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Environmental Assessment Tools in the PEGASO Case - Sevastopol Bay

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Abstract

The FP7 PEGASO project has been launched to investigate different aspects of and local conditions for integrated coastal zone management (ICZM) and application of the ICZM Protocol in the Mediterranean and Black Seas. The Bay of Sevastopol has been chosen as one of the sites (CASES) for practical application of the results of the project, to assess local conditions and provide practically useful end-products for the purpose of ICZM implementation. We have designed the system (http://wiki.iczm.org.ua/en/index.php/Download_the_latest_version_of_the_atlas) incorporating digital atlas and GIS features, but also allowing interaction with data and application of different ICZM tools. The major of these tools are indexes. While interaction with data makes possible to construct different maps, which have not been preloaded, tools make possible to analyze data. The current version of the system incorporates a number of indexes chosen within the frame of the PEGASO project for environmental assessment.

Introduction

The Bay of Sevastopol (Fig. 1, left panel) has been populated for over 25 centuries starting with Ancient Greek city Chersoneses founded in the 6th century B.C. By now, the Bay of Sevastopol is the central element of Sevastopol with all social and maritime interests and conflicts included. The bay has gradually transformed from the natural state, when it provided valuable recreational and marine biological resources, to the current state of highly polluted/eutrophied and biologically deserted coastal marine system with 80% of concrete coastline and over 30 km of piers and docs (Fig. 1, right panel). Thus, integrated coastal zone management (ICZM) has become crucially important to sustain economic development of Sevastopol and to protect/restore its coastal environment.

The FP7 PEGASO project (http://www.pegasoproject.eu/) has been launched to investigate different aspects of and local conditions for integrated coastal zone management and application of the ICZM Protocol in the Mediterranean and Black Seas. The Bay of Sevastopol has been chosen as one of sites (CASES) for practical application of the project results, to assess local conditions and provide practically useful end-products for implementation of ICZM.

The history and major results of Sevastopol Bay studies in relation to ICZM issues has been discussed in detail by Ivanov et al. (2006) and Konovalov et al. (2011). Currently, navy activities are modest and the Sevastopol Bay is a place for a big and intensively growing seaport, ship docking, sea-land transportation of various goods. The population of Sevastopol is about 400,000 permanent residents, but this population can easily triple on summer time. Unfortunately, the major part of municipal and industrial sewage waters (~10,000 m^3 per day) loaded to the bay from ~30 sewers without any or after minimal treatment. Environmental and biogeochemical conditions in the bay's environment have become so extreme that hypoxia is a regular feature of the inner part of the bay on summer time. To make matter worse, up to 40 µM of sulfide have been registered in the bottom layer of waters (Konovalov, 2009). Thus, the inner part of the Bay is a site, where regular hypoxic/anoxic events and consequences can be traced to study the effects of anthropogenic/industrial pollution and water exchange.

Fig.1: The Bay of Sevastopol (images have been taken from http://gamelika.com/imaginator/1/4e5fa9dd2ed5a_sevastopol.jpg and http://www.sevtaksi.com/foto/0014-crimea-sevastopol-juzhnaja-buhta-foto.html)

In order to account for the Sevastopol Bay environmental problems, the next PEGASO CASE priority issues have been identified:

(i) eutrophication and pollution, especially pollution from coastal sources;
(ii) biological desertification and changes;
(iii) climate change and extreme meteorological events.

There are several other threats. These are urban development, industrial development, recreational development, agricultural development, dramatic changes in land use, and coastal erosion. They are currently less important but they will grow in line with the coastal development. These coastal issues and problems are very usual for the Black Sea coast of Ukraine (Odessa, Chernomorskoe, Eupatoria, Yalta, Feodosia, Kerch, etc.) and, as far as it can be seen from the published data, this is true for the entire coast of the Black Sea.

There are national regulations to address individual ICZM issues. There is an ICSM group at the Ministry of Ecology of Ukraine. The ICZM activities in the Black Sea region date back to 1992, when the Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention) was signed (Antonidze, 2010). Yet, an integrated on-going National ICZM Strategy does not exist, as well as there is no ICSM Protocol for the Black Sea. ICZM issues (UNEP/MAP/PAP, 2008) are addressed within the frame of national and regional regulations, yet all these issues are poorly addressed considering the state of the Black Sea and its coastal areas (‘Diagnostic Report’ to guide improvements to the regular reporting process on the state of the Black Sea environment, 2010).

