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Marine sciences in achievements of Croatian-Polish GIS Cooperation (1994-2013)

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The paper presents a range of research carried out for the marine sciences using the GIS applications, which are documented scientific achievements of twenty years of Croatian-Polish cooperation in the field of geographic information systems. The resultant body of work includes, inter alia, *scientific publications that are the effect of twenty international conferences organized in the framework of said cooperation efforts. The study included articles published in 1994 to 2013. An analysis of selected articles was done in accordance with the accepted range of topics in order to categorize and define the research extent. Among the distinguished six subject categories most of the articles were concerned with: marine policy strategy, marine engineering, marine biology, marine physics and some of them in marine fisheries and marine chemistry.*

Key words: marine science, sea water management, GIS technology, Croatian-Polish cooperation

INTRODUCTION

Geographical information system (GIS) technologies have been widely applied at all scientific fields and practical activities (GAJOS & SIERKA, 2011, 2012), among others in marine sciences, too.

The purpose of this article is to characterize the studies in the marine sciences using the GIS technologies, which were carried out under the Croatian-Polish scientific cooperation in the field of GIS. The origins of this cooperation are associated with a special event that took place during the war in the Balkans in 1993. At that time the Croatian GIS expert and his family provided assistance to the Polish group of physicians returning from the humanitarian action in Sarajevo, who had a car accident in Crikvenica, Croatia. In 1994 GIS experts from Croatia took part in the international conference on Spatial

Information Systems GIS/LIS in Commune and Region, organized in Poland in Szczyrk, for the first time. Crikvenica in Croatia is the place where the 20th Geographical Information Systems Conference and Exhibition GIS Odyssey 2013 took place. The remaining eighteen of the twenty GIS conferences took place mainly in Croatia and Poland: GIS Odyssey 2012, Croatia and Bosnia and Hercegovina: Metković, Neretva, Mostar & Međugorje; GIS Odyssey 2011, Croatia: Lovran, Kvarner & Istria; GIS Odyssey 2010, Croatia: Brijuni, Istra & Pula; GIS Odyssey 2009, Croatia: Plitvice, Lika & Zadar; GIS Polonia 2008, Poland: Zakopane & Kraków; GIS Odyssey 2007, Croatia: Šibenik, Split, Trogir & Dalmatian Inland – Vrlika, Sinj; GIS Odyssey 2006, Croatia: Šibenik, Split, Krka & Dalmatian islands; GIS Odyssey 2005, Croatia: Opatija, Pula & Istria; GIS Odyssey 2004, Croatia: Trogir, Kornati, Hvar; GIS Silesia, Poland: Katowice, Sosnowiec, Będzin, Rudy Wielkie, Złoty Potok, Ojców; GIS Odyssey 2002, Croatia: Split, Trogir, Korčula, Mljet, Dubrownik; GIS Polonia 2001, Poland: Warsaw; GIS Croatia 2000, Croatia: Zagreb, Osijek, Lonjsko Polje; Information Management in the New Millennium 1999, Poland: Kraków; GIS in Cultural and Environmental Heritage Management 1999, Great Britain: York; Processing and Protection of Data 1998, Poland: Ustroń; International Geographic Information Systems Conference and Exhibition GIS Croatia 1998, Croatia: Osijek; Freedom of Information and its Limits 1997, Poland: Katowice, Ustroń.

Each conference involves a specific body of work published in hard copy (proceedings, monograph, special issue in journals) and electronically (CD, website). Conference sessions as well as chapters in books related to various problems (GAJOS, 2006, 2007, 2009a, 2009b, 2011a, 2011b; GAJOS *et al.,* 2014; WIĘCKOWSKA & PRZYBYSZ, 2006) and disciplines: geoinformatics, cartography, geodesy, cadastre, ecology, forestry, hydrography, oceanology, fisheries, applied economy and other related.

The aim of this work was to analyze marine sciences articles dealing with using the GIS applications.

