# IMPROVING HUMAN LIVING USING BATHYMETRIC METHODS

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***Abstract**: The continuous technological improvement in bathymetric equipment, positioning capacity, data processing, as well as the development of new ways of depth determinations and exploring the submerged relief, have been noticed in recent years. There are multiple techniques, more or less precise, used for depth surveying. Among these, acoustic and radio bathymetry are most widely used. Survey systems can be autonomous or mounted on various platforms and also can provide different accuracies. If GNSS data is correlated with the bathymetric survey systems, the results have improved accuracy. Additionally, optical methods (based on active or passive sensors) can be used for depth surveys. Comparing to topography, even despite the multiple bathymetric methods and their usage, underwater still remains uncertain or unknown. Though, administrative decisions based on bathymetric data include maritime or nautical navigation safety, coastal spatial planning, environmental protection, underwater exploration, research and monitoring, and not least underwater resources exploitation. A better knowledge and understanding of the underwater relief could lead human to reduce water pollution, and therefore, to a better life.*

***Keywords:** bathymetric survey; underwater relief; digital bathymetric model; underwater mapping*

## 1. Introduction

More than two thirds of our planet's surface are covered by water. Water bodies help to regulate mass and energy transfer between biosphere, lithosphere, and atmosphere, therefore the human need for a better knowledge and understanding of the underwater relief. The term „bathymetry" originally referred to the ocean's depth relative to sea level. Later, it began to be used to define generally the "submarine topography", or underwater relief. As topographic maps represent the three-dimensional features of the terrain, bathymetric maps represent the three-dimensional features of the underwater terrain. For the underwater relief, the general term "seabed" is used [1], [2].

Bathymetry is part of hydrography, dealing with depth surveying and physical features measurements of a water body [3].

Underwater surveys are carried out in order to draw up bathymetric maps, produced to support maritime or nautical navigation safety, and represent the seabed for studying unique underwater ecosystems, extracting valuable minerals via (deep) sea mining or estimate the water pollution level [4].

Bathymetric mapping presents a great importance in fields like [5]:

- drawing up nautical charts for navigation safety;
- water volume computation;
- pollution control;
- mineral and fish industries;

- underwater engineering construction;
- harbor and docks construction and maintenance.

## 2. Materials and Methods

Water is one of the most important resource for human life. The ocean regulates climate, absorbing $CO_2$ produced by human activities, releasing instead oxygen storing a large amount of the extra heat. Waters are an important source of food for humans, but unfortunately overexploited. Waters offers jobs in different fields, such as transportation, pisciculture, goods and services etc. [2].

Therefore, human activities have a great impact on the underwater world. Human impacts on the seabed (Fig. 1) can be divided into two main categories [2]:

- harmless impacts, including exploration, research and monitoring: to map the seabed, ships use bathymetric technology to map water depths throughout the world. Submersible vehicles help researchers study unique seabed ecosystems such as hydrothermal vents;
- harmful impacts, including exploitation and water pollution, by human activity, mining and dredging operations. Plastic pollution is a global phenomenon. Exploitation of the seabed involves extracting valuable minerals via deep sea mining, as well as dredging materials from shallow waters.

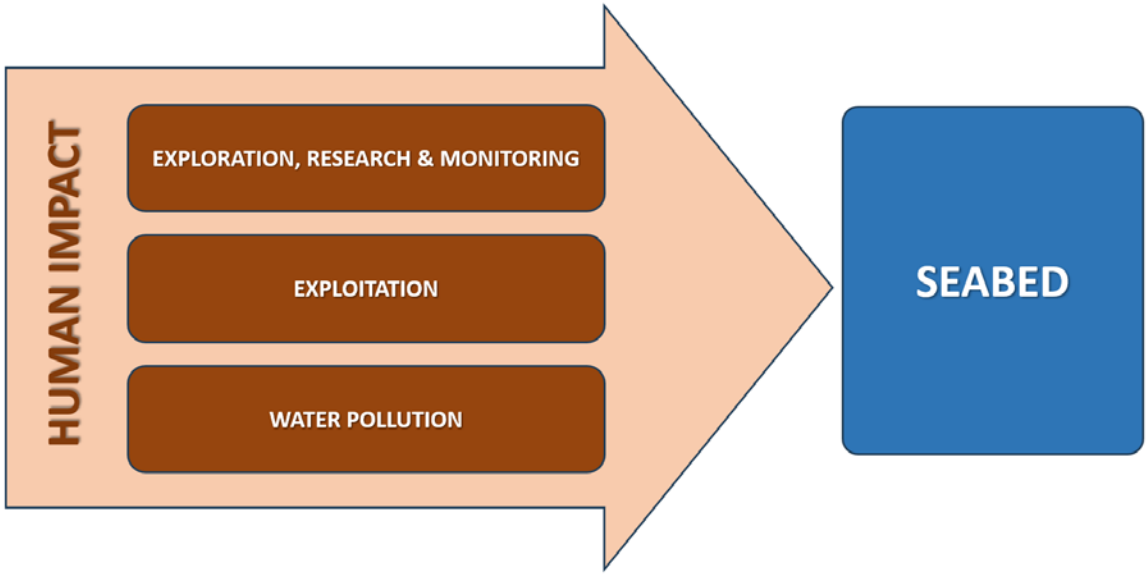


*Fig. 1. Human impacts on the seabed*

While the first attempts to discover the underwater relief referred to single point surveys using hydrometric gauges, modern technologies brought surveyors a series of complex bathymetric equipment and methods, leading to a better accuracy and efficiency.

