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**The maritime hydrography:
a kind of human activity and special maritime service;
the maritime profession and field of higher education
and branch of science**

In this paper, the issues of today's maritime hydrography and its state are discussed. The substance of maritime hydrography and its state of development are presented. The maritime hydrography is shown and discussed from three different points of view: as the kind of maritime human activity and special maritime service; as the maritime profession and field of undergraduate and graduate education, and as the branch of science.

INTRODUCTION

In Poland, there exist two different terms regarding hydrography; these are: a) "hydrography" and b) "maritime hydrography". As a rule, only the term "hydrography" is specified in Polish language's sources. According to such sources as encyclopedia, etc. the term "hydrography" is considered as the science that deals with the water as the element of the geographic environment. It comprises the registration, description and analysis of the waters relations on the Earth in dynamic formulation, and in close connection with the other elements of the geographic environment.

However, the term "maritime hydrography" does not exist at all in English language; whereas the notion of the term "hydrography", in that language, is inseparably connected with the maritime navigation. Therefore, it corresponds with the notion "maritime hydrography", in Polish language.

It should be emphasized that in Polish language sources, such as language dictionaries, encyclopedia, etc. the term "maritime hydrography" does not exist. It is the result, that Poland's history and tradition were always land-oriented. The Poland never was the maritime nation.

Taking into account the above semantic considerations, we decided to use, in this paper the term "maritime hydrography" in order not to cause the misunderstandings in Polish readers to whom this paper, in great extent, is also addressed. However, to avoid the misapprehension in foreign readers, we had to give the above explanations.

This paper discuss the following issues: basic definitions and explanations regarding the subject “maritime hydrography”; the maritime hydrography as the human activity and special maritime service; maritime hydrography as the profession and field of higher education, and maritime hydrography as the branch of engineering science.

1. *The maritime hydrography; basic definitions and explanations*

The hydrography originated yet in ancient times and comprised then the description and mapping of all waters near the surface of the Earth. However, the former aspects of the hydrography became in last centuries the subject of study of other sciences such as hydrology, oceanography and climatology. Therefore, the present meaning of the term “hydrography” is understood primarily as the description and charting of the coastal maritime waters for the aid of navigation. So, the description and charting of the coastal waters for the aid of navigation constitute the main, subject of the maritime hydrography.

The more exact definition of the “maritime hydrography” is the following:

the “maritime hydrography” is the science that studies the physical properties of the maritime coastal areas from navigation point of view, as well as the ways and means of acquisition, processing and use of the hydrographic information for ensuring the safety of navigation and facilitating the exploration of the seabed resources.

The hydrographic information is a kind of geographic information that describes the coastal maritime areas from navigation point of view. The basic content of the hydrographic information constitute the following data: depths and seabed configuration; kinds of bottom grounds and sediments strata; wrecks and underwater obstacles; tides and tidal currents; magnetic variation; features of sea coast; sea ways characteristics; characteristics of harbours approaches and entries; aids to navigation and their features.

The hydrographic information is not only the constituent part of the geographic information but also the constituent part of the information of geographic environment of maritime navigation. This can be expressed as follows:

$$\{Hgin\} \subset \{Envi\} \subset \{Gein\},$$

where:

{Hgin} is the set of hydrographic information;

{Envi} is the set of information of geographic environment of maritime navigation,

{Gein} is the set of geographic information.

Maritime hydrography, as all the other applied sciences, can and should be also considered as:

a) the kind of the human activity carried on mainly by the special maritime services, i.e. the “hydrographic services” that as a rule, are the governmental services, and are supervised by the navies,

b) the kind of the maritime engineering profession, i.e. a kind of occupation requiring advanced education and training and involving intellectual skill, as medicine, law, engineering, teaching, etc. Therefore, the maritime hydrography can and should be also considered as the

field of teaching carried on by the hydrographic faculties of the colleges and universities (polytechnics).

c) the branch of the engineering science that studies the subject of maritime hydrography and works out the proposals regarding the best employment of means and tools of the maritime hydrography, as well as proposals regarding acquisition, processing and use of the hydrographic information for ensuring the safety of navigation and facilitating the exploitation of sea-bed resources.

2. The maritime hydrography as the kind of human activity and special maritime service

In the early stage of navigation's development, and even in the Middle Ages, the safety of navigation was only a matter of the shipmasters, ship owners and ship companies. The hydrographic information was considered as the State's top secret matter.