MATERIALS AND METHODS

Titles of conference sessions and topics in conference books kept changing to reflect emerging new GIS developments and applications across various scientific disciplines and walks of life. The review of 879 descriptions, including 877 article descriptions and 2 descriptions of multi-author monograph in 27 publications of the two-decade long Croatian-Polish GIS and related topics partnership helped to distinguish following 15 thematic areas (GAJOS, 2013): Globalization and Social-Economic Problems. Transition and Challenge in the New Europe. Economics and Regional Development; Geodesy – Cadastre – Cartography; Geoinformatics Systems. Information Technology; Cultural and Natural Heritage Management; Environmental and Earth Resources Management. Structure and Function of the Geographical Environment; Agriculture and Forestry; Sea and Water Management; Ecology; The State and Local Level Administration & Management (Municipal Projects); Space and Law. Legally Protected Regions. Geoinformation and Law. Informatics, Law & Communication; Spatial Information Systems in Practice; Infrastructure for Spatial Information in Europe; Emergency Management, Post-War and Post Disaster Reconstruction Projects; International Cooperation; Others.

With a view to the topical extent of the Acta Adriatica – International Journal of Marine Sciences along with the special issue on GIS application to the research into the marine science, area of Sea and Water Management (63 articles); Environmental and Earth Resources Management. Structure and Function of the Geographical Environment (52 articles); and Ecology (67 articles) were covered by research. A detailed analysis was done of articles in these thematic areas which were published as GIS Conferences materials in 1994 to 2013 to select only paper connected with marine science (38 articles).

The research proceedings relied upon article categorization intended to determine research directions. Categorization is the process in which ideas and objects are recognized, differ-

entiated, and understood. Categorization implies that objects are grouped into categories, usually for some specific purpose. Ideally, a category illuminates a relationship between the subjects and objects of knowledge (Wikipedia.Categorization).

To run the categorization process, the body of literature analysis and critics method was used. The literature review as a scientific examination method is used to review scientific works and for peer review. The objectives and functions of the literature review are: description and evaluation of current knowledge for a given topic (research status); arranging the knowledge through categorization etc. to identify any hitherto missed regularities, relations, facts, phenomena; reveal cognitive gaps uncharted areas; seek inspiration, research subjects; identify new research directions (ANKEM, 2008). The detailed review of selected articles helped classify them into proper categories.

To present the results the bibliometric research method was used. This method is a statistical application for quantitative studies of facts, phenomena and processes related to texts and information (DIODATO, 1994).

RESULTS AND DISCUSSION

The outcome of the research into the literature on the problems connected with using the GIS applications in marine sciences distinguished six thematic categories (Table 1). In Table 1 the eligible number of articles (in the form of bibliographic citations included in the references) in each category, which set the course for marine science carried out during twenty years of GIS cooperation 1994 to 2013, is shown too.

Most articles were found in the following categories, respectively: marine policy strategy, marine engineering, marine biology, and marine physics, some of them in: marine fisheries and marine chemistry. Detailed research issues within each category are described in the following discussion, presenting the most numerous categories as first and in a broader way.

In category of **Marine Policy Strategy** 17 articles were analyzed. Assimilative capacity should be preserved for coastal seas as a natural resource (KNEZIĆ *et al.*, 1999; 2000), what could be supported by objective decision support system. It is not in use only for environmental influences, but also for e.g. ships request for place of refuge (BRADARIĆ *et al.*, 2009). Especially big cruisers should be taken in account (VUKADIN, 2005). With such a system it is possible to adjust coastal zone management and dynamical natural system. Long term field measurements are very useful for testing of all models (ČUPIĆ *et al.*, 2006). Combination of two models with GIS technology support gives an opportunity to assistance many operational level system functions. It was identified that each kind of data and database, not dependence on time and standard (DADIĆ *et al.*, 2000a) and can be used with GIS tools for output data analysis. Some equipment like HF radar except for current prediction can be applied in rescue missions and oil spills dissemination (DADIĆ *et al.*, 2009). That is important for comparison of models and new automatic meteo-ocean measuring stations (DADIĆ *et al.*, 2005). In the frame of different classification criteria for usage and protection of marine areas were defined ecologically sensitive marine areas, e.g. rich areas with flora and fauna, very important for fish spawning (DADIĆ & SRDELIĆ, 2001). An information system for promotion of aquaculture in the Mediterranean region (SIPAM) has been developed based on the FAO–MEDRAP Project (DADIĆ *et al.*, 2002). GIS techniques support safety navigation products, like HIDRIS system (DUPLANČIĆ-LEDER & RACETIN, 2002; DUPLANČIĆ-LEDER & LEDER, 2006) and ADRIA GIS system for decision making of port of refuge (BRADARIĆ *et al.*, 2010). Most of the projects presented in papers can now be realised through IPA - EU funds and programmes (JURIĆ *et al.*, 2011). A lot of other obligations of the Republic of Croatia like European Water Framework Directive (WFD) can be solved with EU funding too (DADIĆ *et al.*, 2012). Research activities in oceanographic sciences were presented in the article "75 Years of the Institute of Oceanography and Fisheries (1930-2005)" (Institute of Oceanography and Fisheries, 2005). Research activities