Depending on the main goal and the type and depth of the water body to be surveyed, there are different bathymetric surveying methods, based on acoustic, optical and radio pulses and their propagation through water (Fig. 2) [2].

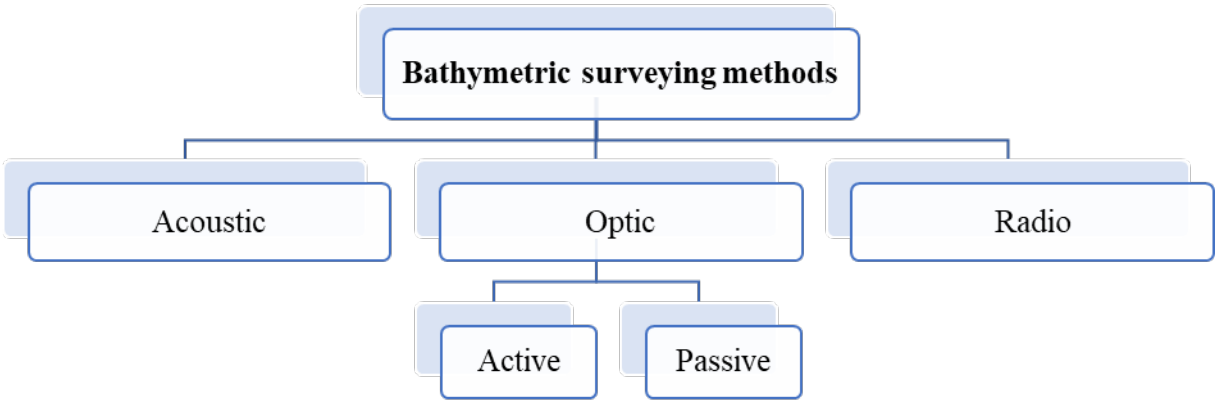


*Fig. 2. Bathymetric surveying methods*

Usually known as echo sounders or sonars, acoustic sensors are used for depth measurements. They emit short sound pulses, which are reflected by the relief on the bottom of the water. The distance from the surface to the seabed is determined by measuring the delay time of the reflected acoustic pulse. Currently, data acquisition via echo sounders use a series of parameters, such as sound velocity, conductivity, temperature and even moving vessels profiles [5], [6], [7], [8].

Optical methods use the light propagation through the water for depth determinations. This method is successfully applied in coastal areas, in shallow waters (less than 60m depths). Despite the poor propagation of the electromagnetic waves through the water, these methods can be successfully used in bathymetric surveys especially where acoustic methods have limitations. The main advantage of applying optical methods refers to the surveying efficiency. The active optical method is similar to the acoustic method, but uses different wavelengths LiDAR systems. The bathymetric equipment is usually mounted on vessels on the water surface, or on an airborne. This method is suitable in case of slightly deep waters, no more than 60m. Beside depth determinations, also shore height determinations are possible, being considered the most productive method for bathymetric mapping in shallow water. Passive bathymetric surveying methods use natural light in depth determinations. Measurements of the amount of reflected light are carried out from aerial or spatial platforms, such as aircrafts or artificial satellites. The color and composition of the waterbody bottom, as well as the water turbidity may influence the surveying accuracy; therefore, it is suitable for shallow waters, no deeper than 30m and the refracted light beam should be corrected first. Beside photographic limitations, the main limitation in case of passive methods is the depth. [5], [6], [7], [8]

Radio bathymetric methods, also called gravimetric bathymetry, use radar equipment mounted on artificial satellites, correlated with sensors on board and on the ground. The distance from the satellite to the water surface is measured. Bathymetric mapping using radio methods is based on the fact that the water surface is slightly raised where there are seabed massive relief structures. The rises, too small to be seen, can be measured accurately by a radar altimeter mounted on an artificial satellite. The advantage of this method consists in the fact that it can be applied not only along the maritime routes, but anywhere on the water surface, so that large areas are covered and can be mapped. [5], [6], [7], [8]

Many bathymetric exploration, research and monitoring programs were developed lately, mainly because of the human need to [5]:

- discover and improve new marine wealth, considered to be the future source for innovation and progress;
- a better understanding of the oceanic functions and their importance in human life;

- people awareness about the vulnerability of the oceanic ecosystems;
- responsible use and conservation of ocean resources;
- take actions for environmental protection.

