DIGITAL ELEVATION MODEL BATHYMETRY MAPPING OF SEAFLOOR USING QINSy QLOUD

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I humbly dedicated this project to my entire family especially my brother Alhaji Rabiu Abubakar who supported me financially to study oversea (Malaysia), may the Almighty Allah Subhanahu Wataala reward him and protect him against the evil. Ameen !

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ABSTRACT

Digital elevation model of seafloor mapping is one of the most active modern underwater acoustics domains to produce near real visualization of the underwater terrain, attracting the attention and knowledge exploration in many branches of science and technology. This study takes interests on the three dimensional (3D) geometrical description of the seafloor topography as well as to have idea on dynamic behaviour of seabed morphology and its material properties. The aims of this study are to generate 3D digital elevation model of the seafloor, visualize and interpret the 3D model and analyse the effect of data duplication on depths where the main source of the data is multibeam echo sounder. The multibeam bathymetry technique has an unlimited range of application in the marine data acquisition and underwater investigation. The recent technological advancement and development on the multibeam bathymetry technique has led to the improvement of underwater mapping and study of seafloor classification. This Project described step by step approach and methodology adopted which focusing on the application of high resolution multibeam, RESON SeaBat8124. When the 3D bathymetric model produced is compared to Surfer and ArcMap software, the 3D model show the same topographical shape and the 3D model look similar. The shape produced by QINSy QLOUD is also the same.

ABSTRAK

Model elevasi digital tiga dimensi (3D) bagi pemetaan dasar laut adalah salah satu moden domain akustik bawah air yang paling aktif untuk menghasilkan berhampiran gambaran sebenar rupa bumi di bawah air, menarik perhatian dan penerokaan ilmu dalam pelbagai cabang sains dan teknologi. Kajian ini menarik minat kepada penerangan geometri tiga dimensi (3D) topografi dasar laut dan juga untuk memahami tingkah laku morfologi dasar laut yang dinamik dan sifat bahannya. Tujuan kajian ini adalah untuk menjana model elevasi digital 3D dasar laut, menggambarkan dan mentafsirkan model 3D tersebut dan menganalisis kesan pertindihan data pada kedalaman di mana sumber utama data adalah pemerum gema berbilang alur. Teknik pengukuran pemerum gema berbilang alur mempunyai aplikasi yang tidak terhad dalam perolehan data marin dan penyiasatan dasar laut. Kemajuan teknologi dan pembangunan terhadap teknik pengukuran *pemerum gema berbilang alur* baru-baru ini yang telah membawa kemajuan terhadap pemetaan bawah laut dan kajian pengelasan dasar laut. Projek ini menerangkan satu per satu pendekatan dan metodologi yang digunakan yang mana tertumpu kepada penggunaan pemerum gema berbilang alur beresolusi tinggi, RESON SeaBat8124 Apabila model batimetri 3D yang dihasilkan dibandingkan kepada perisian Surfer dan ArcMap, model 3D menunjukkan bentuk topografi yang sama dan model 3D kelihatan sama. Bentuk yang dihasilkan oleh QINSy QLOUD juga sama dan serupa.

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LIST OF ABBREVIATIONS

3D	Three Dimensional
BDEM	Bathymetric Digital Elevation Model
DGPS	Differential Global Positioning System
GNSS	Global Navigation Satellite System
GRETL	Gnu Regression,Econometric and Time – Series Library
GPS	Global Positioning System
HIS	Hydrographic Information System
HRP	Heave Roll and Pitch
IHO	International Hydrographic Organization
IMU	Inertial Measurement Unit
LAT	Lowest Astronomical Tide
SBES	Single Beam EchoSounder
SVB	Sound Velocity Probe
MBES	Multibeam EchoSounder
MGDI	Marine Geospatial Data Infrastructure
MLS	Mobile Laser Scanner
MRU	Motion Reference Unit
PDS	Post Dredge Survey
POS	Position and Orientation System
TLS	Terrestrial Laser Scanner
WGS 84	World Geodetic System 1984

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The surficial faces of the seafloor is characterise and determined by collecting a good samples of seabed or sea surface data (Blondel, 2003). These data are analysed, characterise for the determination of grain size, rock type, sand, muddy sand, silt, etc (Blondel, 2003; Kostylev *et al.*, 2001). This is very important in marine Geological studies, and is very crucial when modelling sediment process, pollution, transportation, deciphering tectonic and defining habitats (Gardner, 2004).

