Introduction / General Aspects of Marine Sonar and Seismic Surveys

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INTRODUCTION TO MARINE STUDIES

Exploration of the oceans using the techniques of the marine sonar and seismics has had a profound influence on our understanding of the Earth and its behavior through time. Observations in Deep Ocean have played a key role in establishing modern plate tectonic theory, transforming Earth Science in ways that were quite unexpected when the first geophysicists put to sea.
Measurements in shallower waters have revealed how continental margins formed, subside and become covered with sedimentary accumulation. The remarkable structural details revealed by seismic and other methods in these regions make marine sonar and seismic methods an undisputable tool in the search for petroleum and other natural resources. After long period of exciting developments, it is now appropriate to review these issues in the context of this course.
Juan de la Cosa, the World map of the pilot of Colombo’s second cruise (1500)
Edmund Halley’s Map (1701)
Matthew Maury North Atlantic Bathymetry Map (1855)
HMS CHALLENGER ROUTE (1872-76)

Figure 1.4 (a) The route of HMS Challenger, 1872-76.

(b) HMS Challenger, 1872. She was a steam-assisted corvette of 2306 tons.
Rapid progress in marine sciences, as in other branches of science, has been closely linked to advances in technology. The means of accurately locating sensors and mapping seabed topography are indispensable tools in the search for petroleum and other natural resources.
With all these points after the exciting developments, in the context of this course marine sonar and seismic issues shall be reviewed what marine sonar and seismic can tell us about the structure of the seabed and ways in which the ocean and their margins have been evolved.
Much of marine sonar and seismic have been concerned with investigating the structure, origin and development of the principal physiographic in the ocean. The earliest indications of sea-floor topography came from spot soundings taken with weighted lines during hydrographic surveys started in the 18th century and on the pioneering oceanographic expeditions of 19th century. The period since World War II has been seen enormous advances in marine sonar and seismics.
EARTH SURFACE HEIGHTS AND DEPTHS WITH HISTOGRAMATIC DISTRIBUTIONS
Explorations and investigations have reached far beyond the confines of coastal areas into the deepest waters and furthest reaches of the oceans. It has brought about a radical transformation in our understanding of geological processes, the nature of seabed and development of our planet. It has dramatically altered the ways in which we find and exploit seabed resources and utilization of coastal regions.
FUNDAMENTAL LITOSPHERIC PLATES
Marine research for military purposes during World War II had an important influence on the development of marine sonar and seismic after 1945. It provided both expertise and some of the basic instruments for making geophysical measurements in a hostile marine environment. Techniques for locating submarine and other underwater objects had, of necessity, advanced rapidly during wartime.
Primarily based on the detection of sound and perturbations in the Earth’s magnetic field, they involved the construction of some of the principal tools of marine geophysicists: sensitive magnetometers, hydrophones and the devices capable of producing frequent underwater explosions.
Advances in marine research have been closely related to the availability of ships and other platforms for expanding the observational base, testing new instruments and for carrying out novel experiments. Rapid progress came during the 1950s and 1960s when government agencies financed wide-ranging oceanographic expeditions and gave scientists much flexibility in the way that could conduct their research.
Traditionally, ships were located by celestial navigation, visual sights on known landmarks and magnetic compass. This was the situation until 1945 when restrictions were gradually lifted on electronic navigation systems developed for military purposes. Based on transmission of radio pulses or continuous radio waves, these provided greatly increased positional accuracies, especially in areas distant from shore and subject to frequent cloud cover.
INTRODUCTION TO THE MARINE SURVEYING

Activity offshore has been centered, until recent times, entirely on the fisheries and shipping industries. Since the World War II there has been a remarkable increase in interest in the resources of the sea and seafloor, of which the recovery of hydrocarbons –oil and gas- represents by the greatest industrial investment.
Offshore engineering technology and shipping industry have progressed at a phenomenal rate. Compare the typical, long-established harbors with the civil engineering achievements of today. The one occupies a sheltered location adjoining shallow waters, comfortably able to accommodate vessels which seldom exceed 10 m in draught, and conveniently close to road and rail distribution links.
The other may be a drilling rig or production platform several kms offshore and subjected to violent storms of 20 m alongside, or a pipeline from oil well to shore, traversing the rapid current and shifting seafloor sediments.

