IN SITU MEASUREMENT OF BASIC PARAMETERS OF THE MARINE WATERS USING CTD SYSTEMS

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In situ monitoring of sea water parameters using CTD (conductivity, temperature and depth sampler) or extended multisensor platforms are modern alternatives to classic laboratory - based analysis. This paper describes the methodology used for assembling isoconcentration profiles of some basic parameters of the sea water using CTD in situ measurements. Data were collected during on-site measurements in some protected areas at the Romanian Black Sea border. The monitored parameter values were processed by ODV (Ocean Data View) software in order to obtain specific isoconcentration maps that reflects the variation of these parameters in horizontal and vertical section. The final representative image of the surface parameters spreading for these profiles were obtained by the superposition with a proper georeferenced satellite map view of the screened area.

Keywords: CTD, water parameters, isoconcentration profile

1. Introduction

Seawater is an essential part of the ecosystem, but its effects on humans, plants and animals were not considered to be significant in the past. The measurement of the physical properties of seawater, such as: temperature, salinity, depth and other sensor-based parameters is outstanding for the investigation of the marine environment [1]. Conductivity, temperature and depth (CTD) sensors are

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the main on-site analysis tools for those parameters, offering important data about oceanic circulation and climate processes [2].

Various high accuracy CTD sensors are commercially available, in quite bulky configurations [4], but the further developed compact systems were often considered erroneous or energy - demanding [5]. The next generation of miniaturized, high-accuracy CTD sensor interfaces and multisensor platforms has set new opportunities for the study of oceans and climate changes [6], allowing the establishment of several CTD sensors networks [7]. Undersized, low-powered CTD sensors became strategic devices used for autonomous instruments like moored profiler, gliders, profiling floats and autonomous underwater vehicles (AUV's) [3].

Several derivate units like salinity and density are based on the conductivity measurements, in correlation with the appropriate temperature and pressure values. The exact measurement of small temperature and salinity differences was the topic of interest for both CTD developing teams, and the final users - oceanographic scientists [8]. CTD ship-based operations involve expansive scientific expeditions, several crane-driven sampling deployments at precise coordinates (several ships stops and as possible, drift-less sampling) and generally higher spatial coverage and lower resolution images than those using autonomous vehicle operation (AUV). The main drawback of AUV sampling is related to significantly less spatial coverage (due to battery operation time) comparing to ship deployment. One of the last years' technical solution is related to CTD installation on glider devices (more than 2-months autonomy). In most of the situations, the sea medium parameters are collected mostly up to upper 50 m [9], but almost recent studies are using bottom profiles. Several software platforms were developed to provide specific profiling data up to maximum depth for any specific location using the available historical data [10]. An interesting approach for ocean temperature data collection is related to the use of diving marine predators as carrier for a small data acquisition system and a satellite-positioning transmitter to provide three-dimensional oceanographic information [11]. The CTD system can be used to profile a body of water in several different working modes: incremental mode (like pressure increment mode – ascending / descending or both incremental modes), continuous data acquisition, time series or other horizontal / vertical continuous profiling modes. Each CTD sensor data flow is processed through dedicated computer software by the built-in microcomputer and stored in the CTD memory. To obtain the final results, a data link with an external computer is required, usually at the final of the screening session [12]. Temperature and salinity are two of the most important basic water parameters which determine the characteristics of the sea water column [13], always a requirement for any study of major climatic/physical process.

This paper describes the methodology used for assembling isoconcentration profiles of some basic parameters of the sea water using CTD in situ measurements. Data were collected during on-site measurements in some protected areas at the Romanian Black Sea border. The monitored parameter values were processed by ODV (Ocean Data View, Schlitzer, R., Ocean Data View, http://odv.awi.de, 2015) software in order to obtain specific isoconcentration maps that reflects the variation of these parameters in horizontal and vertical section. The final representative image of the surface parameters spreading for these profiles were obtained by the superposition with a proper georeferenced satellite map view of the screened area.