The Sevastopol City Authorities declare the importance of ICZM for Sevastopol city, thus for the Sevastopol Bay, yet the current state of the bay's environment and inter-annual trends of the bay's environmental properties expose serious concerns about effective ISZM.

This publication is to present a GIS-type tool for the Sevastopol Bay aiming to improve data coverage and provide environment assessment tools (and interactive digital atlas, GIS, and indexes) for stakeholders and end-users, which are developed within the PEGASO project and available at: http://wiki.iczm.org.ua/en/index.php/Download_the_latest_version_of_the_atlas.

Results and Discussion

Monitoring of the Sevastopol Bay and its results (data bases and atlases)

Several research institutions, including Marine Hydrophysical Institute and Institute of Biology of the Southern Seas of the National Academy of Sciences of Ukraine, and controlling organizations carry out monitoring programs for the state of the marine environment of the Sevastopol Bay. The currently accounted data for utilization in the PEGASO project are limited to those in Table 1.

Results of monitoring have been contributed to data bases of the National oceanographic center of Ukraine (http://www.nodc.org.ua/) and presented in a number of publications and, in particular, in the form of "Atlas of the Sebastopol Bay oceanographic properties" (Konovalov et al., 2009). This has made possible a detailed oceanographic description of the Sevastopol Bay (Konovalov et al., 2011) and utilization of these data as a metrics for marine provinces identification in the Sevastopol Bay (Dolotov et al., 2012).

Scientific support, which is one of the components of ICZM (UNEP/MAP/PAP, 2008), assumes participation of various specialists and utilization of various data depending on a specific task. The major disadvantage of traditional sources of data, which are atlases and data base, is the need to address various specialists, different sources of information, and usually paper-printed materials. Geographic Information Systems (GIS) are more helpful. This is the reason that we have designed the system (Fig. 2) incorporating the data base, digital atlas and GIS features, but also allowing interaction with data and application of different ICZM tools.

A standalone version of the GIS-type system for the Sevastopol Bay is available at http://wiki.iczm.org.ua/en/index.php/Download_the_latest_version_of_the_atlas. It starts with information on data available for specific chemical, physical, ecological parameters and pollutants for individual months and years (Fig. 2, upper panel). The system incorporates general information for the Sevastopol Bay, including meteorological, physical, biogeochemical, and ecological properties, and supplementary materials, but it also incorporates an extensive set of documents and scientific publications. Yet, the most valuable part of this atlas in the set of pre-processed maps (Fig. 2, lower panel) that can be displayed and compared or printed for further analysis.

Table 1 Data for utilization in the PEGASO project.

Data description	Typology	Temporal series	Spatial resolution
Weather conditions	Meteorological	From 1997 to 2012	1 point per bay
River discharge	Hydrology	From 1997 to 2012	1 point per bay
Marine environment	Physical data	From 1997 to 2012	Up to 40 points per bay
Marine environment	Chemical data	From 1997 to 2012	Up to 40 points per bay
Marine environment	Biological data	From 1997 to 2012	Up to 5 points per bay

PEGASO tools for the Sevastopol Bay

There are several tools developed within the frame of the PEGASO project and incorporated in the GIS-type system for the Sevastopol Bay. The major of these tools are GIS and indexes. The GIS tool is basically an extended set of regular numerical grids for all considered properties (Fig. 3) that can be arranged as needed (scale of maps, color scheme, isolines and their format) and combined with other layers of information (municipal and industrial buildings, sources of pollutants and their properties, etc.). Though this tool is far more powerful for environmental assessment, it still provides basically scientific information, but it serves as a basis for calculation of indexes.