In the late period of the Middle Ages, and later, in the Renaissance period, there existed (first in Mediterranean countries, and later, in Netherlands, England, etc.) many cartographic workshops that provided with charts the Mediterranean ships and later ships of such companies as Hanseatic League, West – Indian companies (mainly Spanish) and East – Indian companies (mainly Dutch and English). However, in these days, did not exist the official organized institutions, except harbour authorities and pilot associations, that also looked after the aids to navigation, coming then into being. Such institution was, well known, Trinity House, founded in 1517. However, until XVIII century did not exist official institutions that surveyed the coastal waters, especially approaches to the main harbours, and prepared charts and other nautical publications.

The governmental hydrographic services begun to come into being only in XVIII century. As first, the hydrographic service was established in France in 1720 (De Deport des Cartes et Plans de La Marine). However, the field works were carried on only after 1780. By the end of the XIX century, the hydrographic services came into being almost in all main maritime countries. As a rule, they were a part of Naval Forces.

In Poland, the hydrographic service was established only in 1920, i.e. two years after obtaining the State's independence. In 1921 The International Hydrographic Bureau was founded. Since 1970, its new title "The International Hydrographic Organization" (IHO) come into effect. The main objective of IHO is standardization of the ways and means of the hydrographic activities in the whole world.

The content and scope of the today's hydrographic activities, carried on by the hydrographic services, can be expressed as follows:

a) surveying and description of the maritime areas, together with the adjoined coastal zone and with the elements of the maritime environment that are important for maritime navigation;

b) processing the hydrographic data into charts and nautical publication in the forms most suitable for their use by seafarers;

c) maintaining the nautical and hydrographical information in the up-date state.

Besides the above activities, being at the same time, the main tasks of the hydrographic services, the last ones carry on also the two additional tasks:

d) providing the geographical support of the naval forces,

e) providing for the hydrographic support to exploration and exploitation of the seabed resources.

The hydrographic services provided for safety navigation almost for three centuries. However, only now (2000), the responsibilities of hydrographic offices, towards safety of navigation has been established by the International Convention on Safety of Life at Sea (SOLAS 74). The Regulation 9 (Hydrographic services) of chapter V (Safety of navigation) of SOLAS 74 Convention, that should enter into force in July 2002, put the Contracting Governments, under the following obligation:

to arrange for collection and compilation of hydrographic data and the publication, dissemination and keeping up to date of all nautical information necessary for safe navigation.

The above-mentioned Regulation 9 provides also that the Contracting Governments should “co-operate in carrying out as far as possible the following nautical and hydrographic services, in the manner most suitable for the purpose of aiding navigation:

- a) to ensure that hydrographic surveying is carried out as far as possible, adequate to requirements of safe navigation,
- b) to prepare and issue nautical charts, sailing directions, lists of lights, Tide Tables and other nautical publications, where applicable, satisfying the needs of safe navigation,
- c) to promulgate notices to marines in order that nautical charts and publications are kept, as far as possible, up to date,
- d) to provide data managements to support these services”.

The hydrographic services have today to their disposal many very modern tools and means. The most important of them are modern hydrographic ships and boats, equipped with the various modern and efficient hydrographic systems for sea surveying and data processing.

It should be stressed that the surveying tools have overcome very long development and improvement way, i.e. the way from the sounding poles and leadlines to very modern echo sounders and sonars.

The following types of echo sounder and sonars are most representative, i.e. widely known and used:

- a) monochromatic one beam echo sounders,
- b) monochromatic multibeam echo sounders,
- c) side-scan sonars,
- d) search sonars,
- e) mixed echo sounders,
- f) two and more frequency echo sounders,
- g) parametric echo sounders,
- h) chirp sonars,
- i) aerial lasers, and others.

The most modern and most promising surveying system is the monochromatic multibeam echo sounder. It is called also as multibeam array sounder. In fact, it is echo sounding system. There is a wide variety of such systems. They can incorporate from 2 to 180 beams that are transmitted from one or two transducer arrays. The angular coverage sectors, i.e. the beam sectors, range from about 60 to 160 degrees, and even more. These soundings systems provide high precision mapping with 100 percent coverage. The width of the swath can reach 8 depths.

The second very important part of hydrographic services are the today’s hydrographic database management systems, as well as the cartographic and typographic equipment and systems.