## 3. Results and Discussion

Research and monitoring of the underwater world cover a wide spectrum of scientific fields and enables scientists to discover and improve new underwater resources that could be a source of innovation and progress in the future. Accurate information and educational programs allow a better understanding of the water functions. The main objectives are to inform the public about the vulnerability of the underwater ecosystems, take actions for environmental protection and responsible use and conservation of the underwater resources [5], [9].

The world's largest single earth observation programme is Copernicus, coordinated by the European Commission, implemented by European Space Agency and EU member states. It aims at achieving a global, continuous, autonomous, high quality, wide range Earth observation capacity. The information is given by a constellation of several satellites, Sentinels, correlated with data measured on the ground. The main goal of the programme is the assessment and management of water resources and the environment, by surveying the water bodied surface, the amount of micro-algae in suspension, temperature, ice cover etc. Therefore, identification of polluted areas becomes much easier [10], [5], [11].

Applications of the radio bathymetry could be [5]:

- navigation;
- prediction of seafloor depth;
- planning shipboard surveys;
- plate tectonics;
- undersea volcanoes;
- petroleum exploration;
- lithospheric structure.

Radio bathymetry presents a series of advantages, such as [11]:

- cost-related: more cost-efficient bathymetric assessment, requiring no expensive field surveying or equipment; it can also be applied in developing countries with limited resources;
- scale-related: available for remote and inaccessible areas for accurate and consistent bathymetric mapping, avoiding scattered information in time and space (some areas being more intensively surveyed than others and less easily accessible areas being typically under-surveyed);
- location-related: bathymetry surveys are crucial for delineation of borders, therefore the political dimension; quicker to delivery than traditional methods.

A multifunctional marine research ship, called Mare Nigrum, carries out its activity in the Black Sea, being involved in research and monitoring European projects. It provides various research activities in the fields of geology and geophysics, marine biology and ecology, being equipped with modern research equipment (bathymetric multibeam, seismo-acoustic, magnetometric, gravimetric equipment, various sensors etc.). Mare Nigrum has been involved in over 2400 scientific expeditions in the Black Sea: exploration campaigns in Romania's national waters (high-resolution geophysical surveys and geological surveys) and in international waters (Bulgaria, Georgia, Ukraine, Turkey) [12].

Bathymetric researches can help humans to protect the Earth, by [3]:

- proper resources management: reduce, reuse and recycle to conserve natural resources and landfill space;
- a better environment: volunteer for cleanups and protecting the watershed;
- education: help people understand the importance and value of natural resources;
- water conservation: use less water, generate less runoffs and wastewater;
- sustainability: make smart choices for people and environment (seafood, energy, green solutions, reduce pollution etc.).

## 4. Conclusions

Bathymetry and its usage have progressed rapidly in the last century due to the development and improvement of underwater surveying techniques (acoustics, optics and radar). Thou, most of the underwater world is still not enough and accurate researched or even unknown [5].

Due to the less accurate acquisition methods via radio bathymetry comparing to other methods, acoustic bathymetric surveys are required to validate gravimetric bathymetry in remote regions of the world [5].

On coastal stations there are mounted marine radar systems, used in nearshore bathymetry. The technique was recently expanded for radar measurements collected on moving vessel improving the accuracy [5].

Extracting and using bathymetric information presents the following features [5]:

- large surface coverage in case of passive optical and radio methods;
- low-cost surveying;
- there can be detected and quantified even subtle and detailed underwater seabed formations using acoustic and optical methods;
- optical methods are more suitable in case of expansive coastal areas instead of costly echo sounding and airborne LiDAR surveys;
- satellite optical bathymetry is more suitable for remote areas and developing countries;
- optical methods are dependent on the water clarity, but susceptible to error with murky water;
- there is a disturbing restriction, referring to the limited water depth that can be measured, due to the fact that optical light cannot penetrate even pure water for a depth more than 40m.
- bathymetric representations can help scientists determine where underwater ecosystems are located and how they work, and to assist the conservation and monitoring of the coral habitats;
- autonomous vessels are useful and advantageous for offering bathymetric survey services, characterized by safety and low costs
- the use of a USV (Uncrewed Surface Vessel) also has a smaller carbon footprint when compared to conventional vessels;
- in order to carry out a high-resolution survey via acoustic methods, lines with overlapping tracks must be run;
- because the acoustic beam is narrower in shallower water, more tracks are required, therefore acoustic systems are not ideal for tasks in coastal areas. However, acoustic methods can be used throughout all oceanic depths from shallow estuaries to the deepest trenches.

Given its high potential, actual and future concerns turn to the radar altimetry, for finding out methods to determine higher accuracy for deeper seabed. Mathematical computations and modeling of the bathymetric surveys could also improve the accuracy.

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