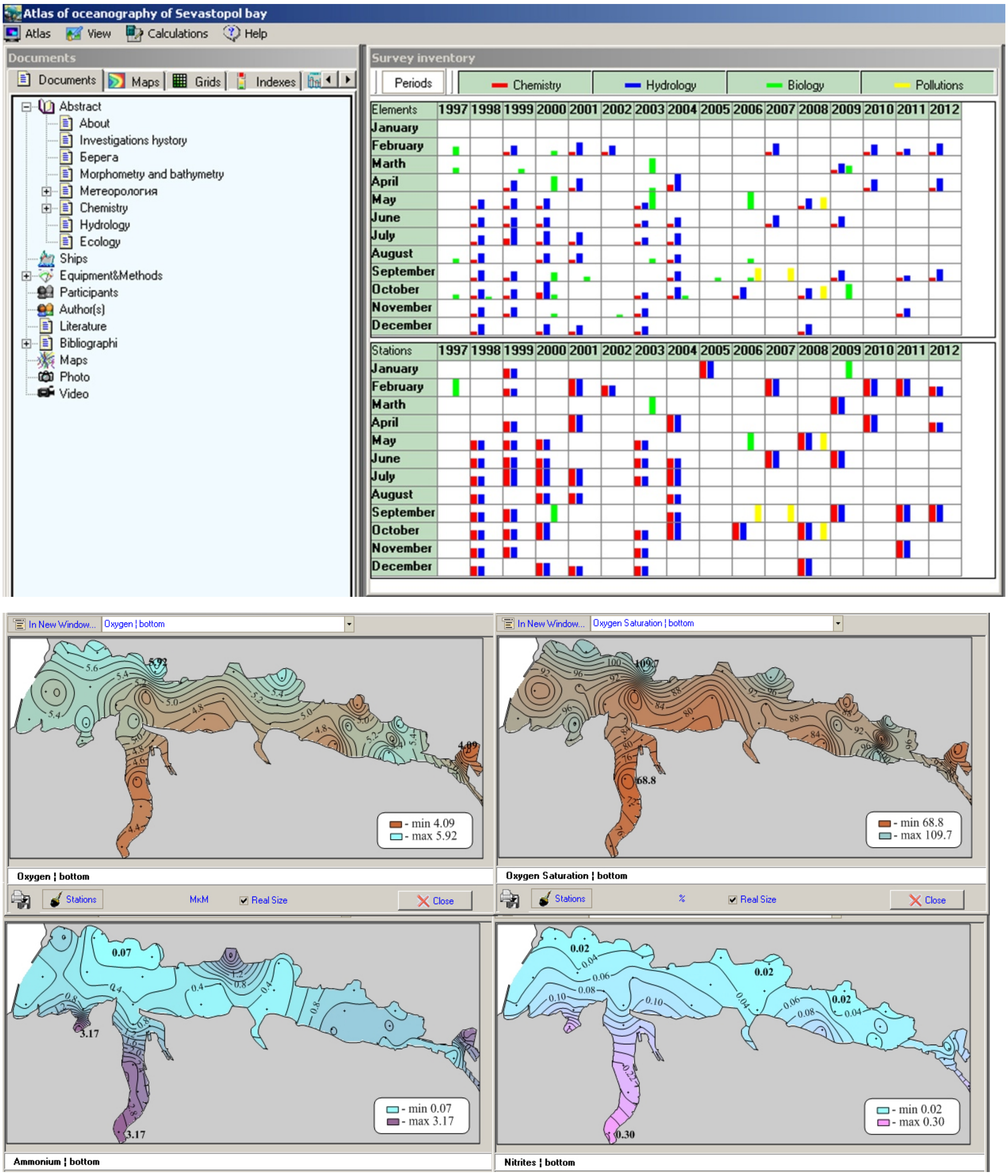


Fig. 2: The data base and digital atlas of the Sevastopol Bay.

While interaction with gridded data makes possible to construct different maps, which have not been preloaded, indexes make possible to evaluate the state of environment (Marti-Rague, 2007) and achieve an integrated regional assessment and ICZM (Antonidze, 2010). Thus, for example, a "traffic light" index has been constructed and introduced into the system. This index is universal and can be applied to any analyzed properties. As an example, this index has been applied to assess average summer concentrations of ammonium in the surface layer of water (Fig. 4). The five-grade color scale is color and boundary value adjustable either following the expert values or making a personal choice. We have used 1-, 3-, 5-, and 10-fold the maximum allowed concentrations for coastal waters used for common purposes. The result clearly demonstrates that only the central part of the bay can be considered as "clean", but the most inner part of the bay and that one under heavy municipal and maritime pressures are highly polluted.

