Monitoring System Conception of Anthropogenic Impacts on the Sea Shelf Areas

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The main goal of work is conception of developing the specialized geoinformation system for visualization and evaluation of the results of satellite and expeditionary monitoring of the sources of the Black Sea coastal area pollution on the example of the Crimean Peninsula. It's supposed that monitoring results will be formed in four ways: special format of STD surveys (station's description file and series of station's tabular data), text data files of optics equipment, worksheets of chemical and biological parameters and also the satellite GeoTIFF images. The resulting system must to provide a visual representation of combining maps on the special thematic base map as a background with possibility of export the resulting image in GeoTIFF format.

Three-dimensional oceanographic data format allows to provide the possibility of building of vertical profiles charts as well as the spatial distributions maps for the different horizontal and vertical sections. Its planned also that developed system must to generate and to use the digital GRID array data.

As a result, a decision to develop the dynamic linked library for import the different data structures onto system data base was made.

As a main visualization module will be used the geoinformation structure that developed since 2014 with the modern coastline digitized from satellite images with 5-meter points precision and included the set of ten vector thematic layers.

All the used solutions were grounded and real life tested. Parallel realization both of the system potential features and its geodatabase is planned.

Keywords: geographic information system, satellite images, sea environment condition monitoring, geodatabases, visualization, digitalization.

Introduction. The present work is a result of the assessment of some conceptual decisions of building the specialized information system for acceptance of the data characterizing pollution distribution processes in the coastal sea area, including satellite images. The work is carried out within the project Development of the methods and creation of the experimental sample of the monitoring system of anthropogenic impacts on the shelf sea areas of the Black Sea coast of the Russian Federation, including the Crimean Peninsula, based on the satellite and contact data (code Diagnostics). In such cases, practical decisions are based on the evaluation of the input data formats and characteristics providing the possibilities of the subsequent spatial analysis. However, in this case the variants of applying marine environment condition observation techniques at the beginning of the works are defined only approximately and consequently the possibilities of integration and visualization in the system of the data being unknown during the format development should have been taken into consideration. At the same time some

commonpossibilities of geographic information systems (GIS) are evidently necessary, and the already existing algorithms could be applied in their realization.

Thus, the principal purpose of the work was the preparation of the geographic basis for realization of acceptance and further visualization of the different data, having unknown at the moment of development formats, including the multi-channel satellite images.

Looking at the problem from the other side, it can be assumed with a high degree of confidence that in the process of the accepted data visualization and analysis it is more convenient to use the widely-known GIS formats, i. e. *ESRI ArcGIS* shape files and geotagged raster images. Based on this, the task of the system development can be shown by the following algorithm:

1. software shell development on the basis of the user interface;

2. development of necessary number of the dynamic libraries for transforming the source data formats in the mentioned above ones or in the other GIS supported formats;

3. implementation of the accepted data visualization algorithms based on the set of thematic cartographic layers.

In the initial phase of the works the first two stages are preferred. As a result, the specialized database is formed. Its structure should also be conceptually proved. First of all, database should to have some structure within operating system catalogues or the developed software product. In the simple case, when all the data have the same structure their organization leads to systematization under the subjects, observation periods and other characteristic features. If the data have heterogeneous structure, it is worthwhile to provide the systematization under this formats. Lately, due to rapid development of GIS with the coordinates of separate objects or images in the database, such systems are defined as geodatabase.

Commonly databases or geodatabases have somefeatures to provide access for particular users or computers. In more developed information systems with the existing set of data applied various types of analysis from building the simplest graphs [1] to generating spatial bivariate and/or three-dimensional distributions [2]. Beyond that point, some information systems permit to generate the appropriate animation subsequences on the grounds of the temporary databases [3]. Possibilities of the further system development will be defined by the objectives.

Cartographic shell. Assuming the GIS conception,we have the task of observation resultsvisualizationwithin the base map and it should include the separate cartographic geodatabase, represented the investigation area with use the number of thematic layers. The count of these layers is determined by the tasks of visualization and possible analysis of the spatial relations between observation data and cartographic objects locations.

