FINAL PROJECT

GIS AS A TOOL TO INTERPOLATE OFFSHORE SEDIMENTS OF PALM BEACH FOR REGIONAL SEDIMENT MANAGEMENT

Submitted

By

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RESEARCH QUESTION

What are the potential sand source areas in Palm Beach offshore that are good for the regional sediment management projects?

Not all sediments are good for RSM projects like Beach nourishment, dune protection, less beach erosion, utilization of dredged offshore sand etc. Detailed study and understanding the sediment properties is very important for the coastal sustainable environments and communities. So, my research is to specify the offshore locations with potential sand source in Palm Beach for sustainable RSM projects.

1. INTRODUCTION:

A range of sedimentary deposits occurs on the inner continental shelf along the southwest coast of Florida. These available sediment properties and detailed study is required to ensure a cost effective and to create a sustainable environment. The nature of sedimentary deposits determines sand quality and its potential use for the Regional Sediment Management. The offshore region of North Palm Beach has history of availability of offshore sediments and many projects of USGS and USAECE has lot of information on the offshore core data. The availability of sediments itself is not always enough to use those sediments. Each project needs a different specification of sediment property. For example, Beach nourishment project in South East Florida require grain size ranging between 0.12 mm and 0.24mm which is not coarse and have gravel, cobble size sediments. The interpolation methods through GIS will help to estimate the availability of potential sand source and required grain size in the offshore region and further helps to classify them based on their uses and utilization for the Florida beaches and projects.

1.1. STUDY AREA

The study area includes the offshore stretch of 10 miles of Palm Beach in Florida. The study area along the East coast of Florida (as shown in Fig 1) with the data locations indicated by the symbol showing average mean grain size occurs in the Atlantic and Gulf Coast Physiographic Province. The seaward side of the study area contains a portion of the Atlantic continental shelf. The Atlantic margin continental shelf varies considerably in width, gradient, and morphologic complexity over the 1800 miles it extends along the east coast of the United States. Almost all of it is covered by a surficial sand sheet, often with some gravel (Hollister, 1985). South of the former glaciated area, the shelf is characterized by fields of linear, northeast-trending shoals (Duane et al., 1972). The shoals, composed of Holocene sands, rarely attain thicknesses greater than 32 ft and generally rest on horizontal strata of marsh, lagoon, and estuarine deposits. Although there are numerous theories concerning their origin, it is generally accepted that they were formed by nearshore processes (Duane et al., 1972; Hollister, 1985; Walker and Coleman, 1987). The sand data, in the study area are generally well-sorted, medium grained sands that are similar in lithology to present shoreline beaches, which is a good sign of indication for using these sediments in the Florida beach projects

1.2. Regional Sediment Management (RSM)

RSM is a system approach to manage sediments for sustainable projects, environments and communities. A main premise for this RSM Plan assumes that every sand source has a “best use” project or projects based on economics. The best use of a source directly relates to the costs of acquisition and transport. This premise allows for development of a strategy that maximizes the economical use of sources and recognizes the need to maintain a holistic, regional management approach. RSM is management of sediments in order to maximize the natural and economic importance of beach. RSM includes involving many entities for different environments and for different purposes (e.g., enhancing marshes or wetlands or benthic habitats, creating islands or reducing impacts to reefs). It includes the use of off shore sediment for beach nourishment and to restore the beaches to reduce the erosion. It also includes dredging which helps to keep channels of inlands and intracoastal water ways clear and safe for navigation. The main goals of RSM projects is i)to understand the sediment system, ii) keep sediments in the system, iii) reduce unwanted sedimentation, iv) mimic natural sediment processes, v) enhance the environment, vi) protect and maintain infrastructure and vii) create balanced sustainable solutions. The best grain size for the most of the projects in RSM for Florida beaches is grain size greater than 0.12mm and less than 0.24mm. The inappropriate sediment can cause a serious damage to the beach ecology.

1.3. GIS (Spatial Interpolation and Analysing fields)

The data used for the project is point data of mean grain size of the Palm Beach offshore sediments. To interpolate the data and to understand the probability and prediction of certain grain size and to obtain the appropriate analizing layers for the selected area Spatial Interpolation of the data is done. Spatial interpolation technique is used to predict the value of scalar field at unknown locations from the values and locations a set of survey locations or control points. The approaches of surface analysis by proxy polygon, Spatial Average Interpolation and Inverse Distance Weighted interpolation are all deterministic and do not involve statistical theory and doesn’t give the smoother surface due to preferred weightage based on the number lags or lag distance. Whereas approaches like Kriging makes the use of statistical theory and also gives equal weightage to all the data. So, kriging and also Inverse Distance Weighted were preferred over other interpolation methods.