Digital elevation model bathymetry of the seafloor is one of the most active domains of modern underwater acoustics, attracting the attention and exploration in many branches of science and technology (O'Brien *et al.*, 2013). The seafloor is a platform for engineering structures, a source of row materials, a reposition for unwanted materials, route of communication, a potential background, a laboratory of great importance can be studied and many more thing besides (Chen *et al.*, 2010; Wilson, 2003)

The science related to the sea depth is bathymetry and the production of good quality bathymetry map is paramount safety. There was a need for seafloor mapping in coastal navigation since the olding days, in which good quality bathymetric maps are very important to safety (Negahdaripour and Madjidi, 2003). Such maps have greatly benefited from acoustic techniques with regard to accuracy and completeness in shallow water, that is on the continental shelf (Walker *et al.*, 2002). The required accuracy is better than 1% of the water depth. The underwater maps produced are expected to provide accurate bathymetry, the presence of the obstacle on the seafloor and, if possible, the nature of the seafloor (Snellen, 2012).

1.2 Problem Statement

The interest on this study is on the 3D geometrical description of the seafloor topography/morphology, and also to have idea on dynamic behaviour of seafloor or seabed topography and seabed material properties.

The main source of the data is multibeam echo sounder. The multibeam bathymetry technique or method has an unlimited range of application in the marine data acquisition and investigation. Recently there is a technological advancement and development on the multibeam bathymetry which has led to the improvement of mapping and study of seafloor classification.

The data acquired during the survey are going to be process and analysed using the software QINSy and QINSy QLOUD software is an offline tool that is fully integrated with QINSY. Large data sets are extremely handling using QinSy Qloud, using parameters such as Total Propagation Error (TPE) and THO S-44 guide lines, based data cleaning are performs statistically both in the CUBE algorithms (UNH), and in the least square statistical spline method.

The advantage of seabed mapping using QLOUD is that,Data cleaning are done Automatically because of its cleaning tools using Clips, Area Spline cleaning and CUBE algorithms, these are applied to the entire survey and the cleaning can be done step by step to selected section, where centre and outer beams overlap.

The Total Propagation Error TPE values are weighted at each data point correcly. The data is viewed as individual soundings, or as gridded data, which is often dictated by the deliverable. For example, viewing every last individual sounding is wasted effort if the deliverable is a single mean sounding per grid cell. presentation of the SD attribute of a gridded dataset in one pane, and the 3D points cloud in another pane. This give room for flexible viewing options, By pin pointing bad SD values, the spotlight is quickly directed in the points cloud for more focused analysis.

One of the most important parts of this project is survey planning and implementation for data acquisitions to meet the necessary requirement. A proper arrangement need to be done from the most suitable survey methodology based on the various factors such as the equipments operating system, the survey area that is the site, setting out, data collection, processing the data in order to smoothing the survey and avoid problems that may arise.

1.3 Objective of the Study

The objectiv of this study are

(i) To Generate Digital Elevation Model of the seafloor surface using QINSyQLOUD

(ii) To visualise the outliers/noise/spike that were imported into QINSy QLOUDand make furthere cleaning of the bathymetric data.

(iii) To Transfer the clean data into other softwares in form of ascii file format or griddata file format for digital elevation model generation and analysis.

(iv) To detect the effect of duplicated data when other software are used

1.4 Scope of the Study

This project concerns the analysis of QLOUD software performance and its capabilities in various operational requirements.

This project is concern with the production of 3D viewing and normal grid presentation of the cleaned DTM points in QLOUD

The scope of this study is to look at the validated data if they can be exported back to QINSy sounding grid file or any third party software

1.5 Significant of the Study

The sampling of water at different depths and by taking samples of the sea bed gives data and the data gathered are used to understand water movement, the spread of pollutants and fish behaviour in the ocean. This information facilitates habitant mapping and an understanding of how our ocean operates. Therefore this study will provide

(i) A good view of the subsea landscape.

(ii) It will also evaluate the scope and limitations of a range of suitable techniques for assessing the effects of site specification and activities and activities at the sea.

(iii) One of the significant of this study is to evaluate additional techniques for use in broad scale mapping exercise.

(iv) One of the significant of this study is the determination of the seabed characteristics that is subject to changes in time with various factors to be looked into based on the interpretation of the QLOUD.

(v) The significant of this study is a chance to obtain knowledge on how to used or conduct survey for data acquisition using QINSy8.0 QLOUD, on the other way round the result obtained can be used for educational purpose, this study my served as a guidance to conducting a survey on water and it can also be used as a references for further studies.