In addition to offshore drilling and harbor construction, the totality of industrial activity embraces the following operations:
* Dredging, for harbor conservancy, mineral recovery and reclamation;
* Coastal protection engineering;
* Salvage;
* Desalination of seawater to improve fresh water supplies;
* The extraction of mineral and chemicals from seawater;
* The provision of recreational facilities such as beaches and marinas;
* The prevention or elimination of pollution;
* The development of communications and distribution routes by shipping lane, submarine cable and underwater pipeline;
* The development of the fishing industry.

The impact of this proliferation of activity on the engineer and surveyor has been profound.
MAIN ASPECTS OF THE OFFSHORE SURVEYING

- Position
- Tidal Data
- Seafloor Morphology
- Seabed Topography
- Charting of Underwater Features
- Sub Seabed Geology (Marine Geologist/Geophysicist)

Seawater Circulation, Composition and Properties (Oceanographer)
The nature of the sea environment is probably the most fundamental single factor which separates land from sea surveying. The effect of the sea on the common surveying techniques has been mentioned, but more important still is an appreciation of the vicissitudes of the sea which not even a manual of seamanship can properly explain. Experience is the only real solution, which both engineering and land surveyor will most probably lack. In its stead, an honest humility towards the sea and the seaman in whose care surveyor will be placed is strongly recommended.
The first object of a hydrographic survey is to depict the relief of the seabed, including all features, natural and manmade, and to indicate the nature of the seabed in a manner similar to the topographic map of land areas. The factors define the location of a single point on the earth’s surface taken in isolation, and for the sea surface these are:
(i) The position of the point in the horizontal plane in, for example, latitude and longitude, grid coordinates or angles and distances from known control points.

(ii) The depth of the point below the sea surface, corrected for the vertical distance between the point of measurement and water level and for the height of the tide above the datum or reference level to which depths are to be related.

The problem, then, is how to apply these factors in order to obtain a pictorial representation of the seabed relief.
In the most highly automated survey systems, position fixes are obtained at a rate compatible with the sounding rate, but this is not as yet, a common situation. Instead, a fix may be obtained at intervals of a minute or so, and the survey vessel is assumed to follow a track which is shown on the plot as a succession of fixes joined by straight lines. It is imperative that control of the vessel is such that this assumption is valid within the plottable accuracy of the chosen scale of the survey.
The sounding procedure described above, while providing data for an indication of relief, cannot guarantee a complete coverage of seabed. Isolated pinnacles, wrecks and other obstructions may be missed if they lie between the sounding lines. Further, the echo sounder profile will not show the nature of the seabed – where rocks outcrop form sand, where gravel, stones of boulders occur, and so on.
The congenital sounding operation may therefore be modified – by running intermediate lines, (interlines) to increase the density of areal coverage or cross-lines to obtain an improved angle of cut of contours – or supplemented by special instrumentation, such as wire sweeping. Additionally tidal and tidal-stream observations are frequently specified. These various operations are dealt with in succeeding chapters, while their roles in the hydrographic survey are illustrated next:
THE MAIN FIELDS OF HYDROGRAPHIC OPERATIONS

- Establish Hydrographic Control from Geodetic Framework
- Tidal Observation (tidegauge, scale)
- Location and Clearance Sweeps for Isolated Features (wire sweep, sonar, etc)
- Current and Tidal Stream Investigation (current meter, pole logships, floats, etc)
- Position-Fixing (sextant, EM positioning systems, satellite, etc)
- Seabed Sampling (grab, dredge, corer, etc)
- Sounding (echo-sounder)
- Topographical and Morphological Investigation of Seabed (Sonar)
PLANNING OF THE MARINE SURVEY

As with any activity, careful planning and preparation will pay dividends in the subsequent operation, although no two surveys are alike, the sequence of events will usually follow much the same pattern:

(i) The drawing up of a specification to client’s requirements;
(ii) The examination of available documents, e.g. charts, maps, air triangulation and other control data from earlier surveys;
(iii) If possible all possible, a field reconnaissance;
(iv) The preparation of sheets required for the survey, e.g. master plotting sheet, sounding boards, underlays for position-fixing lattices, and the fair sheet;
(v) The preparation of the operational plan, including decisions on positional control, tide gauge location, instrumentation and techniques to be used, personnel, equipment and logistical requirements and time/resources schedules;
(vi) The field work, e.g., establishing positioning and tidal control, sounding, sweeping and miscellaneous operations;
(vii) The interpretation, processing and presentation of data.
The factors to be considered in the sounding operation are as follows:

(i) Types of vessel required;  
(ii) Type of echo-sounder/sonar instrumentation required;  
(iii) Position-fixing method to be used;  
(iv) Method of achieving the required coverage of the seabed;  
(v) Personnel requirements;  
(vi) Logistical requirements.
THE SURVEY VESSEL

While many surveyors will be committed to a particular vessel, there will be those to be provided by the survey team, there should be ample electrical power for all foreseeable needs for the job will obviously depend on the overall purpose of the survey (e.g. whether or not geophysical or other additional tasks are required), the weather conditions to be allowed for, the size of the survey team, whether they are to live on board the vessel, and so on. It is impossible to lay down rules, but the following requirements will always apply:
(i) The vessel should be spacious enough to allow for plotting and fixing, the former preferably under cover and free from engine vibration.

(ii) If fixing by visual methods, an all-round view is required by the anglers.

(iii) The vessel should be stable and maneuverable at slow speeds.

(iv) Unless batteries or a generator are to be provided by the survey team, there should be ample electrical power for all foreseeable needs.

(v) The range (fuel capacity), food storage and working facilities should be compatible with the planned operational arrangements.

(vi) Speed capability need not normally exceed 10 knots or so, though the distance between the base and the survey areas may dictate a faster vessel to avoid loss of time on passage.
The Survey Plan

In order to achieve satisfactory coverage of the seabed with maximum economy it has already explained that parallel lines of sounding should be run over the area. Further considerations will include the following, all of which are interrelated:
(i) The scale of survey appropriate to the precision and thoroughness required;
(ii) The spacing apart of the sounding lines;
(iii) The interval between fixes along a line;
(iv) The speed of the vessel while sounding;
(v) The direction in which lines are to be run.
Navigation Systems

The navigation and positioning instruction in this is aimed at the marine scientist as a working field scientist. It covers the fundamentals of field operations onshore in coastal areas, in coastal waters, and on the high seas. Techniques used onshore for coastal positioning are inland surveying methods; such topics are not included here; the viewpoint is entirely marine issue.
The discussion of navigation systems is divided into four topics:

(i) Fundamentals of timing, charting, and plotting.
(ii) Vessel control.
(iii) Positioning and data processing systems.
(iv) Organization of marine surveys.
MARINE SONAR AND SEISMIC SURVEY COURSE PROGRAM

* Introduction / General Aspects of Marine Sonar and Seismic Surveys (Mustafa Ergun)
* Principles of Acoustic Measurements (Seda Okay)
* Bathymetric Data Acquisition (Muhammed Duman)
* Bathymetric Mapping (Muhammed Duman)
* Mapping with Sub Bottom Profiler/Sparker/Other Marine Seismic Methods (Seda Okay)
* Seismic Data Acquisition (Günay Çifçi/Orhan Atgın/Özkan Özel)
* Applications of Marine Seismic Data Management (Orhan Atgın/Özkan Özel)
* Principles of Seismic Imaging and Interpretation (Oz Yılmaz)
* Principles of Marine Seismic Data Processing (Luis Pinheiro)
* Applications of Marine Seismic Data Interpretation (Luis Pinheiro)
* General Discussion (All lecturers)
MARINE CRUISES:

* Multichannel Seismics (Seda Okay/OrhanAtgün/ÖzkanÖzel/MertKüçük)

* Marine sonar surveys; multibeam; side scan sonar and sub bottom profiler (Seda Okay/OrhanAtgün/ÖzkanÖzel/Mert Küçük)

* Discussion about the Collected Data