Table 1. The results of categorization of published articles (1994-2013)

Categories	Articles (in References)	No. of articles
Marine Biology	DADIĆ *et al.*, 2000b VUKADIN 2002 DADIĆ *et al.*, 2004 GRYGIELEWICZ, 2004 KRSTULOVIĆ-ŠIFNER, *et al.,* 2004 VUKADIN, 2004 DADIĆ *et al.,* 2008 DYNOWSKI *et al*., 2012	8
Marine Chemistry	VUKADIN, 2003 VUKADIN, 2004	2
Marine Engineering	DADIĆ *et al.*, 2000a VUKADIN, 2005 BALJAK & VIDAN, 2006 BRADARIĆ *et al.*, 2006 ČUPIĆ *et al.*, 2006 IVANČIĆ, 2006 MIHANOVIĆ *et al.*, 2006 VLADISLAVIĆ *et al.*, 2007 BRADARIĆ *et al.*, 2010 KASUM *et al.*, 2010	10
Marine Fisheries	MIŠURA *et al.*, 2004 VRGOČ *et al.*, 2005	2
Marine Physics	VILIBIĆ *et al.*, 2002 VUKADIN, 2002 VUKADIN, 2003 BEG-PAKLAR *et al.*, 2007 MOROVIĆ *et al.*, 2007 CHYBICKI *et al.*, 2011	6
Marine Policy Strategy	KNEZIĆ *et al.*, 1999 DADIĆ *et al.*, 2000a KNEZIĆ *et al.*, 2000 DADIĆ & SRDELIĆ, 2001 DADIĆ *et al.*, 2002 DUPLANČIĆ-LEDER & RACETIN, 2002 DADIĆ *et al.*, 2005 Institute of Oceanography and Fisheries, 2005 VUKADIN, I. 2005 DUPLANČIĆ-LEDER & LEDER, 2006 KOZLIČIĆ *et al.*, 2006 BRADARIĆ *et al.*, 2009 DADIĆ *et al.*, 2009 ČUPIĆ *et al.*, 2006 BRADARIĆ *et al.*, 2010 JURIĆ *et al.*, 2011 DADIĆ *et al.*, 2012	17

in hydrography and nautical cartography on the East Adriatic coast was presented in the article „200 Years of Hydrography in Croatia" in honor of Anniversary of Hydrographic Institute of the Republic of Croatia in Split (KOZLIČIĆ *et al.*, 2006).

In category of **Marine Engineering** 10 articles were analyzed. Methods and procedures for validation and processing of oceanographic data were presented as well (DADIĆ *et al.*, 2000a). A big cruise ships with capacity of more than 3000 passengers (VUKADIN, 2005) became in the last 30 years an important subject containing/ using technologies for fix/ solving thousands of tons of waste. In that case it is important to trace vessels movement by AIS (BALJAK & VIDAN, 2006). Especially navigation of ships near the big harbors is very dangerous and depends on previous hydrographic measurements and charts, classical and ENC (Electronic Navigational Charts) (BRADARIĆ *et al.*, 2006; 2010). Importance of long term tide measurements (ČUPIĆ *et al.*, 2006) and precision of MSI (Maritime Safety Information) (IVANČIĆ, 2006) were identified as crucial for safety of navigation. Even vertical land movement can be recognized from long term tide measurement data (MIHANOVIĆ *et al.*, 2006). In the case of disaster (KASUM *et al.*, 2010) GIS tools (BRADARIĆ *et al.*, 2010) have to be used.