1.6 Instrumentation

The instrumentation is divided into two categories for the scope of this project is concern, That is data acquisition system and data processing software. For the data acquisition, we will be using the new advance multibeam technology for Teledyne RESON SeaBat series along with RESON PDS 2000 operating system for data acquisition mode and the software to be used for data analysis and integration will be QINSy QLOUD which is another new software for data cleaning and filtering. For positioning and orientation for this project, Trimble Applanix POSMV will be used.

1.6.1 Teledyne RESON SeaBat

RESON multibeam T20-P is the recent Product of advance multibeam by Teledyne RESON Company. The T20-P is the first portable multibeam system that consist of T20 sonar head as the acoustic sensor and portable sonar processor as shown in the figure 3.1, the multibeam system is also come with the sound velocity probe that used to give out the sound velocity correction.

Figure 1.1: RESON SeaBat 8124

1.6.2 Applanix POS MV

Applanix Position and Orientation System of marine vessel is a GNSS aided inertial navigation system which has the ability in providing a complete set of measurement including estimation of heave and ellipsoidal altitude. It consist of 2 GNSS antenna for positioning system, IMU to dealt with motion of the vessel and POS computer system as a processing unit that give out revised vessel position and correction for vessel motion.

Figure 1.2: Applanix POS MV System

1.6.3 RESON PDS2000

RESON is one of the world leaders in SBES and MBES dredge guidance system and Hydrographic software. RESON PDS2000 is designed to efficiently create high quality,fast result for multibeam survey,single beam survey,volume calculation or Chart production.

1.6.4 QINSy QLOUD Software

QINSy QLOUD is fully integrated with QINSy, handling extremely large data sets, it performs statistically based data cleaning using parameters such as Total Propagation Error (TPE) and IHO S-44 guide lines, both in the CUBE algorithms (UNH), and in the least square statistical spline method.

QINSy QLOUD Imports DTM points from QINSy QPD files, (include multiple data attribute flags generated in QINSy). QLOUD also import DTM points from any other software point file. With or without attributes and metadata. The moment the data is loaded into QLOUD, the surveyed is viewed as a single cloud of data point, presented in the full geographical contex, of ENCs, DXF and GEOTIFF imagery.

1.7 The Study Area

The Figure 1.3 shows the approximate area of the study, which is located at Tebing Runjuh, Gelang Patah Johor Darul Takzim.

