
Chronicle

The SatBałtyk project: Satellite Monitoring of the Baltic Sea Environment

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Marine research in Poland has a long tradition. The first purpose-built laboratories were founded in the 1920s on the Hel Peninsula and in Gdynia. After World War II a number of large, dynamically developing marine science institutes came into existence (Dera et al. 2007)¹. One of these is the Institute of Oceanology of the Polish Academy of Sciences (Dera 2003)², where marine optics, one of several disciplines practised at the Institute, has been able to flourish; today, it is of fundamental importance in remote sensing techniques for monitoring the marine environment. The first research to be carried out in this field at the Institute investigated the optical properties of the constituents of sea water, their influence on underwater visibility and the structure of the underwater light field. This research was later extended to the various processes in the sea that are stimulated by sunlight, especially the photosynthesis of organic matter in marine algae. Concurrently, more or less since the mid-1990s, great emphasis has been placed on the development of bio-optical modelling and remote optical means of investigating the functioning of marine ecosystems, particularly those based on satellite observations. The synthesis of these several branches of optical research led to the development, in 2001–2005, of the comprehensive DESAMBEM^{8,9} algorithm, which enables Baltic ecosystems to be monitored from space. This will now be discussed in greater detail.

The marine regions that Polish oceanographers have usually concentrated on are the seas of northern Europe, including the European Arctic. For Poland, however, the most important marine area is the Baltic Sea,

¹Dera J., Massel S., Pliński M., 2007, *Poland's contribution to the study of seas and oceans*, pp. 73–121, [in:] *Current and future problems in the Earth and mining sciences*, B. Ney (ed.), PAN, Warszawa, 414 pp., (in Polish).

²Dera J., 2003, *Institute of Oceanology, Polish Academy of Sciences – 50 year history*, *Oceanologia*, 45 (1), 133–168.

where decisions regarding the economy, transport, recreation and the signing of international conventions between the countries bordering the Baltic Sea should be underpinned by complete, up-to-date information on the state of this environment and the changes it is subject to. Given the current state of the technology used in marine science, remote sensing combined with appropriate mathematical models and in situ test measurements is the most effective means of acquiring this information (ESF Marine Board 2008)³. Obtaining this data by traditional methods, from on board ships, is far more costly, not very effective, and does not satisfy present-day requirements for the continuous monitoring of the sea.

It is for this reason that in 2001–2005 the Institute of Oceanology PAN, together with the Institute of Oceanography (University of Gdańsk), the Pedagogical (now Pomeranian) Academy of Słupsk, and the Sea Fisheries Institutes of Gdynia, conducted research within the framework of a project commissioned by the Polish Committee for Scientific Research – DESAMBEM (DEvelopment of a SATellite Method for Baltic Ecosystem Monitoring; project No. PBZ-KBN 56/P04/2001⁴). That project's objective was to develop scientific principles and methods for utilising remote sensing technology to monitor the Baltic, an enclosed sea with a high level of biological productivity but seriously endangered by the effects of economic development. DESAMBEM was able to make use of the long experience and extensive database of the team of marine optics scientists to develop and empirically validate the detailed models and algorithms for defining the characteristics of the state and functioning of the Baltic ecosystem on the basis of currently available satellite data (e.g. Woźniak et al. 2007⁵).

The implementation of the DESAMBEM methods has become possible thanks to EU funding. This began in early 2010 with the initiation of another large-scale research project entitled: Satellite Monitoring of the Baltic Sea Environment (SatBałtyk), funding for which was recommended by the Polish Ministry of Science and Higher Education following the project's entry to a competition entitled 'scientific research serving the development of an economy based on knowledge'. This competition was

³ESF Marine Board Position Paper 12, 2008, *Remote sensing of shelf sea ecosystems; state of the art and perspectives*, 60 pp.

⁴Woźniak B., Krężel A., Dera J., 2004, *Development of a satellite method for Baltic ecosystem monitoring (DESAMBEM) – an ongoing project in Poland*, *Oceanologia*, 46 (3), 445–455.

⁵Woźniak B., Krężel A., Darecki M., Dera J., 1997, *Satellite monitoring of spatial variability in the Baltic Sea ecosystem: possible applications of the DESAMBEM algorithm*, SPIE, http://spie.org/x648.xml?product_id=730231\&origin_id=x648, Proc. Vol. 6615, doi:10.1117/12.740434.

organised within the framework of the Innovative Economy Operational Programme (priority 1: *Research and development of modern technologies*, subaction 1.1.2: *Strategic scientific research and development programmes*).