On this basis and in compliance with system development implementation, it is necessary to provide priority developing of the base map thematic layers, as only in this case the possibility of data visualization becomes available. In turn to prepare and represent base map layers the GIS cartographic shell is needed. Traditionally GIS tools based on the window interface including at least the content panel (list of the displayed thematic layers) and the cartographic information render window. Often additionally and sometimes on user demand other panels can be displayed, for example, tool panels, attributive

tables, conventional signs, etc. In the system development process, it was decided to use the same type of interface (Fig. 1).

In according to window interface features, interface has main menu providing access to more frequently used commands and settings, i.e. selection of base map layers, display settings of the separate elements, etc. While improving the system, the list of the menu commands can modify and improve. Conventional signs of all displayed thematic layers are assumed to represent on the special panel at the right side of the interface.

The principal attention in the process of development should be concentrated to the GIS functionality provided during work with the data on the base map as a background. The expected set of observation data and variants of their interpretation are mentioned below. Here we only describe the conception of features of cartographic module including a set of the base thematic cartographic layers.
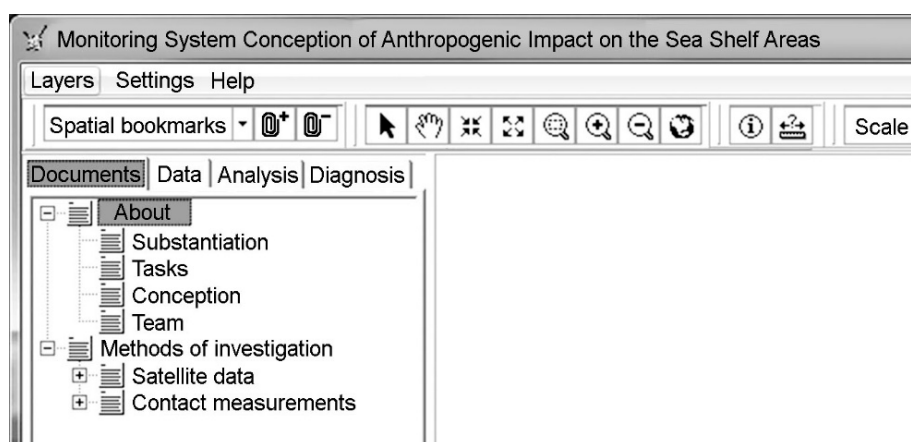

Fig. 1. Fragment of software user interface

As the primary map of the research area, the vector map including all elements necessary to display is used. In the present case, the GIS debugging is proposed to carry out using the area of the Crimea shoreline, including the nearshore waters. However, as indicated in the title of the present article, widening the scope of the research area up to the Caucasian Black Sea coast is also possible. In this case, the total spatial coverage of the research area is defined dynamically depending on the availability of the observation data, but not less than the Crimea shoreline. Therefore, scaling tools with storing both the general representation extent and the list of user spatial bookmarks should be implemented.

As major interest of the research is cover to the coastal and shelf sea, the base map should include at least the set of isobaths for the whole area and also points layer of the depth for the particular and the most important from the viewpoint of pollution areas. As the derivative digital array it is assumed to generate series of grid structures in the form of digital relief model. The supplementary arrays can appear in the process of the development, for examplelocation points of differentkind objects in the coastal zone. Land area must also include the basic map elements in

the form of lines of equal elevation, terrain elevation points, roads, forests and gardens, water objects, cities and towns and villages. Any number of layers should be available to be represented with user defined symbols. The proposed format for all digital maps is *ESRI ArcGIS* [4], widely approved by the World GIS Society.

Generally,the main map object of the coastal area is the coast location line, and this object has been required special attention. Until now, we used the set of Crimea vector maps, freely available on the Internet [5], but in the framework of the current work their accuracy was too low anditcan be shownas numerous topology distortions (Fig. 2).

By our assumption, the used digital array was obtained by digitizing of the USSR map fragments as of the 90s of the last century (scale 1:100,000), which was detected by its overlapping on the last one in *ESRI ArcGIS desktop* program. One of solutions of this problem was to create a new modern file of the coastline based on satellite data. In our earlier studies related to the digitization of satellite images [6 – 8], it was shown that this work can be completed successfully using the latest snapshots of *Google Maps* with an accuracy of up to 1 m. More recently, this version was confirmed by leading scientists at the conference held by the Government of Sevastopol in June 2015 [9].