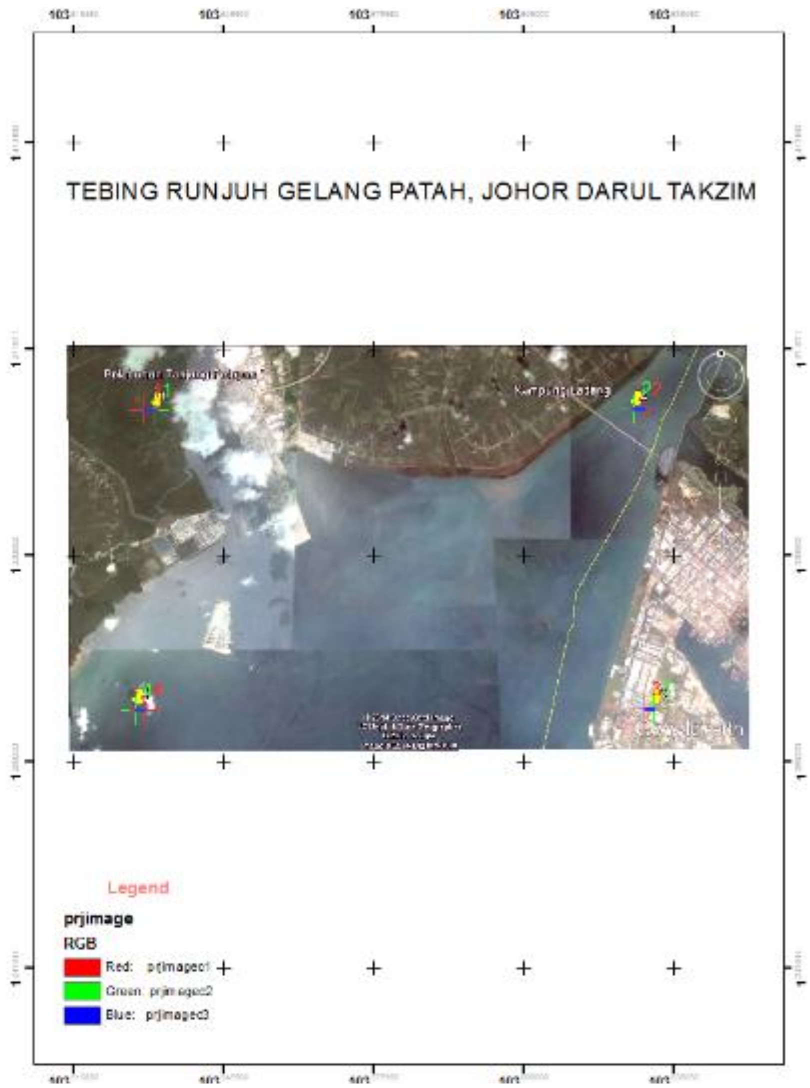

Figure 1.3: GELANG PATAH

1.7.1 Brief of the Project Methodology

Method of this research must be planned so that the scope of the research and primary objective of the research will be achieved.

This study contains five (5) stages through the research methodology which are shown below.

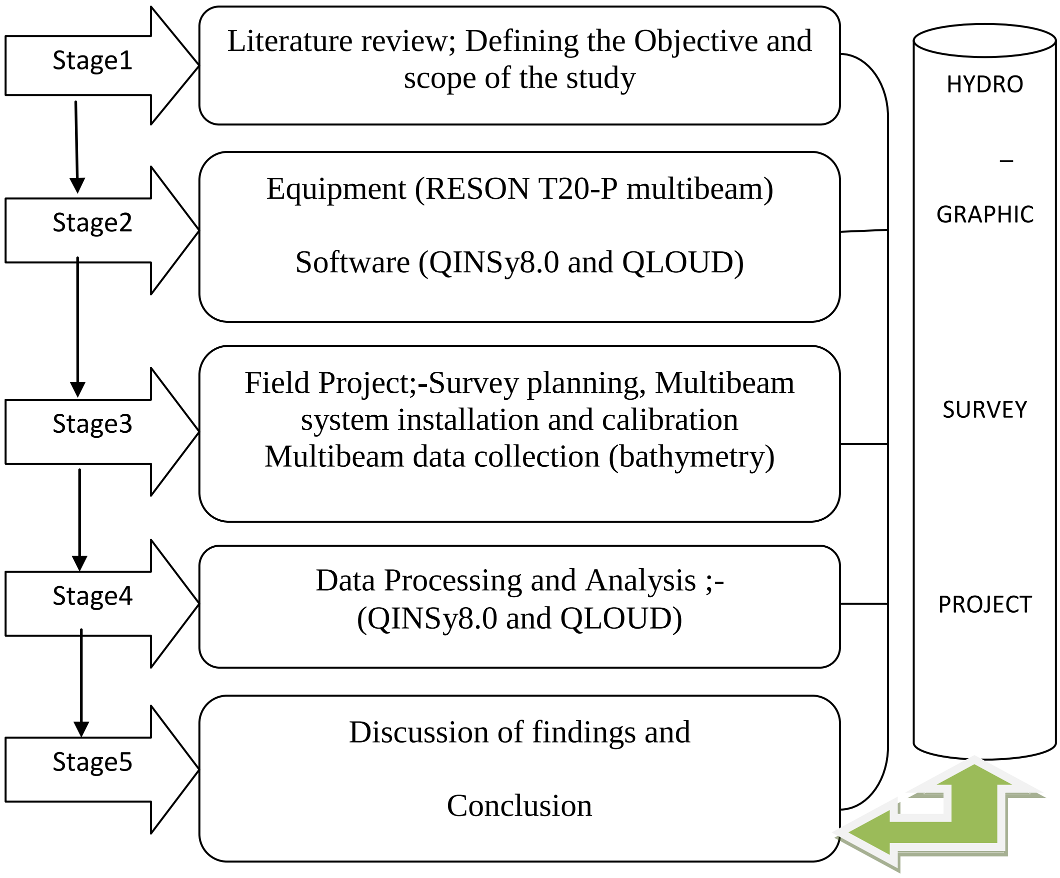

Figure 1.4: Project Methodology

Stage 1 Literature Review:-

Literature Review will be mainly focused on the concept of seafloor mapping Bathymetric data, sidescan sonar, multibeam, QLOUD software and QINSy 8.0 software. The sources for this literature review can be acquired from the reference books and also acquired from the internet such as journals. Information can be acquired also from JUPEM and other organisation that are dealing with seafloor mapping.