The main aim of the SatBałtyk project is to prepare the technical infrastructure and set in motion practical operational procedures for the efficient, routine monitoring of the state of the Baltic environment, i.e. the production of maps of its structural and functional characteristics, including the inflow and characteristics of radiant energy (PAR⁶, UV⁷), temperature distributions, the dynamic state of the sea surface, the concentrations of chlorophyll and other phytoplankton pigments, blooms of toxic algae, the occurrence of upwelling events, the appearance of patches of pollutants such as oil slicks, and the characteristics of the primary production of organic matter. Figure 1 shows a set of such maps. In addition, the development and possible practical application of remote sensing for assessing the ice cover in the Baltic is anticipated. The expected end result of the project is to set up an operational system for the rapid and efficient determination of the above-mentioned characteristics of the Baltic Sea in the form of maps showing their distribution in this sea.

The database and procedures will make use of the flow of information arriving from accessible remote sensing systems covering the Baltic Sea region, and the Polish economic zone in particular (e.g. the AVHRR instruments on board TIROS N/NOAA, the Seviri instrument on board Meteosat 9, the MODIS instrument on board EOS AQUA, the MERIS instrument on board ENVISAT), and the information available from earlier mathematical models of the sea and atmosphere. The theoretical foundations of this system, the models and other mathematical relationships utilised by the system are covered by the above-mentioned DESAMBEM algorithm, described in detail in Woźniak et al. (2008)⁸ and Darecki et al. (2008)⁹.

During the implementation of the SatBałtyk project the DESAMBEM algorithm will continue to be improved and extended with new formulae. In addition, empirical verification and corrections to the algorithm will be

⁶PAR – photosynthetically available radiation (~ 400–700 nm).

⁷UV – ultraviolet radiation.

⁸Woźniak B., Krężel A., Darecki M., Woźniak S.B., Majchrowski R., Ostrowska M., Kozłowski Ł., Ficek D., Olszewski J., Dera J., 2008, *Algorithm for the remote sensing of the Baltic ecosystem (DESAMBEM), Part 1: Mathematical apparatus*, *Oceanologia*, 50 (4), 451–508.

⁹Darecki M., Ficek D., Krężel A., Ostrowska M., Majchrowski R., Woźniak S.B., Bradtke K., Dera J., Woźniak B., 2008, *Algorithm for the remote sensing of the Baltic ecosystem (DESAMBEM), Part 2: Empirical validation*, *Oceanologia*, 50 (4), 509–538.