Yet, the most valuable part of the current version of the system incorporates a number of indexes chosen within the PEGASO project for environmental assessment (http://www.coastalwiki.org/w/images/b/b6/PEGASO_T4.1_Indicator_methodological_paper_V1.pdf). All indexes have been divided in 8 groups in line with the considered policies:

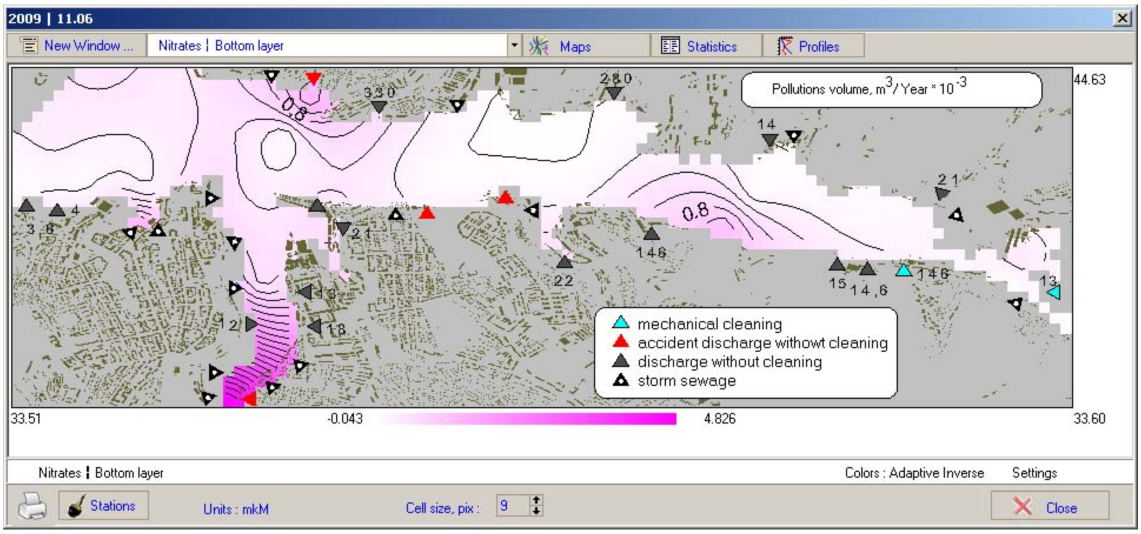


Fig. 3: The GIS-type tool for the Sevastopol Bay.

