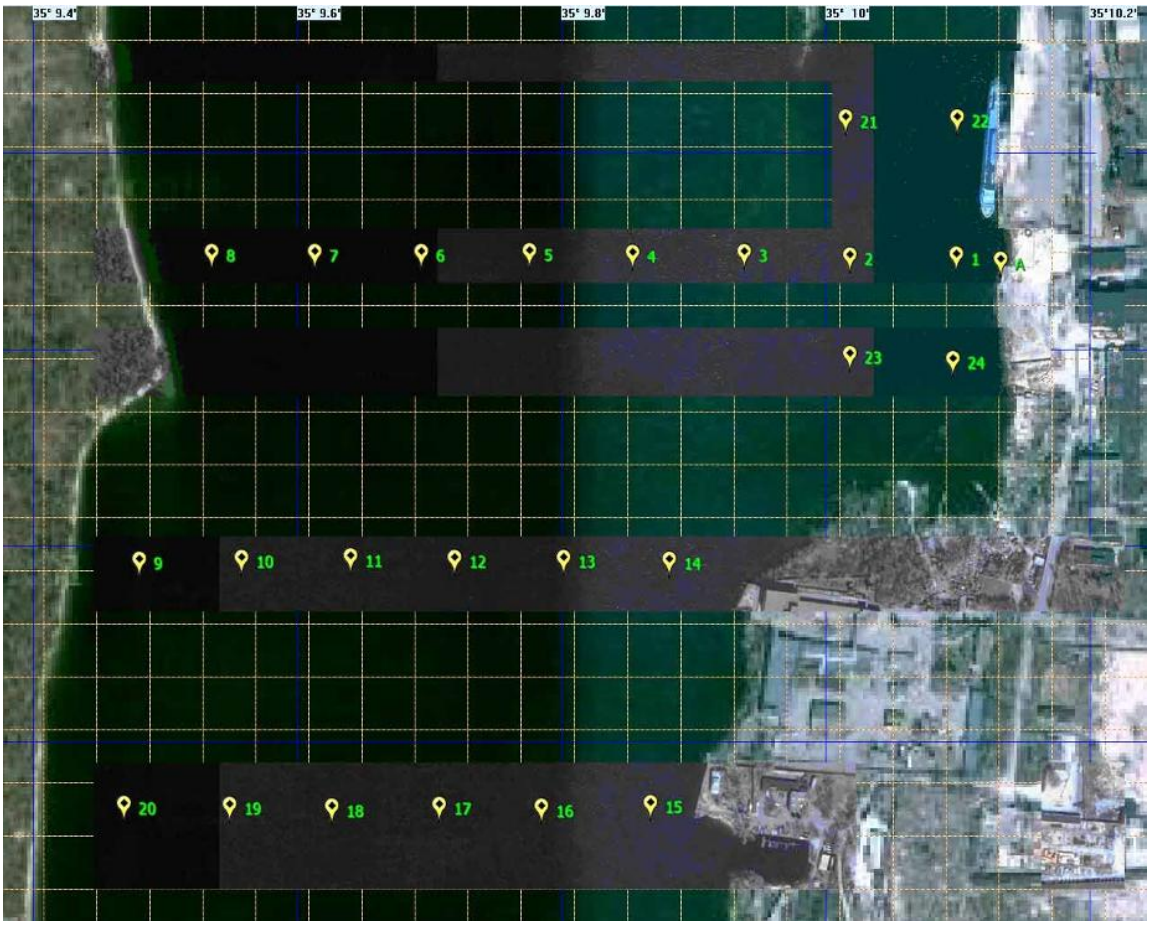

Fig. 3. *The proving ground with the points of sampling in the bottom upper layer*

According to the acoustic profiling data, the geo-acoustic parameters of surface sediments in the proving ground in Fig. 3 with the use of the remote method [Gonchar A., 2014] were determined. Information about the state of bottom grounds of the whole proving ground area was obtained. There are only some specific points (along the sea lane and next to the shipyard) that are the result of profilogram processing using the method of remote profiling ground bottom surveying in the article [Gonchar A., 2012] (Table 1).