2. Materials and methods

2.1. Materials and measurement device

A SD204 Emma Technologies multiparameter probe C.T.D. equipment was used for the sampling expeditions. The system is configured with several modular sensors for the measurement of various water parameters: conductivity, salinity, temperature, depth, water flow velocity, chlorophyll, redox potential, pH, photosynthetic active radiation and dissolved oxygen. Data are recorded by the built in microcomputer and stored in the CTD internal memory. The accompanying software, SD200W, contains versatile functions for programming, post- and online data processing. The programmed settings and calibration coefficients are maintained in a nonvolatile memory, and will not be changed/ lost at power failure. The instrument is equipped with a titanium case and external protective cage, and can be deployed manually or by on ship crane. Data are recorded in physical units and simultaneously transmitted via an RS232 I/O watertight connector for on-line use, or may be downloaded by serial connection at the sampling session end.

The C.T.D. sensors used for the determination of the temperature (°C) had a range -2 to +40°C, resolution 0.001°C, accuracy +/- 0.01°C, response time 0.2 sec. For conductivity determinations, a 4-electrodes cell with range 0 to 70 mS/cm, resolution 0.01 mS/cm and accuracy +/- 0.02 mS/cm was used. The salinity values (g/L) are automatically calculated from the conductivity data. The available pressure range is 500m, resolution: 0.01 dbar, Accuracy: +/- 0.01% FS (-2 to +40'C), Response time: 0.1 sec. All sensors calibration, testing and validation operations were performed by the manufacturer (sensors calibration, recalibration and validation are always provided by the CTD manufacturer).

Other devices and materials: ultrapure water obtained by Milipore Elics S system was used for all final cleanup steps, external computer with serial connection and GPS device, on board ship deployment facilities (manual deployment was used) for the scientific expeditions.

2.3. Methods

Sampling and deployment

Before deployment the CTD system is configured by external computer connection using the proper acquisition parameters (0.1 decibar sampling rate in descending acquisition mode) and sealed for operation. After sensors cleaning with ultrapure water, the CTD is prepared for deployment and acquisition mode is started contactless due to a magnetic activation device. After stopping the boat, GPS coordinates are recorded, the CTD is deployed and immersed at the desired depth, brought back on board and cleaned with ultrapure water. After contactless acquisition cease, the system is ready for the next sampling station.

Data acquisition, processing and GIS integration

At the end of the sampling session the external data connection port is used for computer connection and the dedicated data acquisition software is used to download the whole internal stored data files. After several conversion steps, the exported files are opened with Libre Office Calc software and correlated with the deployment GPS coordinates. After proper conversion and data formatting (related to horizontal or vertical profile ODV input file requirements), the final ODV input files are obtained. After several ODV processing steps, the final DIVA gridding processed images are saved.

The obtained horizontal isoconcentration images are imported with Global Mapper GIS software and used as individual planes (with proper transparency levels), correlated by GPS coordinates with the satellite map of the whole region. The GIS software processing step yields the final isoconcentration profile, a relevant image for the surface spreading of the screened parameter.

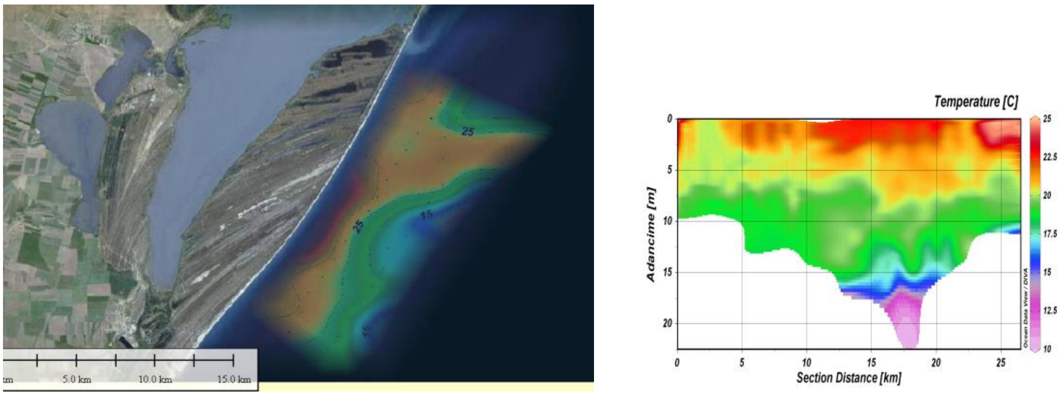
The vertical isoconcentration profile is correlated (by the ODV software) with the sampling cruise vessel route.