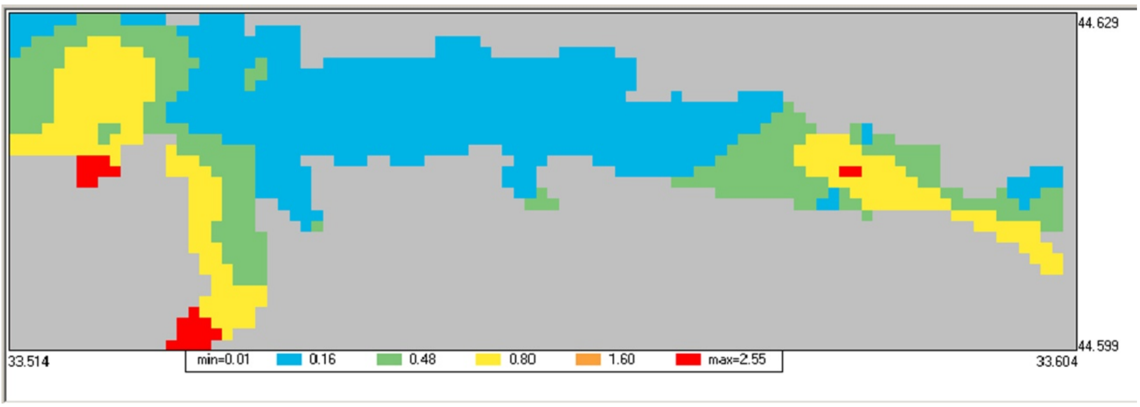
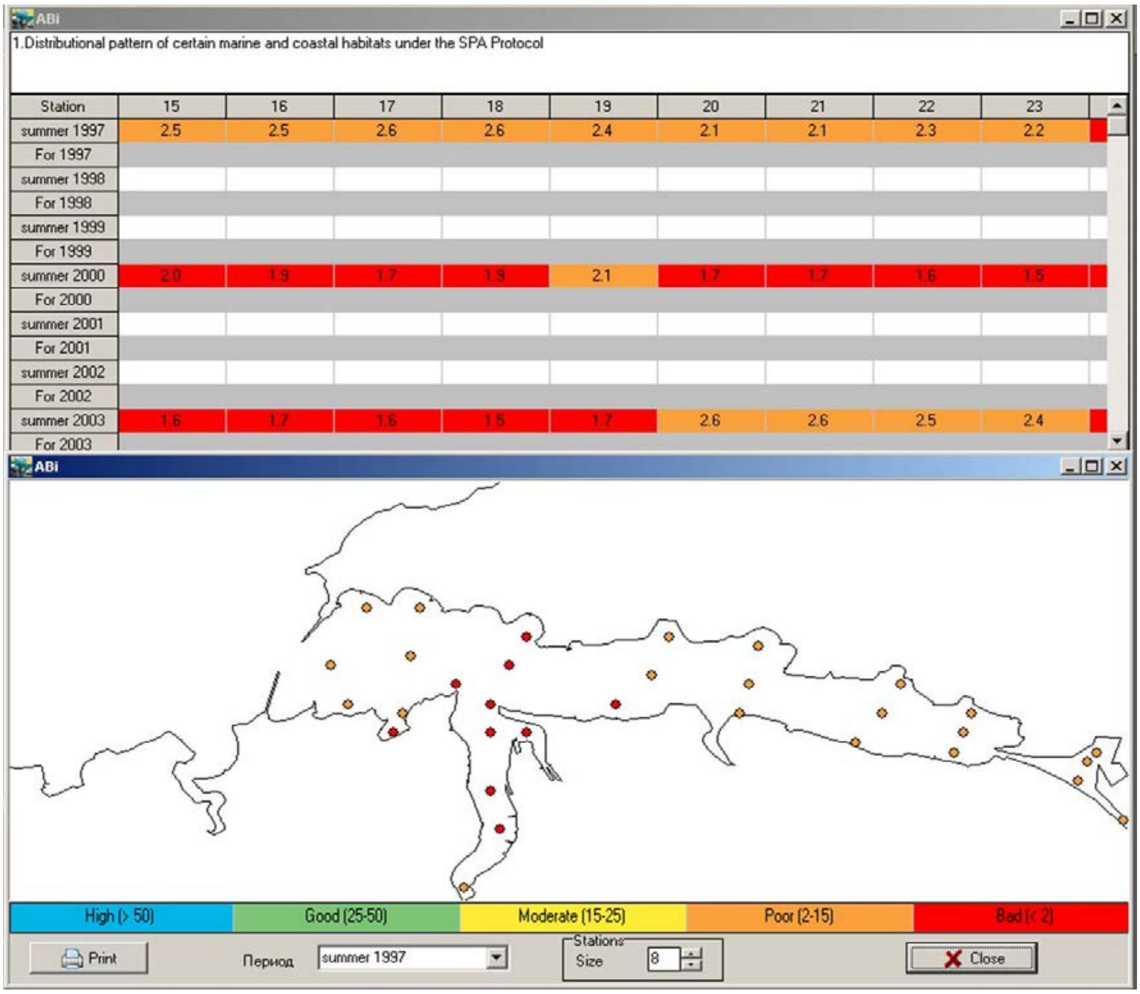


Fig. 4: The 5-grade "traffic light" index for the average summer concentration of ammonium in the Sevastopol Bay waters.