All these, highly computer-aided systems, are used in editing and issuing process of modern nautical charts and publications produced also in great part in digital form. The traditional, i.e. the paper nautical charts and publications are superceded by the maritime Geographic Information Systems (GIS) such as Electronic Chart and Display Information Systems (ECDIS), and others.

The above-mentioned, as well as many others not-mentioned modern hydrographic tools and means express the hard fact that the “information age” did not omit the maritime hydrography but, on the contrary, it firmly entered the space of maritime hydrography.

The third main component of the hydrographic services constitutes the hydrographic personnel. Besides the ships and boats maintaining personel, all other hydrographic professionals must possess the special undergraduate or graduate education. It means that they must possess the bachelor- or master-degrees in field of maritime hydrography.

3. The maritime hydrography as the profession and field of higher education

Maintaining and operating the hydrographic services needs the well educated professionals, i.e. the people who possess the advanced professional education and training for carrying on the hydrographic activities.

The requirements and standards regarding the content, scope and level of the hydrographic education are in great extent specified by the International Hydrographic Organization (IHO) and International Federation of Surveyors (FIG).

Now, generally, two levels of hydrographic education area carried on ; this is:

- a) bachelor- degree level ,
- b) master-degree level.

There are also two levels of hydrographic specializations:

- a) class B – lower level,
- b) class A – higher level.

Class A courses are taught both on the bachelor and master-degree levels. They prepare the professionals not only for performing but also for managing the hydrographic processes both while sea surveying and while transforming the hydrographic data into the nautical charts and publication.

It should be stressed, that appears now the new tendency in hydrographic profession and education. The hydrographic specialization began to compliment the other maritime specializations, such as “maintaining the navigation’s infrastructure and handling the aids to navigation”, and other specializations.

The hydrographic education on bachelor-degree and master-degree levels are carried on, among other things, by the following educational institutions:

- a) faculties of applied marine sciences,
- b) faculties of underwater sciences,
- c) faculties of the physical sciences, (e.g. University of Plymouth),
- d) departments of hydrography (e.g. Amsterdam Polytechnic), and others.

In Poland, the hydrographers are taught:

- a) in Naval Academy (Department of Navigation and Naval Weapons, Institute of Navigation and Hydrography),
- b) in Maritime Academy, Szczecin (The Department of Navigation).

The demand for hydrographers is permanently growing. And it is not only the result from the growing demand of hydrographic services but mainly the result from the growing new maritime industries that are now coming into existence.

The maritime human activities, both military and economic, are going under sea surface, to the sea bottom, and even lower, especially in the coastal areas. The above truth confirms the permanent growth of exploration and exploitation of sea-bottom resources such as crude oil, gas and other mineral deposits. But also the sport and tourist activities are going under sea-surface. Also such activities as underwater archeology and similar research activities are also now rapidly developed.

The hydrographic information, especially regarding the sea-bottom configuration; kinds of grounds; ground sediments and their structure; underwater obstacles, etc. are highly demanded for the following maritime engineering activities:

- a) geophysical investigations,
- b) geotechnical investigations and wells drillings,
- c) off-shore platform constructing,
- d) pipe and cable laying,
- e) dredging,
- f) searching and removing the underwater obstacles, and others.

Taking into account the above facts, it can be concluded that the hydrographers besides the hydrographic services, are also highly demanded by the following institutions:

- a) maritime administration and harbours authorities: for permanent monitoring the depths in harbour-approaching areas, in harbours and in the coastal zones,
- b) maritime-engineering companies: for carrying on the precise surveying and charting the areas where the off-shore engineering works are being performed,
- c) mineral-exploitation companies: for monitoring the underwater infrastructure, and others.

As was already mentioned, that the maritime hydrography, besides the hydrographic services, where the traditional maritime hydrographers are still highly demanded, is getting also to be the constituting part of the following maritime activities:

- a) maintaining the navigational infrastructure and handling the aids of navigation,
- b) exploration and exploitation of coastal seas and EEZ,
- c) coastal zone engineering and management,
- d) underwater search, survey, rescue, and others.

It means that there are coming into being the new kinds of maritime human activities and, therefore, the new kinds of maritime engineering professions whose main component constitutes the maritime hydrography.

In general, the maritime hydrography curricula of undergraduate and graduate studies should include the following fields of teaching (Tab.1):

The most important fields of teaching of maritime hydrographers curricula are two teaching subjects, these are:

- a) sea surveying,
- b) land surveying.