Table 1

Geo-acoustic parameters of bottom sediments at points of sampling and their stratification with the percentages of compound in a layer within several lithological classes (according to the research results on the proving ground on 21.08.15)

Number of the point	Latitude	Longitude	Reflection coefficient	Density, kg/m^3	Sound speed, m/sec	Sand, %	Silt, %
1	47°47,5408	35°10,0967'	0,3	1712	1638	68	32
2	47°47,5404'	35°10,0162'	0,33	1770	1669	60	40
3	47°47,5422'	35°09,9364'	0,31	1736	1645	65	35
5	47°47,5426'	35°09,7748'	0,32	1740	1670	91	9
11	47°47,3886'	35°09,6393'	0,34	1870	1622	98	2
16	47°47,2623'	35°09,7835'	0,35	1878	1650	99	1
18	47°47,2623'	35°09,6252'	0,34	1840	1645	93	7
23	47°47,4908'	35°10,0165'	0,26	1620	1590	55	45
24	47°47,4882'	35°10,0944'	0,28	1650	1600	57	43

The designed geo- and hydro-acoustic complex provided an optimum implementation of the complex in the exploration of the proving ground during which the data and processing is simultaneous collected. In Fig. 4 the data proving ground is shown, which combines depth data, geographical coordinates and interpolation of the intensity of the density in the sediment upper layers of the explored area with points of sampling.

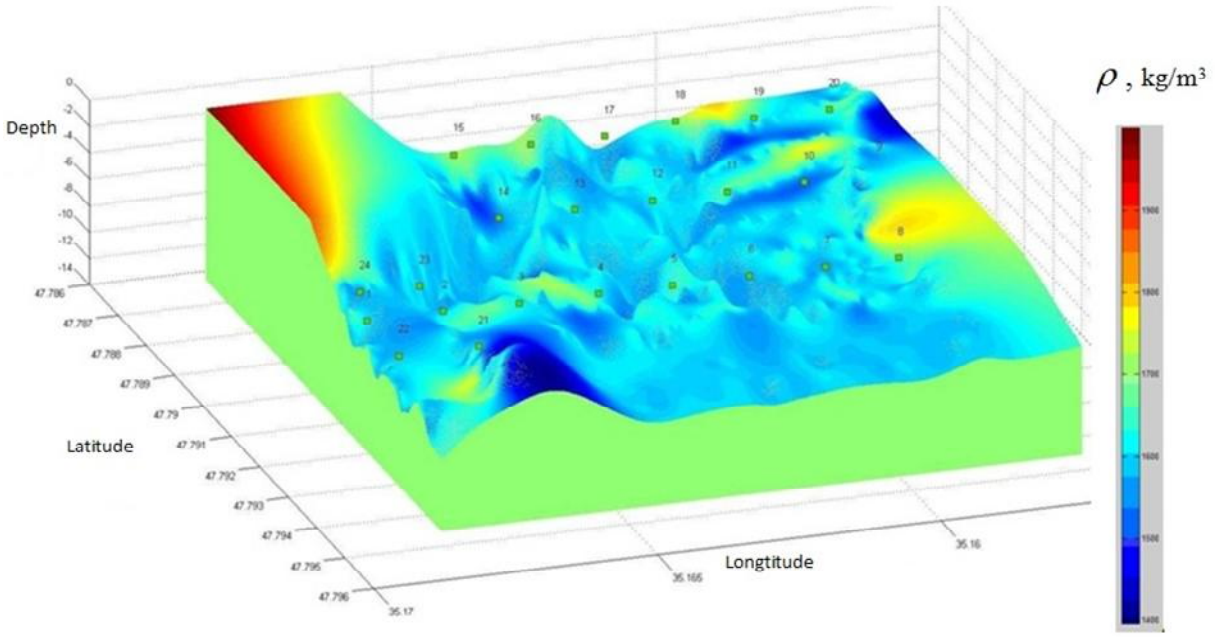

Fig. 4. *3D-visualization of the explored area according to the depth data with interpolation of the intensity of the density with points of sampling*

In accordance with the obtained parameters a stratification of the sediment upper layer was conducted based on the statistical analysis with the probability of determination of the ground type not less than 0,85. The map-case with the specified lithological classes of the sediment upper layer on the explored proving ground is shown in Fig. 5.

The correctness of stratification is confirmed with help of analyses of the samples taken from the bottom ground. Fig. 6 shows photos of the sampling of the bottom ground at the adjusted points of the proving ground are shown.