1. Preserve the wealth of natural capital in coastal zone
    1. Distributional pattern of certain marine and coastal habitats under the SPA Protocol
    2. State of the main species stocks by sea area
    3. Effective management of protected areas: share of coastal and marine habitats and species listed under international agreements (SPA protocol) that are in good
2. To ensure appropriate governance allowing adequate and timely participation in a transparent decision-making process of all relevant social actors
3. To ensure cross-sectorial coordination among competent authorities
4. To formulate land-use strategies, plans, and programmes covering all coastal and marine uses
    1. A governance system and legal instrument in support of Marine Spatial Planning is in place
    2. There are spatial development plans which include the coastal zone but do not treat it as a distinct and separate entity
5. To give priority to public services and activities requiring the proximity to the sea, and to take into account the specific characteristics of the coastal zones when deciding about coastal uses
    1. Economic production per sector (turnover)
    2. Employment structure
    3. Percentage of economic activities area in the coastal area
    4. Value added per sector
6. To have a balanced use of coastal zone, and avoid urban sprawl
    1. Land use flows: The area of new developments and its share on previously developed and undeveloped land in the coastal zone
    2. Area of built-up space in the coastal zone (both the emerged and submerged area of the coastal zone)
    3. Water efficiency index (special reference to article 9.1c)
    4. Changes in size, density, and proportion of the population living on the coast
7. To perform Environmental Impact Assessment for human activities and infrastructures
    1. Bathing water quality
    2. Hydrochemical quality
    3. Concentration of nutrients
    4. Number of hypoxia events or extent of hypoxic areas
    5. Eutrophication index
    6. Water column stratification
    7. Pollution by hazardous substances in biota, sediment and water columns (PLI)
    8. Trends in the amount of litter washed ashore and/or deposited on coast
8. To prevent damage to coastal environment, and appropriate restoration if damage already occurred
    1. Areal extent of coastal erosion and coastal instability
    2. Areal extent of sandy areas subject to physical disturbance (beach cleaning by mechanical means, sand mining and beach sand nourishment)

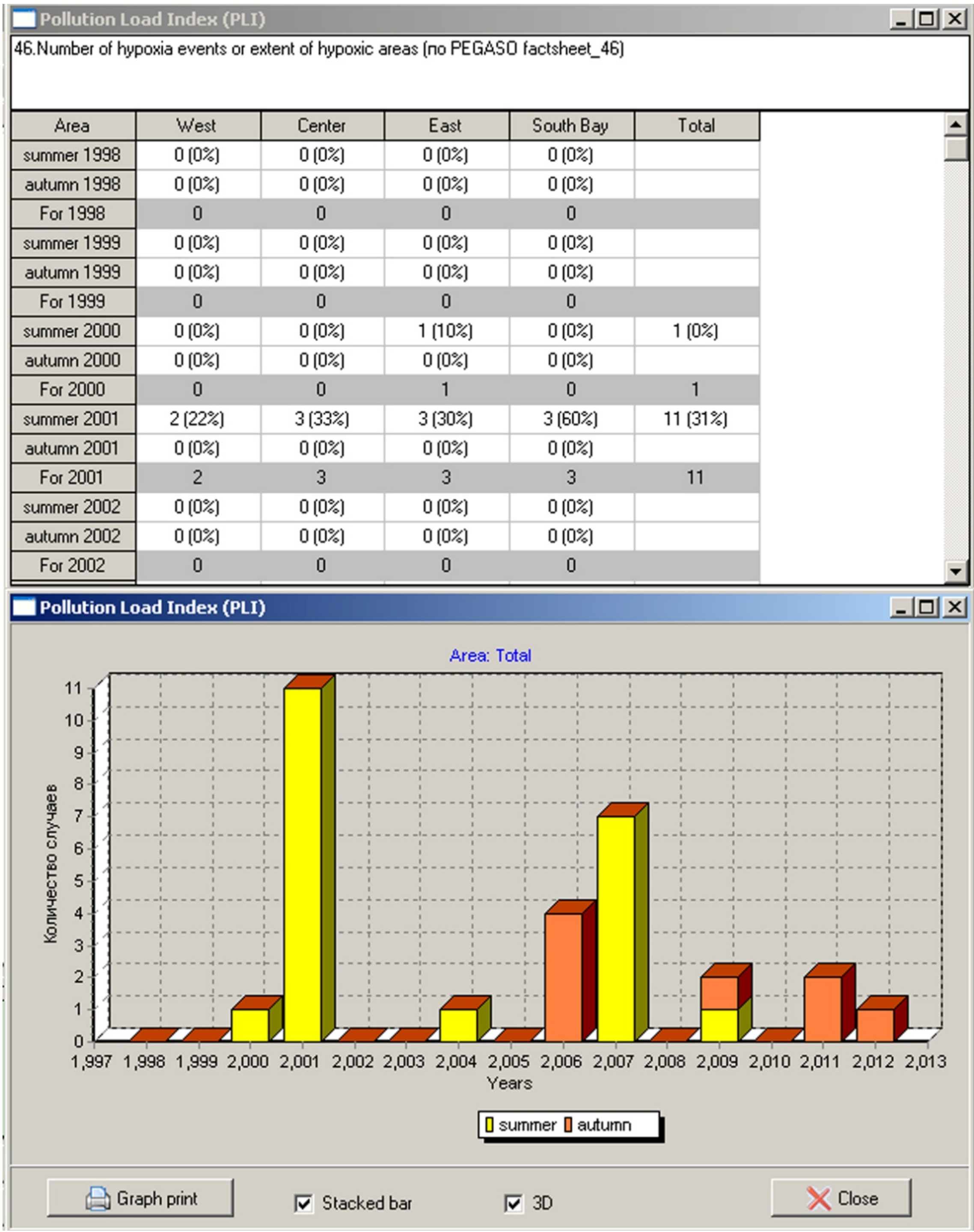
3. Risk assessment: economic assets at risk of storm surges and coastal flooding (considering sea level rise scenario's and return periods of storm surges)
4. Risk assessment: biological diversity (habitats/species) at risk of storm surges and coastal flooding (considering sea level rise scenario's and return periods of storm surges)
5. Risk assessment: Population living in the at risk area of storm surges and coastal flooding (considering sea level rise scenario's and return periods of storm surges)
6. Productive and protected areas lost due to siltation, saltwater intrusion
7. Sea surface temperature
8. Sea level rise