In category of **Marine Biology** 8 articles were analyzed. The main problem that was considered in this articles is the demand on monitoring (DADIĆ *et al.*, 2000b; DYNOWSKI *et al.*, 2012) of different species of fishes and plankton, especially species which came from another seas (GRYGIELEWICZ, 2004), or they belong to the invasive types (KRSTULOVIĆ-ŠIFNER *et al.*, 2004). Some results in the particular areas show higher abundance and occasional eutrophication (VUKADIN, 2002; 2004) near the big cities, on the east Adriatic coast. This was not the case in the last few decades. GIS technique deserves main place for interesting presentation of the acquired data. Through the GIS technique objective analysis (DADIĆ *et al.*, 2004; 2008) of total stock and spatial distribution became evident to everybody, and tool is important for main global decisions.

In category of **Marine Physics** 6 articles were analyzed. Few types of sea level fluctuations are described in article (VILIBIĆ *et al.*, 2002) that includes information on tides, storm sechies etc. Some authors investigate nutrient loads, main physical and chemical parameters (VUKADIN, 2002; 2003 – see **Marine Chemistry** category too), and calculated influence on individual areas and aquatic systems. Simulations with numerical modelling (BEG-PAKLAR *et al.*, 2007), can help in exploitation, investigation and protection of marine resources. XBT data indicates thermal fronts and upwelling effects (MOROVIĆ *et al.*, 2007) on the East coast of the Adriatic Sea. Mathematical models of the atmosphere and the hydrosphere help for weather predictions based on current weather data (CHYBICKI *et al.*, 2011). Developer solutions are applicable for various industry sectors including energetic, logistics but also administration, security and safety of navigation.

In category of **Marine Fisheries** 2 articles were analyzed. Marine and freshwater fisheries (MIŠURA *et al.*, 2004) were distinguished as important for the Republic of Croatia. GIS tools and new laws will lighten monitoring of commercial and non commercial fishing. Demersal fishing activities are especially important on the east coast of the Adriatic Sea, because there are main habitats (VRGOČ *et al.*, 2005).

CONCLUSIONS

The result of the twenty years of mostly Croatian-Polish scientific cooperation in the field of GIS is in 879 articles in 27 book publications, an important scientific achievement. The total of 38 articles raising the issues of GIS application in the marine sciences subject of research, the aim of which was to determine the directions of research being conducted. The outcomes of such analysis allowed the conclusion that these studies were of multi-faceted nature, with research facilities including both elements scientific and technological. The research was largely focused on thematic categories such as: marine policy strategy, marine engineering, marine biology, and marine physics. There are

only two articles connected with marine fisheries and marine chemistry, even both topics are very important for inland sea like the Adriatic.

The authors of the most articles connected with marine science, especially Adriatic Sea are Croatian. That means future conferences should be more connected with exchanging of knowledge about different seas.

The main aim of this GIS scientific conferences was to introduce young and good scientists to the experienced, make connections and possibility of cooperation. From this point of view, this meeting were one of the best place. Some papers from a different fields were prepared as a high level scientific research and could be accepted by any important international journal. From the previous work on the common mainly Croatian-Polish cooperation, it is obvious that this kind of scientific conference needs more instructions which topics and fields are expected to be analysed. Also suggestion is to call invited lecturer with main topic. That approach will improve lecturers from more countries. This could be the future for this GIS conference, with indication that this new postulate after 20 years of experience can be achieved in a short time.

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Postignuća u znanosti o moru tijekom hrvatsko-poljske GIS suradnje (1994-2013)

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SAŽETAK

Rad daje pregled obavljenih istraživanja u području znanosti o moru upotrebom GIS alata, nastalih tijekom 20-godišnje Hrvatsko-Poljske suradnje u području primjene zemljopisnih informacijskih sustava. Rezultirajući opus uključuje, između ostalog, znanstvene radove koji su izloženi na dvadeset međunarodnih skupova organiziranih u okviru gore spomenute suradnje. Ovdje je dat pregled radova objavljenih u razdoblju od 1994. do 2013. godine. Odabrani radovi su klasificirani po prihvaćenim tematskim područjima, u sklopu kojih su kategorizirani i analizirani po temama. Većina se radova u sklopu šest prihvaćenih tematskih područja bavila: strategijom zaštite mora, pomorstvom, biologijom, fizikom i kemijom mora te ribarstvenom problematikom.

Ključne riječi: znanosti o moru, upravljanje morem, GIS tehnologija, hrvatsko-poljska suradnja