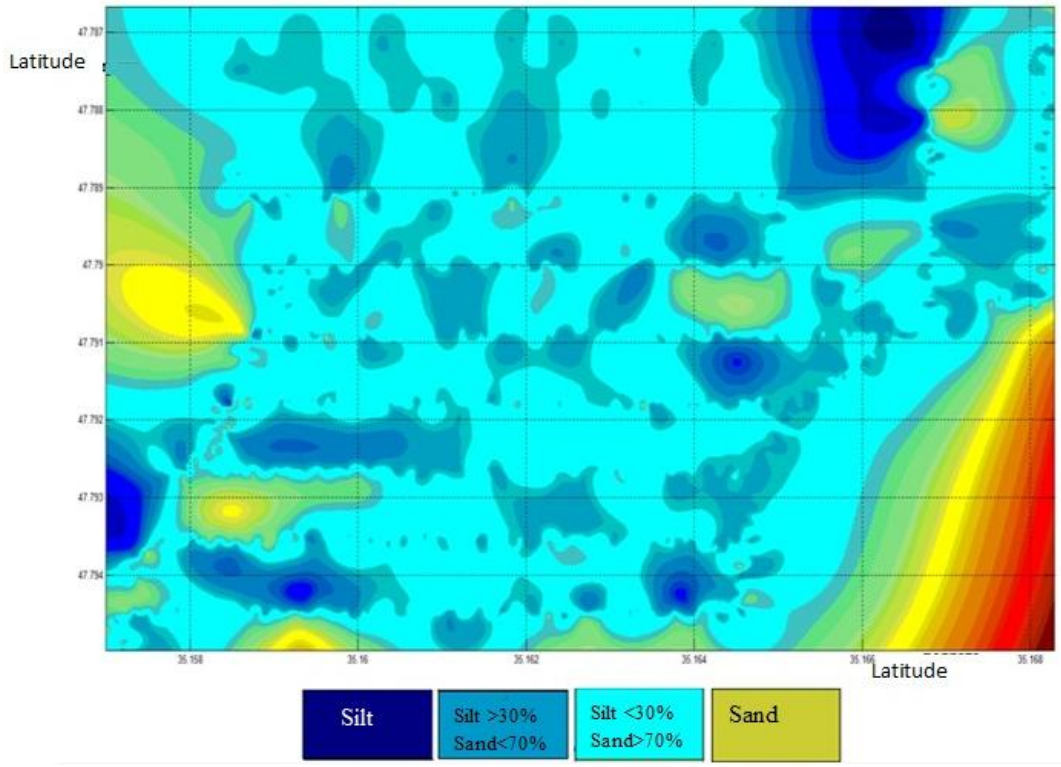

Fig. 5. *Stratification of the sediment upper layer of the explored proving ground*