Stage 2 Familiarisation;-

Initial Idea on the multibeam bathymetric method and the software need to be used is of vital important, because it help in solving the statement problem and to know your expected end product.

i) Multibeam Bathymetric system for data acquisition
ii) The software QINSy8.0 and QLOUD for data processing.

Stage 3 Survey planning and data collection

Every survey activities need planning prior to the commencement of the job. For successful job to be done there are things that are need to be put in mine such as area of the survey, how the survey need to be done type of equipment need to be carried with, the personal on board. Interesting features and valuable information that are needed at last even the safety of everyone on board is put into consideration.

The field Project is done after all the components of the multibeam system are fully installed, that is every component is checked and its position is properly istolled and is functioning. DGPS are fixed on the side of the vessel, all cables are properly fixed in there appropriate position. Then calibration of the equipments is done and the centre of gravity of the vessel is taking to enable proper installation of the DGPS. Then the survey exercise can now proceed.

Stage 4 Analysis

The analysis is going to look into survey implementation. Making sure that the standard of International Hydrographic Organisation (IHO) is achieved, and also check on the capability of QLOUD software. The analysis is going to look at the QINSy QLOUD performance to generate 3D.

Stage 5 Conclusions and Recommendation

At this stage, the aim and objective of the project will be looked into to see if the objective of study is achieved or not.

REFERENCES

.

Anderson, J. T., Holliday, D., Kloser, R., Reid, D. and Simard, Y. (2007). *Acoustic seabed classification of marine physical and biological landscapes*. International Council for the Exploration of the Sea.

Blondel, P. (2003). Seabed classification at ocean margins *Ocean margin systems* (pp. 125-141)Springer.

Borrough, P. A. a. r. A. M. (1998). *Principles of Geographic Information Systems*. Oxford University Press: New York.

Cartwright, D. S., & Clarke, J. H. (2002). Multibeam surveys of the frazer river delta, coping with an extreme refraction environment. *Proceedings of the Canadian Hydrographic Conference*.

Chen, C.-W., Shen, C.-w., Chen, C.-Y. and Cheng, M.-J. (2010). Stability analysis of an oceanic structure using the Lyapunov method. *Engineering Computations*. 27(2), 186-204.

Clarke, J. E. H., Mayer, L. A. and Wells, D. E. (1996). Shallow-water imaging multibeam sonars: a new tool for investigating seafloor processes in the coastal zone and on the continental shelf. *Marine Geophysical Researches*. 18(6), 607-629.

Connary, S. D. and Ewing, M. (1974). Penetration of Antarctic bottom water from the Cape Basin into the Angola Basin. *Journal of Geophysical Research*. 79(3), 463-469.

Desbarats, A., Logan, C., Hinton, M. and Sharpe, D. (2002). On the kriging of water table elevations using collateral information from a digital elevation model. *Journal of Hydrology*. 255(1), 25-38.

Dierssen, H. M. and Theberge Jr, A. E. (2010). Bathymetry: History of Seafloor Mapping.

Dinn, D. F., Bosko D. Loncarevic, and Gerard Costello. (1995.). The effect of sound velocity errors on multi-beam sonar depth accuracy. *OCEANS'95. MTS/IEEE. Challenges of Our Changing Global Environment. Conference Proceedings..* . Vol. 2.

Dworski, J. G. and Jackson, D. R. (1994). Spatial and temporal variation of acoustic backscatter in the STRESS experiment. *Continental Shelf Research*. 14(10), 1221-1237.

Foster-Smith, R. and Sotheran, I. (2003). Mapping marine benthic biotopes using acoustic ground discrimination systems. *International Journal of Remote Sensing*. 24(13), 2761-2784.

Gardner, P. D. a. J. v. (2004). Predicting Seafloor Facies from Multibeam Bathymetry and Backscatter Data *American Society for Photogrammetry and Remote sensing*. Volume.70, no 9,, 1081-1091.

Hughes Clarke, J. E., Danforth, B. W. and (1997a)., P. V. (1997). Areal seabed classification using backscatter angular response at 95 kHz. In High Frequency Acoustics in Shallow Water. *Proceedings of SACLANT Conference*. 45, 5.

IHO (2011). *MANUAL ON HYDROGRAPHY*. (Vol. Publication C-13) M O N A C O: INTERNATIONAL HYDROGRAPHIC BUREAU.