The curricula of these teaching subjects should be built according to the following scheme:

- a) laws, regulations and requirements, of IHO and IMO, as well as State's standards regarding this kind of surveying,
- b) equipment and systems of this kind of surveying,
- c) theory of surveying process,

- d) procedures of carrying on the surveying process,
 e) data acquisition, recording, adjusting and processing.

T a b l e 1. The basic fields of teaching of the curricula of "maritime hydrography" for bachelor-degree level

No	The substance of the field of teaching
1	Basic statistics and adjustment calculus
2	Fundamentals of atmospheric sciences
3	Hydrographic information and geomatics for hydrographers
4	Fundamentals of maritime navigation
5	Fundamentals of hydroacoustics and underwater search and survey
6	Fundamentals of hydrodynamics and the geomorphological processes in the coastal zone
7	Geodesy, cartography and GIS
8	Precise positioning systems
9	Tidal theory
10	Sea surveying
11	Fundamentals of photogrammetry, remote sensing and image processing
12	Land surveying
13	Hydrographic information management and systems
14	Hydrographic services and ways of aiding navigation
15	Project on: a) hydrographic surveying, or b) land surveying, or c) data base and ENC in ECDIS, or d) data base and management of GIS for non-ship users, and other similar projects

The above presented hydrographer's curricula regard mainly the basic hydrographers' specialization, i.e. the specialization of hydrographers who are going to be employed in hydrographic services. The competences of these hydrographers must comprise:

- a) planning and carrying on the survey works both with the traditional means and ways and with the modern hydrographic equipment and systems,
- b) transforming the hydrographic data into the main hydrographic products, mainly, nautical charts, using both the traditional means and modern hydrographic information management systems.

The above given curricula regard mainly the bachelor-degree level. The curricula for master-degree level should also provide the teaching subject regarding:

- a) planning the survey operations with cost-effect evaluation;
- b) management of surveying operations,
- c) management of the hydrographic institutions,
- d) evaluation of hydrographic activities with the management evaluation methods.

It means that the above – given curricula (Tab. 1) must be complemented with the law and economic issues regarding the hydrographic services institutions.

And the last question regarding the hydrographic profession and hydrographic curricula. The hydrographic profession as many other marine engineering professions, requires very profound training, including the field practices. The traditional training cannot be superseded

by the simulators deployment. The needed simulators almost do not exist because cost-effect calculations do not justify their use. It is the result that the hydrographic students are not numerous. Therefore, the hydrographic training must be carried on in traditional way. However, the modern highly computer-aided equipment and systems must be fully applied.

4. *The maritime hydrography as the special branch of science*

The maritime hydrography for very long time, after establishing the hydrographic services, i.e. almost until the half of the last century, was considered as a craft and art. The term “craft” means the occupation that requires the special skill of manual arts. In this case, the skill of chart making. The term “art” means the branch of creative work, esp. painting, drawing, or work in any other graphic or plastic medium.

There exists a lot of definitions of the term “science”. We take out only two of them that, in our opinion, very well specify the notion of the term “science”.

The first, very general definition of the term “science” is the following:

Science: systemized knowledge derived from observation, study and experimentation carried on in order to determine the nature or principles of what is being studied.

The second definition of the term “science”, that very well suits to all applied sciences and therefore, to maritime hydrography, is the following:

Science: it is such branch of teaching that fulfils the following requirements:
a) *possesses the specific knowledge domain;*
b) *possesses the own research subject, i.e. research area,*
c) *possesses the specific research methods,*
d) *possesses the qualified research personnel,*
e) *possesses the internationally recognized research achievements.*

We will try to show that the maritime hydrography fulfils all the above requirements. We will also try to identify and specify these requirements in regard to maritime hydrography.

The maritime hydrography is now, not only in our country but also in many European countries, the profession that needs the higher professional education and, therefore, it is the field of undergraduate and graduate education.

The maritime hydrography is the engineering science, supportive to navigation that very closely co-operates with the following branches of science:

- a) geodesy, cartography and geomatics,
- b) oceanography,
- c) hydroacoustics,
- d) geology and geomorphology,
- e) geophysics,
- f) remote sensing,
- g) marine civil engineering, and others.

The knowledge domain of the maritime hydrography is given in record of teaching issues constituting the curricula of maritime hydrography (cf.Tab.1). Therefore, there is no reason to present it once again.