Information on indexes is generated in the form of tables and various maps and graphs (Fig. 5 and 6). The most important advantage is that all indexes are calculated "on demand" for needed stations, areas, and periods of time. This makes possible to actually provide an integrated regional assessment, to monitor spatial and temporal variations in the state of coastal environment, to trace negative and positive trends due to changes in anthropogenic pressures or/and climate changes.



Station	15	16	17	18	19	20	21	22	23
summer 1997	2.5	2.5	2.6	2.6	2.4	2.1	2.1	2.3	2.2
For 1997									
summer 1998									
For 1998									
summer 1999									
For 1999									
summer 2000	2.0	1.9	1.7	1.9	2.1	1.7	1.7	1.6	1.5
For 2000									
summer 2001									
For 2001									
summer 2002									
For 2002									
summer 2003	1.6	1.7	1.6	1.5	1.7	2.6	2.6	2.5	2.4
For 2003									

Fig. 5: An example of information in the form of tables and maps for ABi(distributional pattern of certain marine and coastal habitats under the SPA Protocol).



Pollution Load Index (PLI)

46.Number of hypoxia events or extent of hypoxic areas (no PEGASO factsheet_46)

Area	West	Center	East	South Bay	Total
summer 1998	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
autumn 1998	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
For 1998	0	0	0	0	
summer 1999	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
autumn 1999	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
For 1999	0	0	0	0	
summer 2000	0 (0%)	0 (0%)	1 (10%)	0 (0%)	1 (0%)
autumn 2000	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
For 2000	0	0	1	0	1
summer 2001	2 (22%)	3 (33%)	3 (30%)	3 (60%)	11 (31%)
autumn 2001	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
For 2001	2	3	3	3	11
summer 2002	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
autumn 2002	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
For 2002	0	0	0	0	

Fig. 6: An example of maps in the electronic version of the atlas of the Sevastopol Bay.

Conclusions

The FP7 PEGASO project has been launched to investigate different aspects of and local conditions for ICZM and application of the ICZM Protocol in the Mediterranean and Black Seas. The Bay of Sevastopol has been chosen as one of the sites for practical application of the project results, to assess local conditions and to provide practically useful end-products for the purpose of ICZM implementation.

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