3. Results and discussion

The final horizontal and vertical isoconcentration profiles for temperature, salinity and conductivity were obtained after several sampling expeditions, targeting the screening of the Corbu – Vadu – Chituc – Periboinea – Portita – Perisor – Sachalin – Sfantu Gheorghe – Sulina protected areas. The following results are related to the Chituc protected site, a fairly unperturbed area, located at almost equal distances from Navodari and Sfantu Gheorghe harbours. The whole data acquisition and integration process followed the already described methodology: sampling and deployment, data acquisition, processing and GIS integration, yielding the final isoconcentration profiles.

The temperature variation profiles (Fig.1.) were obtained using data acquisition from 68 sampling stations (the vessel course followed the 5, 10, 15 and 20 isobaths), and a full vertical data chain with a resolution of 0.1 decibar (10 readouts per meter) were acquired for every sampling station. The significant temperature values are: T_{min} = 4.1^{o}C, T_{max} = 28.1^{o}C, T_{avg} = 21.9^{o}C.

As expected, the vertical profile shows a significant temperature drop with depth increase due to water layers stratification. The horizontal profile reveals the surface temperature distribution of the screened area, correlated with several parameters as: surface wind direction, currents and fresh water temperature at Edighiol channel mouth.

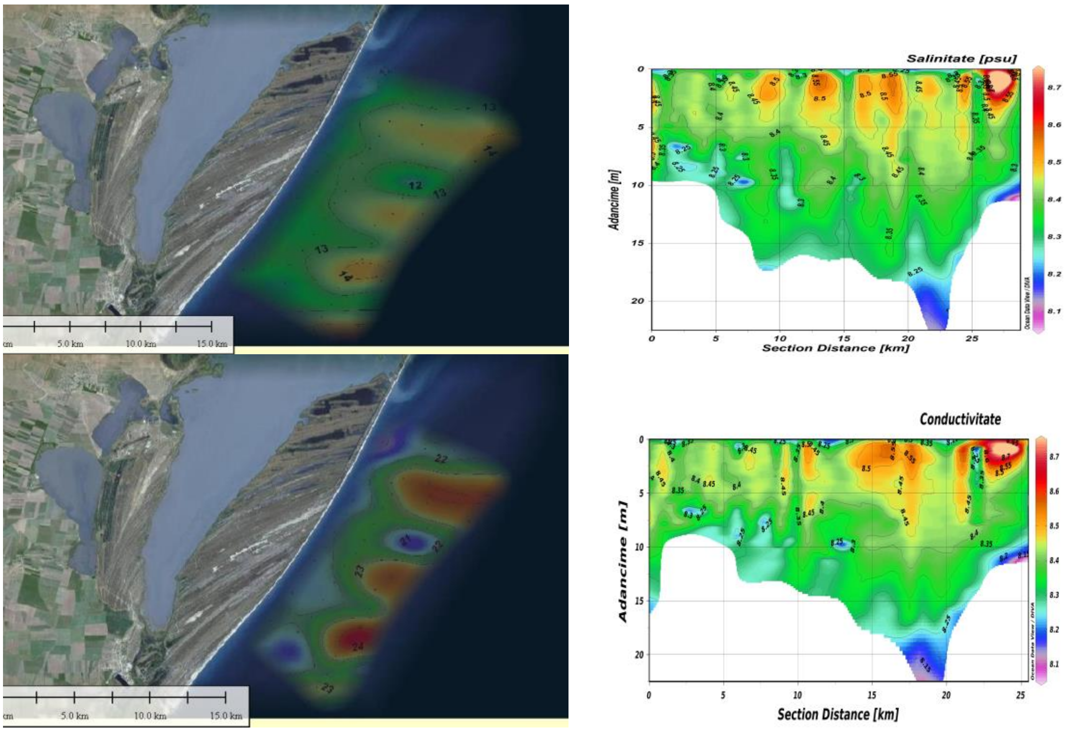


(a) (b)