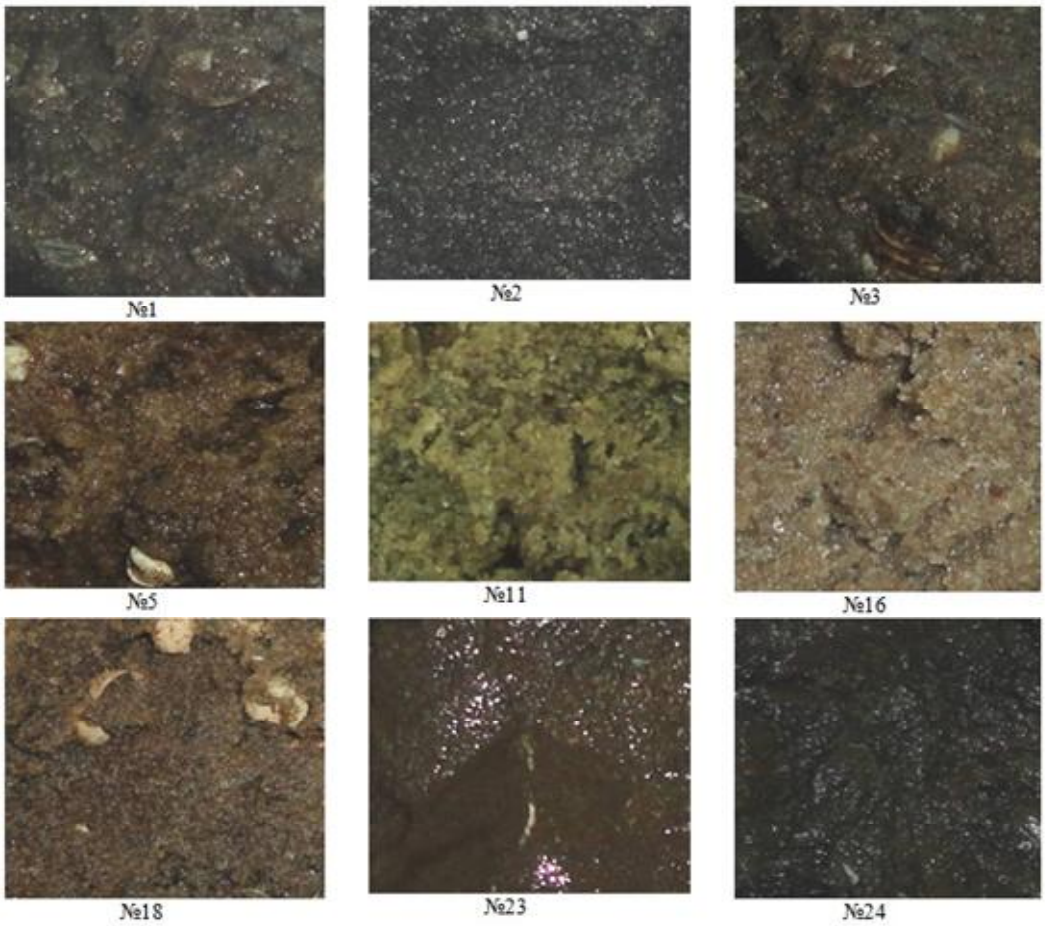

Fig. 6. *Photos of the sampling of the bottom ground at the adjusted points*

The geo-acoustic parameters of the sediment were determined by the remote method (table 1), conducted a stratification (Fig. 5), and accepted results of the stratification using analyses of the sampling of the bottom ground (Fig. 6).

With the use of designed geo- and hydro-acoustic complex consisting of a side-scan sonar ГБО-100М, a sonar profiler, an echo-sounder EM-100 for studying the interconnection of the processes in the water column and sediment upper layers as elements of the difficult geo- and hydro-dynamic system was conducted repeating the research in the proving ground in Fig. 3.

Using the designed methods in accordance to the data of the second observation in the proving ground the geo-acoustic properties of the sediment upper layer and classified sediments as heterogeneous layers were determined with the percentages of combinations of several lithological classes. The results of prophilogram processing at points of sampling of the bottom upper layer are shown in the table 2.

Let's compare the results of processed prophilograms of the research carried out on 21.08.15 and 12.11.15. There are graphs to compare determined coefficient of reflection and density at 24 points of the research carried out on 21.08.15 and 12.11.15 in Fig. 7.

CAN YOU at this time make a sentence to comment or describe the 2 different dates in which the studies were made in the figure 7 graph or just leave it to the reader to deduct or find any observations? What can you say about changes? See suggested sentence to insert below.

Table 2

Geo-acoustic parameters of the sediments at points of sampling and their stratification with percentage of compound in the layer of lithological classes (according to the results of the research on the proving ground on 12.11.15)

Number of the point	Latitude	Longitude	Reflection coefficient	Density, kg/m^3	Sound speed m/sec	Sand %	Silt %
1	47°47,5408	35°10,0967'	0,3	1709	1639	70	30
2	47°47,5404'	35°10,0162'	0,33	1772	1668	58	42
3	47°47,5422'	35°09,9364'	0,31	1738	1650	65	35
4	47°47,5419'	35°09,8523'	0,35	1840	1668	91	9
5	47°47,5426'	35°09,7748'	0,32	1735	1679	91	9
6	47°47,5423'	35°09,6927'	0,33	1840	1611	97	3
11	47°47,3886'	35°09,6393'	0,34	1872	1624	100	0
16	47°47,2623'	35°09,7835'	0,35	1882	1650	99	1
18	47°47,2623'	35°09,6252'	0,34	1846	1647	93	7
23	47°47,4908'	35°10,0165'	0,26	1620	1586	54	46
24	47°47,4882'	35°10,0944'	0,28	1649	1597	57	43