**Fig. 2.** An example of the Crimea vector map topology distortion

The check of the satellite images of the recent years showed good image quality for June 5, 2014 for the whole of the Crimean Peninsula, with the exception of a shift of one fragment in the region of Feodosiya Bay. After adjusting thismistake map has been digitized and reprojectedfor detailed inspection of key map points location (Fig. 2). In general, contours totally matched each other, which is not true for some areas, two fragments of which are shown as an example in Fig. 3. Compared with the previously digitized array shown 27590 points, the new version contains 194115 pixels, an average of 1 point on 5 m of the coastal zone.
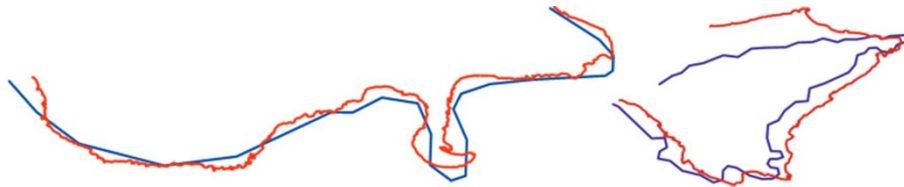
Fig. 3. Two fragments of the Crimea coastal zone: quantity of the points in the previous version equals to 27 and 67 (blue lines), and 2588 and 1185 in the new one (red lines)

Along with the shoreline a different kinds of coastal objects were digitized too, such as: lakes and channels, back walls, groins and piers, and also the noticed sewer pipes. Of course, spatial location of the shore area objects will be monitored continuously. From the old set of digital maps the thematic layers (roads, rivers, towns and contour heights) are used, which are not critical in solving the tasks of the present work.

At the moment, a preliminary version of the operating system shell, corresponding to all of the above requirements, has been issued. See Fig.1 to find obvious tools designed to work with a set of base maps. One of the variant of the map representation is a relief of the land, based on fixed horizontal lines with a choice of colors from the four options and feature for creation of the custom sets if needed. There is also the possibility of representing the relief in the form of a solid fill colored contour (Fig. 4). Currently the same approach to the visualization of the bottom topography is implemented.
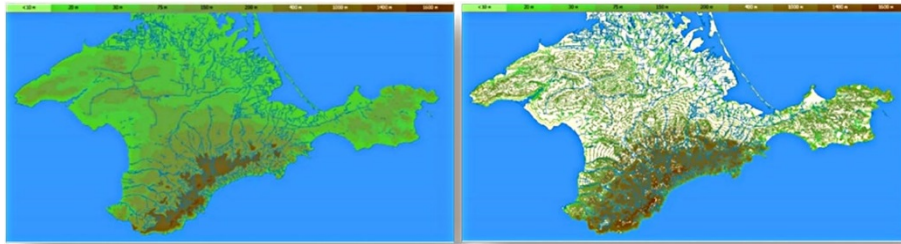
Fig. 4. Base map representation variants: left – solid fill, right – lines of equal elevations

Reference data. Both the results of standard hydrological, hydrochemical and hydrobiological observations and satellite methods possibilities are proposed to use as the reference data. The first ones, usually designed in the form of text files or worksheets and required to be transformed in the conventional GIS formats for visualization. The results mainly have a three-dimensional (including the depth) vector points, linear and polygonal structures with the obligatory attributive data in the table format. Often the vector structures are transformed in two-dimensional raster grids to display the space distribution on the separate levels and sections. In the course of work with two-dimensional raster structures it's possible to use geoprocessing methods for consequent arithmetic calculations for each cell of the grids with obtain the new distributions.
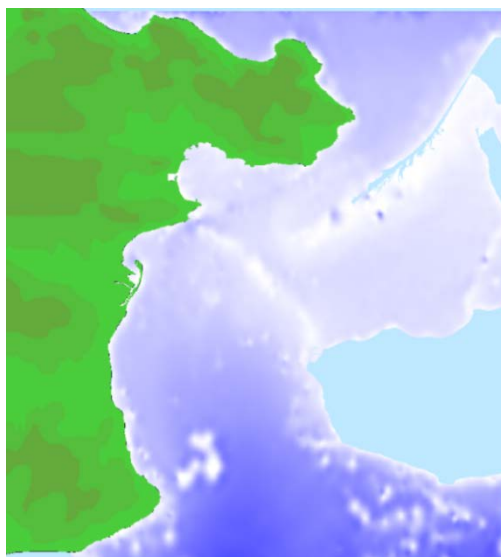
Fig. 5. An example of grid model bottom relief mapping