Jakobsson, M., Cherkis, N., Woodward, J., Macnab, R. and Coakley, B. (2000). New grid of Arctic bathymetry aids scientists and mapmakers. *EOS, Transactions American Geophysical Union*. 81(9), 89-96.

Jensen, F. B. (1994). *Computational ocean acoustics*. Springer.

Kilfoyle, D. B. and Baggeroer, A. B. (2000). The state of the art in underwater acoustic telemetry. *Oceanic Engineering, IEEE Journal of*. 25(1), 4-27.

Kokossalakis, G. (2006). *Acoustic data communication system for in-pipe wireless sensor networks*, Massachusetts Institute of Technology.

Kostylev, V. E., Todd, B. J., Fader, G. B., Courtney, R., Cameron, G. D. and Pickrill, R. A. (2001). Benthic habitat mapping on the Scotian Shelf based on multibeam bathymetry, surficial geology and sea floor photographs. *Marine Ecology Progress Series*. 219, 121-137.

Lurton, X. (2010). *An Introduction to Underwater Acoustics: Principles and Applications*. (2, illustrated ed. Vol. 4110)Springer, 2010.

Maguire, D. J., Goodchild, M. F. and WRHIND, D. (1991). *Principles and Applications*. Longman.

Majumder, S., Scheding, S. and Durrant-Whyte, H. F. (2001). Multisensor data fusion for underwater navigation. *Robotics and Autonomous Systems*. 35(2), 97-108.

Mark Lawrence GEOPHYSICAL TECHNIQUES FOR MARITIME ARCHAEOLOGICAL SURVEYS. *Wessex Archaeology*. 12.

Mayer, L., Clarke, J. H. and Dijkstra, S. (1998). Multibeam sonar: potential applications for fisheries research. *Journal of Shellfish Research*. 17, 1463-1468.

Mayer , l., J.E. HughesClarke and S. Dijkstra (1997). Multibeam Sonar: Potential application for fisheries research. *Evironmental Data for Fisheries Research and Management*. SWFSC-239, 79-92.

Medwin, H. and Clay, C. S. (1997). *Fundamentals of acoustical oceanography*. Access Online via Elsevier.

Nair, R. R. and Chakraborty, B. (1997). Study of multybeam techniques for bathymetry and seabottom backscatter application. *Nation Istitute of Oceanography*. vol.1(no1), 17-24.

Negahdaripour, S. and Madjidi, H. (2003). Stereovision imaging on submersible platforms for 3-d mapping of benthic habitats and sea-floor structures. *Oceanic Engineering, IEEE Journal of*. 28(4), 625-650.

O’Brien, S., Wiggert, J. D. and Dodd, D. (2013). Development of a Bathymetric Dynamic Digital Elevation Model for the Northern Gulf of Mexico.

Pouliquen, E., Lyons, A. and Pace, N. (2000). Penetration of acoustic waves into rippled sandy seafloors. *The Journal of the Acoustical Society of America*. 108(5), 2071-2081.

Preston, J., Christney, A., Bloomer, S. and Beaudet, I. (2001). Seabed classification of multibeam sonar images. *Proceedings of the 2001 Oceans, 2001. MTS/IEEE Conference and Exhibition*: IEEE, 2616-2623.

Russell, J. L., Stouffer, R. J. and Dixon, K. W. (2006). Intercomparison of the Southern Ocean circulations in IPCC coupled model control simulations. *Journal of Climate*. 19(18).

Satyanarayana, Y., Naithani, S. and Anu, R. (2007). Seafloor sediment classification from single beam echo sounder data using LVQ network. *Marine Geophysical Researches*. 28(2), 95-99.

Snellen, P. D. D. G. S. D. I. M. (2012). *Seafloor Mapping* Netherlands: Delft University of Technology.

Walker, L. J., Wilkinson, B. H. and Ivany, L. C. (2002). Continental drift and Phanerozoic carbonate accumulation in shallow-shelf and deep-marine settings. *The Journal of geology*. 110(1), 75-87.

Wang, K. and Lo, C. P. (1999). An assessment of the accuracy of triangulated irregular networks (TINs) and lattices in ARC/INFO. *Transactions in GIS*. 3(2), 161-174.

Wilson, J. F. (2003). *Dynamics of offshore structures*. John Wiley & Sons.

Yosup Park, S. L., Seomkyu Jung (2011). Characterization of Backscattering Signal of 300kHz Multibeam Echo Sounder *Proceedings of symposium om ultrasonic Electronics*. 32, 289-290.