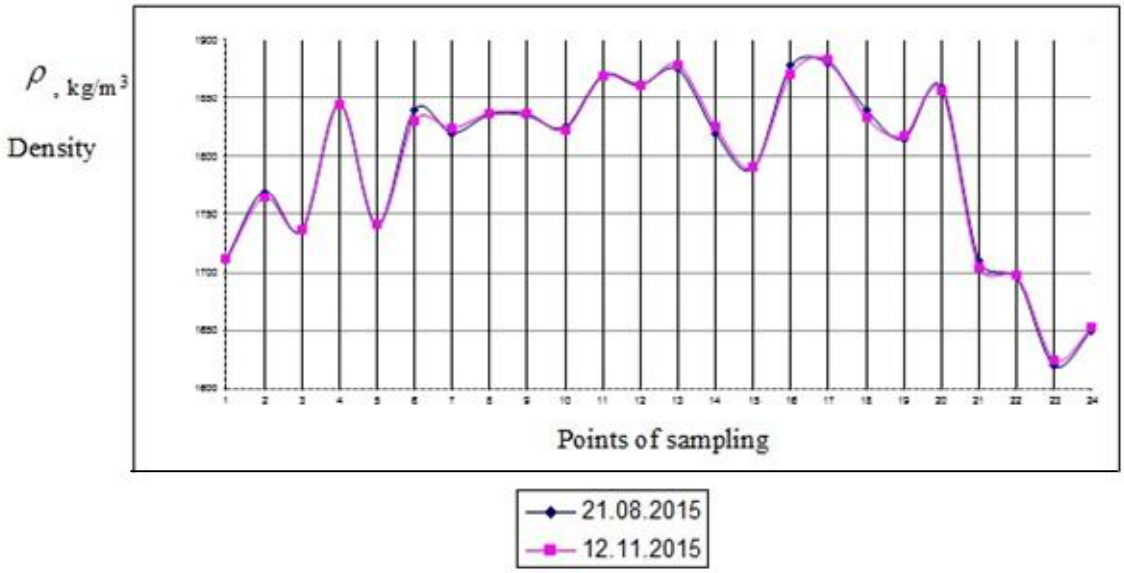

Fig. 7. Comparison of the obtained density at 24 points of sampling (research carried out on 21.08.15 and 12.11.15)

Scientific novelty

Such direction of works combines geo-physic and geo-chemical research methods of the Dnipro waters, and its contact with the bottom upper layer using a remote survey. The contact survey provides the analyses of distribution and deposition of heavy metals in sediments as well as a control and confirmation of the results of the remote survey.

Practical importance

Previous analyses of the results of the survey (Fig. 4–5) indicates the presence of spreading irregularities of certain lithological types in the sediments in silted areas that correspond to the areas of minimal hydro-dynamic activity, as well as economic activity in the area of the shipyard. Silt accumulation occurs during the lowering of the relief within the fairway, since they function as traps creating conditions for silt accumulation.

The graph in Fig. 7 shows an insignificant change in physical and mechanical properties of the sediment upper layer. This above last sentence should be inserted above just before or after figure 7. of the researched proving ground in different seasons using the change of silt concentration in sand.

We will use the nonparametric static Wilcoxon T-criterion [Frank Wilcoxon, 1945] as a control for differences in the two samples of paired measurements.

Empirical value of the criterion will be numerically $T_{емп} = 86{,}5$. $T_{кр}$ with the value 0,05 is 53. So $T_{емп} > T_{кр}$, it means that there is a shift to a "typical" way that significantly prevails in intensity. There are significant differences in Wilcoxon criterion between samplings carried out on 21.08.15 and 21.08.15. Indicators of sampling obtained on 12.11.15 are much higher than ones obtained on 21.08.15.

Results. Thus the season natural research in the chosen proving ground was carried out (Fig. 3) with the use of a designed geo- and hydro-acoustic complex and primary information about the ecological condition of the river bottom and its sediment. Processing using the method of automated profile ground survey of the sea bottom allowed one to determine the geo-acoustic parameters of the sediment upper layer. Sediments were classified as heterogeneous layers with percentages within several combinations of several lithological classes. The graphs that compare certain reflection and density coefficients at 24 points of samples show insignificant change of physical and mechanical parameters of the sediment upper layer in the researched proving ground in different seasons despite the changing silted concentration in the sand.