Special type of hydrological observations is fixing of the parameters of sea currents oh the different depth in the form of vector arrays having, except of the spatial location point, two additional values: direction and velocity. Such regular arrays are frequently obtained by means of the model calculations being highly developed recently and mapping the reference data for pollution distribution modeling within the whole water column of the research area. Therefore we come to the conclusion, that the most prospective both for visualization and modeling is the using of these grid arrays that was demonstrated in the other projects [2, 3]. In Fig. 5 you can see an example of such high resolution array displaying the bottom relief in the Kerch channel area.

One more advantage of this format using is its basic similarity with the satellite image format permitting to use the same visualization and data processing algorithms.

In the process of evaluating of possibilities of using of the satellite images for pollution detection in the sea water it was established that this problem breaks up into two separated ones [10], based on both with sea surface film pollution by oil products and subsurface dynamic processes while sewage distribution. The first problem is proposed to solve by research of sea surface structure, the second one – by measurements of the sea surface optical parameters. In both cases the observation results will results on the raster images having the spatial distribution, including the depth value.

Data Loading Modules. Because the input data sets have not primary specified formats, data loading modules are not used in every work session, more convenient is to realize this system part as dynamic libraries, widely known as *Dynamic Linked Library* (DLL-files). Thus, addition of the new file formats will not be required the software main module modification and require only supplementary DLL development.

In Fig. 6 you can see the module scheme (for one module) proposed for realization of the data processing consequence by DLL module with their assimilation in GIS geodatabase.
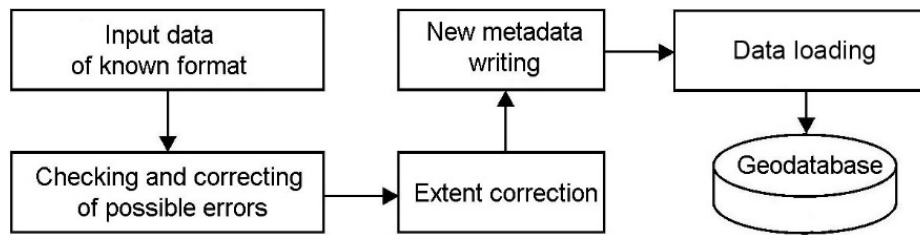

Fig. 6. Data load module structure

The contents structure. Many windows applications are based on many document interface (MDI). It is very useful for different data formats representation. Designed GIS is use MDI for contents sectioning of:

– text documents reflecting the main tasks of the project and the ways to solve them, the characteristics of all data types, description of its acquisition methods, geodatabase structure, applied visualization and analysis algorithms;

– structured under the subjects and chronology data in GIS formats adopted for visualization (Fig. 7);

– set of anapplied and potentially possible analytical data operations;

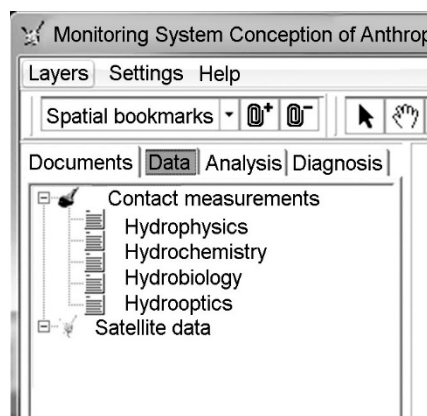– variants of the diagnostic and prognostic solutions.

Fig. 7. An example of the contents organizing in the form of multi-document interface

Used MDI located on special panel in the system structure (see. Fig. 1, left).Currently the filling of the contents by text and numerical data is carried out.

Conclusion. In accordance with the project tasks the GIS software conception was developed, including its contents, data assimilation algorithms, cartographic design and data visualization. All the used solutions were grounded and real life

tested. Parallel realization both of the system potential features and its geodatabase is planned.