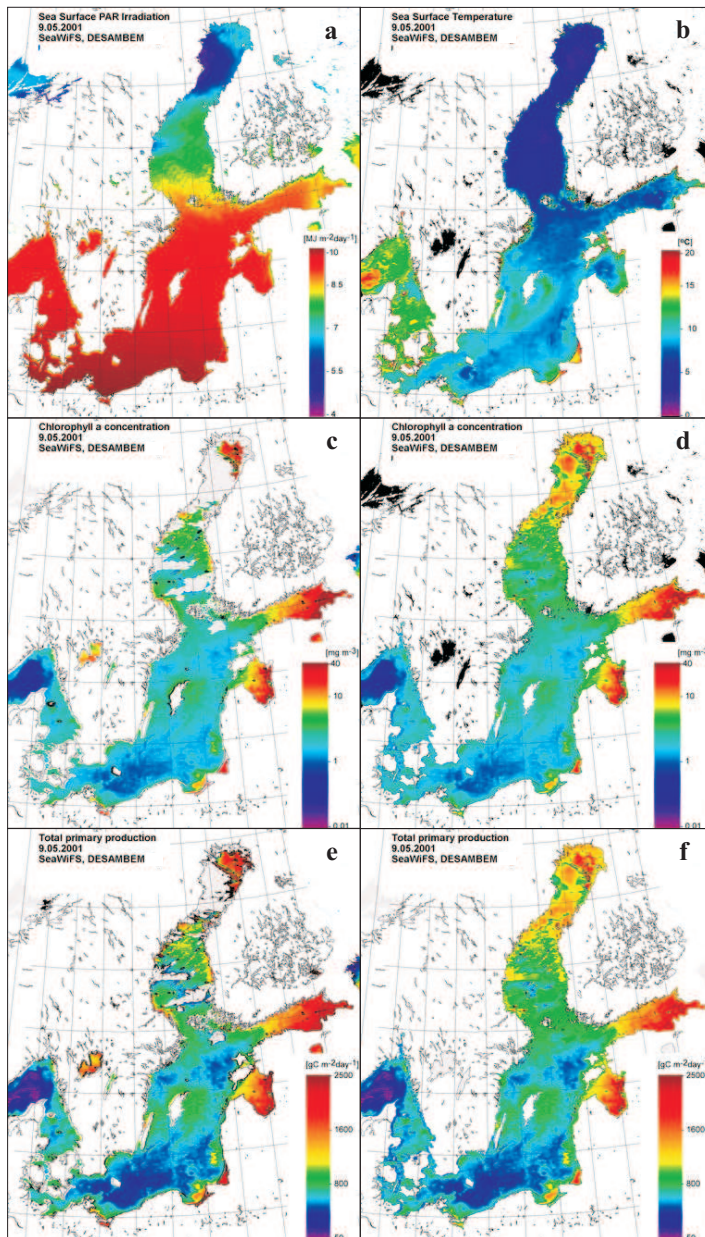


Figure 1. Example of the remotely sensed distribution of 4 selected parameters of the Baltic ecosystem on 10 May 2002 calculated from the DESAMBEM algorithms: a) PAR irradiance at the sea surface PAR ; b) the sea surface temperature SST ; c) surface concentration of chlorophyll a $C_a(0)$ for the cloud-free area; d) surface concentration of chlorophyll a $C_a(0)$ for the whole Baltic, with data reconstructed in the gaps due to cloud cover; e) total primary production P_{tot} for the cloud-free area; f) total primary production P_{tot} for the whole Baltic, with data reconstructed in the gaps due to cloud cover (from Darecki et al. 2008)

carried out on the basis of the results of in situ test measurements from on board ships and from moored measurement buoys.

SatBałtyk is a joint project carried out by four institutions, which to this end have signed an agreement to form the SatBałtyk Scientific Consortium. The members of the consortium are:

1) The University of Gdańsk, ul. J. Bażyńskiego 1a, 80–952 Gdańsk, represented by the Vice-Chancellor of the University of Gdańsk (UG), Professor Bernard Lammek.

2) The Pomeranian Academy, ul. Arciszewskiego 22a, 76–200 Słupsk, represented by the Vice-Chancellor of the Pomeranian Academy (AP), Professor Roman Drozd.

3) The University of Szczecin, al. Papieża Jana Pawła II 22a, 70–453 Szczecin, represented by the Deputy Vice-Chancellor for Science and International Cooperation, Professor Andrzej Witkowski, and the Bursar of the University of Szczecin, Andrzej Kuciński MSc.

4) The Institute of Oceanology of the Polish Academy of Sciences (IO PAN), ul. Powstańców Warszawy 55, 81–712 Sopot, represented by the Director of the Institute, Professor Janusz Pempkowiak.

Institutions Nos. 1–3 are Partners to the Project, while Institution No. 4 is the Project Leader.

The sum of more than 38 million zloties (PLN) has been allocated to the construction of the SatBałtyk system and the achievement of the project's objectives.

The Director of the SatBałtyk project is Professor Bogdan Woźniak (Photo 1) <wozniak@iopan.gda.pl>, and the Deputy Director of the Project is Dr Mirosława Ostrowska (Photo 2) <ostra@iopan.gda.pl> both from IO PAN.



Photo 1. Professor Bogdan Woźniak, head of the SatBałtyk project



Photo 2. Dr. Mirosława Ostrowska, deputy head of the SatBałtyk project

The Project is being carried out in 4 separate thematic groups, the work of which will be coordinated by the following persons:

- 1) Dr Mirosław Darecki <darecki@iopan.gda.pl> (IO PAN) will be in charge of the team working on the topic: ‘The carrying out of supplementary scientific studies, the preparation of the technical aspects of the Project, and the starting up, validation and practical application of the remote sensing system for monitoring the Baltic with respect to the state and functioning of its ecosystem’.
- 2) Professor Adam Krężel <oceak@univ.gda.pl> (Institute of Oceanography UG) is responsible for the execution of the following tasks: ‘The development and empirical validation of a packet of algorithms for determining physical fields (e.g. temperature, irradiance) in the sea and their inclusion in the remote sensing system for monitoring the Baltic’.
- 3) Dr Dariusz Ficek <ficek@apsl.edu.pl> (Institute of Physics AP) will head the group working on: ‘The development and empirical validation of a packet of algorithms for determining primary production and the radiation balance of the sea, and their inclusion in the remote sensing system for monitoring the Baltic’.
- 4) Professor Kazimierz Furmańczyk <kaz@univ.szczecin.pl> (Institute of Marine Sciences US) will coordinate the work of the team dealing with: ‘The development and empirical validation of methods for determining the influence of coastal zone processes on the marine environment and their inclusion in the remote sensing system for monitoring the Baltic’.

Around 50 persons are directly involved in the Project’s implementation.

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