Generally determination of the interconnection of the processes in time and planar transformation of anthropogenic substances that under certain conditions enter natural complexes with regularities of the sediment flow distribution in different mediums that can allow creation of a complete picture of interconnection of anthropogenic and natural processes and their prediction. The presence of representative field data about the state of natural medium in the affected zone of the urban centers, with the high level of anthropogenic pressure, as well as the level of negative influence and its self-reproduction will allow to determination of methods of minimizing the impact of economic activity on natural complexes in future.

Problems of hydro-physic monitoring, necessity of conducting of the continuous observations, and complication of hydro-acoustic research on the shelf set a task not only to collect and store information but to anticipate complex data processing with the view of excluding regularities and knowledge creating conditions for scientists' collaboration. Designed geo- and hydro-acoustic complex can solve such problems.

REFERENCES

Ambrosimov A, Libin N, Korzh A Instrumental observations variability hydro regime of the Middle Caspian in July 2008 // Ecological systems and devices. 2010, no. 6. pp. 24–35.

Ananov O, Voitov A, Precision monitoring of water areas using mobile multipurpose complex survey of the bottom of the situation // XII international Conference "Applied Technology hydroacoustic and Hydrophysics", GA, 2014, St. Petersburg, 2014. pp. 11–15.

Arkhipov V., Belova N., Noskov A., Solomatin V. Dynamics shores and bottom Baidaratskaya lips on the track transition the main gas pipelines. Zemla Cryosphere. 2006 m. X. no. 3. pp. 3–14.

Gonchar A., V. Hudokon, L. Shlychek. Data processing in a multi-channel system of information gathering and processing complex environmental monitoring tools waters. sonar log (Problems, methods and tools for the study of the oceans). 2009, no. 6, pp. 123–128.

Gonchar A., Gonchar Y., Shundel O, Fedoseenko S., remote profiling methodology groundwater survey to determine the types of sediments. XII international Conference "Applied Technology hydroacoustic and Hydrophysics". GA. 2014, St. Petersburg, 2014, pp. 417–422.

Gonchar A., Shundel O., Fedoseenko S., Shlychek L. Probabilistic evaluation of layer definitions lithological characteristics of sediments in profilogram. XI international Conference "Applied Technology hydroacoustic and Hydrophysics". GA. 2012. St. Petersburg, 2012, pp. 265–268.

Kaevitser V., Razmanov V., Krivtsov A., Smoljaninov I., Dolotov S. Remote sensing of sea bottom acoustic signals with linear frequency modulation. Radiotehnika. 2008, no. 8.

Korjakin Y., Smirnov S., Yakovlev G. Naval sonar equipment. Status and Challenges. St. Petersburg: Nauka, 2004.

Liss A., Ryzhikov A. Prospective domestic computing means for digital computer systems sonar systems. X Conference "Applied Technology hydroacoustic and hydrophysical". St. Petersburg: *Nauka,* 2012. pp. 151–154.

Lobkovskii L World Ocean. Volume 1. Geology and tectonics of the ocean. Catastrophic events in the ocean. Moscov: *Nauchnij mir*, 2013, P 644.

Lobkovskii L, Levchenko D, Leonov A, Ambrosimov A Geo-ecological monitoring of oil and gas offshore waters. Moscov: Nauka, 2005, 326 p.

Rimsky-Korsakov H., Nikitin G. Optimization of hydro-physical research and assessment of their effectiveness. X International Conference. "Modern methods and means of oceanographic research". Moscow, 2007. – pp. 20–24.

Stewart Robert H. Introduction To Physical Oceanography. Department of Oceanography. Texas A & M University 2008, 345 p.

Kraeutner P. H. Small Aperture Acoustic Imaging using Model Based Array Signal Processing Ph. d. thesis, Simon Fraser University, Burnaby, B. C. Canada. 1998.

Frank Wilcoxon Individual Comparisons by Ranking Methods Biometrics Bulletin, Vol. 1, No. 6. (Dec., 1945), pp. 80–83.