REFERENCES

1. Kuznetsov, A.S., Kazakov, S.I., Dolotov, V.V., 2014, "*Tekushchee sostoyanie i perspektivy razvitiya informatsionnoy sistemy EO MGI* [Current state and prospects of the information system development of MHI Experimental branch]", *Ekologicheskaya bezopasnost' pribrezhnoy i shel'fovoy zon i kompleksnoe ispol'zovanie resursov shel'fa*, iss. 28, pp. 403-413 (in Russian)

2. Konovalov, S., Vladymyrov, V., Dolotov, V. [et al.], 2013, "Environmental Assessment Tools in the PEGASO Case-Sevastopol Bay", Proceedings of the Global Congress on ICM: *Lessons Learned to Address New Challenges*, Oct. 30, Turkey, Marmaris, 13 p.

3. Dolotov, V.V., Inyushina, N.V., Chudinovskich, T.V., 2006, "*Elektronnye raschetnykh gidrofizicheskikh poley i rezul'tatov naturnykh nablyudeniy za soderzhaniem nefti v Chernom more, sovmeshchennye v ramkakh edinoy obolochki* [Electronic atlases of the computational hydrophysical domains and the results of the oil content expeditionary monitoring in the Black Sea, combined in a single shell]", *Morskoy gidrofizicheskiy zhurnal*, no. 6, pp. 68-72 (in Russian).

4. ESRI Shapefile Technical Description: An ESRI White Paper-July 1998, http://mapexpert.com.ua/index_ru.php?idif=lpo_ag_39&table=new_post.

5. http://maps.ua/.

6. Goryachkin, Yu.N., Dolotov, V.V., 2011," *Izmeneniya beregovoy linii akkumulyativnykh beregov Zapadnogo Kryma* [Shoreline changes of the Western Crimea accretion coasts]", *Ekologicheskaya bezopasnost' pribrezhnoy i shel'fovoy zon i kompleksnoe ispol'zovanie resursov shel'fa*, iss. 25, vol. 1, pp. 8-18 (in Russian).

7. Goryachkin, Yu.N., Dolotov, V.V., 2011, "*Opyt ispol'zovaniya kosmicheskikh snimkov sverkhvysokogo razresheniya otkrytogo dostupa dlya monitoringa dinamiki beregov Kryma* [Experience of using ultra-high resolution satellite images of open access to monitor the dynamics of the Crimean coast]", Tez. IX Vserossiyskoy otkrytoy konferentsii "Sovremennye problemy distantsionnogo zondirovaniya Zemli iz kosmosa", IKI RAN, 14-18 noyabrya 2011 g., http://d902.iki.rssi.ru/theses-cgi/thesis.pl?id=2566 (in Russian).

8. Dolotov, V.V., Popova, A.V., 2014, "*Dolgoperiodnaya dinamika plyazha pos. Lyubimovka* [Long-period dynamics of the beach in Lyubimovka village]", *Ekologicheskaya bezopasnost' pribrezhnoy i shel'fovoy zon i kompleksnoe ispol'zovanie resursov shel'fa*, iss. 28, pp. 31-41 (in Russian).

9. 2015, "*Kompleksnyy mnogourovnevyy monitoring i sputnikovaya navigatsiya* [Complex multi-level monitoring and satellite navigation]", Ekonomika i bezopasnost', Materialy mezhdunarodnoy konferentsii 9–14 iyunya 2015 g., Sevastopol, http://www.ipa.nw.ru/conference/ KMM2015/inf1.htm (in Russian).

10. 2015, "*Otchet o nauchno-issledovatel'skoy rabote po teme "Razrabotka metodov i sozdanie eksperimental'nogo obraztsa sistemy monitoringa antropogennykh vozdeystviy na shel'fovye zony Chernomorskogo poberezh'ya Rossiyskoy Federatsii, vklyuchaya Krymskiy poluostrov, na osnove sputnikovykh i kontaktnykh dannykh (promezhutochnyy)"* ["Development of methods and the creation of an experimental monitoring system sample of anthropogenic impact on the shelf zones of the Black Sea coast of Russia, including the Crimean peninsula, on the basis of satellite and contact data (interim)]", Sevastopol, Morskoy gidrofizicheskiy institut RAN, 190 p. (in Russian).