Fig.1. Temperature variation for Chituc protected area, horizontal (a) and vertical (b) profiles obtained in August 2012

Temperature is an important parameter being correlated with many physicochemical parameters, as well as the growth and development of all living components of the ecosystem. High temperatures in conjunction with a reduced water circulation can lead to major imbalances by dramatically reducing oxygen levels. The obtained data suggest an upward trend compared with literature data. A common observation for all perimeters related to 2012 measurements, is the persistence of relative high temperatures on the vertical profile up to November.

The salinity was determined using the conductivity values recorded with the CTD system, and is correlated with the total amount of dissolved salts in the water body (using temperature and pressure corrections). Usually the salinity measurements using g/L units, but PSU (practical salinity units) units are also used. The significant salinity values for the screened area are: S_{min} = 14.9 g/L, S_{max} = 18.0 g/L, S_{avg} = 14.9^{o}C, and were obtained using data acquisition from 68 sampling stations (the vessel course followed the 5, 10, 15 and 20 isobaths). The salinity isoconcentration profiles are shown in Fig.2. and are correlated with the conductivity profiles, as expected.



(a) (b)

Fig.2. The salinity and conductivity isoconcentration profiles for Chituc protected area, horizontal (a) and vertical (b) profiles obtained in August 2012

The vertical profiles show a significant salinity increase with depth increase due to water layers stratification by density differences. The horizontal profile reveals the surface salinity distribution of the screened area, correlated with a change in water mass due to currents and surface winds, or an influx of salts or other minerals, possibly caused by seasonal changes, the proximity of a fresh water source, pollution or other factors.

The special importance of this parameter is derived from the strict adaptation to salinity conditions of the Black Sea (around 18 g/L) of most marine organisms from all ecosystem levels. Reducing salinity is likely to significantly reduce habitat's biodiversity. The 16÷18.5 g/L domain corresponds to a normal seasonal variation, the 10÷16 g/L domain is determined by significant freshwater input from the Danube, and is typical associated with disturbances in marine ecosystems but values under 10 g/L corresponds to completely unfavorable areas for marine life organisms adapted to specific salinity of the Black Sea. Usually low values are expected in the proximity of Danube mouth, but can be correlated also with seasonally flooding.

6. Conclusions

The vertical and horizontal isoconcentration profiles correlated with satellite map using GIS software represents a particularly valuable tool in the oceanographic research due to their relevance in screening data interpretation and the wide application area. Despite of the significant advantages, the whole data acquisition, processing and integration process involves a huge amount of work, from all on-site or on-ship operations to the difficult computer processing.

Related to the obtained temperature, salinity and conductivity profiles, the vertical isoconcentration profiles can be correlated with the water layers stratification process, while the horizontal profiles reveal the surface distribution of the parameter in screened area, correlated with a change in water mass due to currents, surface winds, seasonal changes, anthropic proximity reasons, fresh water input, flooding, pollution or other factors.

The marine protected areas in the near Danube mouth proximity, can be considered the subject of a permanent estuarine stress due to the significant fresh water, sediments and pollutants input. Related to the salinity, marine living being are adapted for a certain range of salinity, and significantly salinity changes can affect the ecosystem variability. Related to temperature measurements, the observed upward trend compared with literature data, raises some questions about the known influence of high temperatures in conjunction with a reduced water circulation in major imbalances by dramatically oxygen levels mitigation but also to the water stratification process and inherently to changes in many other water parameters.

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