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ГІДРОГЕОАКУСТИЧНИЙ КОМПЛЕКС ЯК ІНСТРУМЕНТ ВИВЧЕННЯ ВЗАЄМОЗВ'ЯЗКУ ПРОЦЕСІВ У ВОДНІЙ ТОВЩІ ТА ДОННИХ ВІДКЛАДЕННЯХ

Запропоновано сучасний вітчизняний гідрогеоакустичний комплекс, що є інструментом вивчення взаємозв'язку водної товщі та донних відкладів як елементів складної геогідродинамічної системи. Наголошено на актуальності донного профілювання і розглянуто питання спільного представлення результатів зйомки рельєфу дна і його ґрунтових карт у вигляді тривимірних зображень (3D). Вирішено питання отримання невідомої інформації про стан донних відкладів, осторонь від носія гідроакустичного профілографу, методом просторової інтерполяції. Наведено результати комплексного дослідження структури верхніх шарів донних ґрунтів і рельєфу донної поверхні за допомогою розробленого комплексу в межах проекту "Створення системи спостережень за впливом господарської діяльності на природні комплекси та оперативного контролю негативних змін у їх складі". Зазначений напрям робіт поєднував геофізичні та геохімічні методи досліджень акваторії р. Дніпра, контактну та дистанційну зйомку верхнього шару донних відкладень. Контактна зйомка забезпечувала як аналіз розподілу і депонування важких металів у донних відкладах, так контроль та підтвердження результатів дистанційної зйомки. Попередній аналіз результатів свідчить про наявність закономірностей розповсюдження певних літологічних типів донних відкладень – замулені ділянки відповідають районам мінімальної гідродинамічної активності, а також активної господарської діяльності. Проблематика гідрофізичного моніторингу, необхідність проведення тривалих спостережень і складність гідроакустичних досліджень на шельфі залежить не тільки від збору та зберігання інформації, але й передбачає комплексне опрацювання даних з метою вилучення закономірностей і знань, створюючи умови для спільної роботи фахівців різного профілю. Розроблений гідрогеоакустичний комплекс здатен вирішувати ці задачі.

Ключові слова: рельєф дна; донні відклади; гідролокатор бічного огляду; гідроакустичний профілограф; ехолот; геоакустичні параметри донних відкладів.

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ГИДРОГЕОАКУСТИЧЕСКИЙ КОМПЛЕКС КАК ИНСТРУМЕНТ ИЗУЧЕНИЯ ВЗАИМОСВЯЗИ ВОДНОЙ ТОЛЩИ И ДОННЫХ ОТЛОЖЕНИЙ

Предложен современный гидрогеоакустический комплекс как инструмент изучения взаимосвязи водной толщи и донных отложений, как элементов сложной гео- гидродинамической системы. Отмечается актуальность донного профилирования и рассматриваются вопросы совместного представления результатов съемки рельефа дна и его грунтовых карт в виде трехмерных изображений (3D). Решена задача получения неизвестной информации о состоянии донных отложений, в стороне от носителя гидроакустического профилографа методом пространственной интерполяции. Приведены результаты комплексного исследования структуры верхних слоев донных грунтов и рельефа донной поверхности в рамках проекта "Создание системы наблюдений за влиянием хозяйственной деятельности на природные комплексы и оперативного контроля негативных изменений в их составе". Указанное направление работ сочетало в себе геофизические и геохимические методы исследований акватории р. Днепра, контактную и дистанционную съемку верхнего слоя донных отложений. При этом контактная съемка обеспечивала как анализ распределения и депонирования тяжелых металлов в донных отложениях, так контроль и подтверждение результатов дистанционной съемки. Предварительный анализ результатов свидетельствует о наличии закономерностей распространения определенных литологических типов донных отложений – заиленные участки соответствуют районам минимальной гидродинамической активности а также активной хозяйственной деятельности. Проблематика гидрофизического мониторинга, необходимость проведения длительных наблюдений и сложность гидроакустических исследований на шельфе ставят задачи не только сбора и хранения информации, но и предусматривают комплексную обработку данных с целью извлечения закономерностей и знаний, создавая условия для совместной работы специалистов разного профиля. Разработанный гидрогеоакустичний комплекс способен решать эти задачи.

Ключевые слова: рельеф дна; донные отложения; гидролокатор бокового обзора; гидроакустический профилограф; эхолот; геоакустични параметры донных отложений.

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