The subject of the maritime hydrography, as a branch of science, was also already presented (cf. section 1 of this paper). However, because of its importance for discussed question, it is repeated below:

Maritime hydrography is the science that studies the physical properties of the maritime coastal areas from navigation point of view, as well as the ways and means of acquisition, processing and using of the hydrographic information for ensuring safe of navigation and facilitating the exploitation of the seabed resources.

As was mentioned in the section 2 of this paper, the main activity areas of maritime hydrography are the following:

- a) surveying and description of the properties of the coastal maritime areas from maritime navigation point of view,
- b) processing the hydrographic data into the nautical charts and publications,
- c) maintaining the process of updating the nautical and hydrographic information,
- d) providing geographical support of naval forces,
- e) providing for the hydrographic support to exploration and exploitation of the sea-bed resources.

Taking into account the above facts, the main research areas of maritime hydrography can be specified as follows:

- a) *study the properties and characteristics of the hydrographic equipment and systems and working out the proposals regarding the best variants of their deployment in accordance with the properties of the surveying tasks,*
- b) *study the ways and tools of the processing the hydrographic data and working out the proposals regarding the best ways of satisfying the needs of safe navigation by the hydrographic final products, such as nautical charts and publications, including their digital forms,*
- c) *study the maintaining process of updating the nautical and hydrographic information and working out the proposals regarding the improvement of efficiency of this process,*
- d) *study the needs of naval forces for the special kinds of additional geographic information and working out the proposals regarding the best ways of geographic support of naval forces,*
- e) *study the needs of exploitation and exploration industries for new kinds of hydrographic information and working out the proposals regarding the best ways of hydrographic support of maritime industries exploiting the seabed resources.*

The maritime hydrography possesses its own research methods. Most important of them are the following:

- a) observation/data gathering, and mathematical methods of its processing and reasoning,
- b) experimentation and testing,
- c) mathematical modelling and computer-aided simulation,
- d) logic inference, and others.

The maritime hydrography possesses the qualified research personnel. In case of our country, the hydrographic research personnel is collected mainly in the Institute of Navigation and Hydrography that was funded in the period from 1973 to 1981. In other countries, the hydrographic research personnel is concentrated in the hydrographic departments of the proper higher education institutions or even in the Governmental Hydrographic Research Institute (St.Petersburg).

The hydrographic research personnel possesses also the internationally recognized research achievements. These achievements are being presented during the national and international conferences, and in the national and international hydrographic journals.

This way, we have presented the maritime hydrography, its substance and tasks. We also described and presented the maritime hydrography as the kind of human activity and special maritime service; as profession and field of undergraduate and graduate education; and as the branch of applied science.

The maritime hydrography, as many other professions and applied sciences, undergoes now the changes being the result from rapid development of information technology, including the tools and means of data acquisition, processing and use.

The main trends of maritime hydrography development, as was already mentioned, manifest themselves in the merging the maritime hydrography into new professions and sciences whose main components is the maritime hydrography; these are:

- a) maintaining the navigational infrastructure and handling the aids to navigation,
- b) exploration and exploitation of coastal seas and EEZ,
- c) coastal zone engineering and management,
- d) underwater search and rescue, and others .

Nonetheless, the traditional maritime hydrographic profession, i.e. the profession that aids the maritime navigation, is not endangered in the foreseeable future.

However, its tools and means will be permanently improved and changed.

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Received May 29, 2001
Accepted October 24, 2001

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Hydrografia morska jako rodzaj działalności ludzkiej, zawodu morskiego i dyscypliny naukowej

S t r e s z c z e n i e

W artykule przedstawiono rozważania dotyczące hydrografii morskiej i jej obecnego stanu. Przedstawiono zakres hydrografii i jej rozwój. Hydrografia morska przedstawiona jest w trzech aspektach: jako rodzaj działalności ludzkiej i specjalnego serwisu morskiego, jako zawód morski i rodzaj kształcenia studentów oraz jako dyscyplina naukowa.

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Морская гидрография – вид деятельности человека, морская профессия и научная дисциплина

Р е з ю м е

В статье рассматривается современное состояние гидрографии. Гидрография обсуждается в трёх отношениях: как вид деятельности человека и морской сервис специального назначения, как морская профессия и вид обучения гидрографии, как научная дисциплина.