Inverse Distance Weighted Interpolation

This is the most popular approach that makes use of an inverse power or negative exponential function to give more weight to nearby sample values in the calculation of spatial average. Rather than giving most importance to all the points nearest locations are given more prominence in calculating the local mean.

Kriging

Kriging has whole family of methods which are simple, ordinary, universal, block, indicator, disjunctive and co-kriging. Ordinary kriging uses the modelled semivariogram to determine appropriate weights, based on the observed sample values for an estimate of unknown values of a continuous surface. These estimations are statistically optimal, but the method is computationally intensive. The analysing field through geospatial analyst extension produces few plots like semivariogram cloud, histogram and NNQ plots that shows spatial structure and distribution of set of observations.

2. OBJECTIVES

The objectives of the project are to: estimate the area with certain grain size which fit for RSM projects in the study area. And to interpolate the unknown area of the study area and to estimate the availability of the potential sand source in the whole study area. To analyse and to generate surface map to show probability and prediction of grain size not exceeding 0.24 mm threshold.

3. DATA SOURCE

Samples from the beaches of Palm Beach County were collected on May, 05, 2012 and May 06 2012 through Vibra core method. The sample data in the study location are details of core sediment data collected for the project Southeast Florida SAND Study by driller Corps of Engineers-CESAJ. The collected core samples were analysed by Coastal Planning and engineering on May 08 2012. The analysis includes washing the core samples and oven drying. The dried samples were sieved and a data sheet of sand grain size and few statistics like sorting, skewness and kurtosis was prepared. All the analysed data was grouped in Regional Offshore Sand Source Inventory (ROSSI) in Maps section (http://rossi.urs-tally.com/Map). A total of 18 core samples of offshore Palm Beach at different sampling locations were used in the project shown in Table 1.

4. METHODOLOGY

The data point in Table 1 were converter to shape file and graduate symbology was used for mean grain size because the analysis was only done for the mean grain size of the data but not to kurtosis, sorting and skewness. Raster operations like Proxypoly, Inverse Distance

Weighted interpolation, Spatial Average interpolation from Spatial Analyst extension were performed and the best results of interpolation were seen with nearest neighbouring points in Inverse Distance weighted interpolation because Spatial average interpolation treats all included sample locations equally, whereas IDW gives nearer locations more prominence in calculating the local mean. With a variable search radius, the number of points used in calculating the value of the interpolated cell is specified, which makes the radius distance vary for each interpolated cell, depending on how far it has to search around each interpolated cell to reach the specified number of input points. Thus, some neighbourhoods will be small and others will be large, depending on the density of the measured points near the interpolated cell. The specified number of neighbour points produced much better results than fixed distance methods, because in fixed distance method some points are not within the chosen distance of any known sample so some areas of the map were left blank as it was not possible to estimate the whole surface of the study region. While with a specified number of neighbour points method the effective radius which is used in the calculation of each local mean varies based on the density of the points. The areas with densely clustered have reduced radius and with sparse points, the radius is increased which gave a smoother map and leaves the map with no gap. The IDW method with nearest neighbour points shown in Fig 2 given a smooth plot compared to the other Raster Spatial Analyst tools. As the nearest neighbour points increasing at 15 points the map surface is smoother and the power is set to 2 causes the weights drop off faster with distance. Histogram, Normal QQPlot, Trend Analysis, and Semivariogram and Covariance cloud were explored from explore data in Geostatistical Analyst extensions. The Kriging and trend removal models from Geostatistical Analyst extension tool were performed and the results of cross validation statistics were derived. The comparison tool shows the cross-validation statistics. Generally, the best model is the one that has the standardized mean nearest to zero, the smallest root-mean-squared prediction error, the average standard error nearest the root-mean-squared prediction error, and the standardized root-mean-squared prediction error nearest to 1. The mean (-0.02051348), standardized mean (-0.5590447) values are close 0 and root mean square standardized (3.236286) value is not close to one for trend removal model while the mean (-0.026756) standardized mean (-0.1661114) and root mean square standardized (1.528142) for kriging shows values which are close to 0 and 1 respectively. The average standard error is smaller in trend removal but the root mean square and average standard error are close in ordinary kriging. Kriging model is obtained by using the ordinary kriging and set maximum and minimum neighbour search point to 15 and 5 for the spatial interpolation of the grain size patterns of Palm Beach offshore. As per the comparison of the prediction standard errors table (Table 2) for both trend removal and ordinary kriging, kriging produced best fit model. So, kriging is considered as the best fit model for spatial interpolation for the grain size data. The prediction map for grain size patterns was performed using above mentioned parameters in kriging. Standard error and Probability maps for the respective kriging map were projected for the further analysis.

5. RESULTS

The grain size pattern of sediment in state of Palm Beach offshore stretch was shown in Fig 1. The IDW method with nearest neighbour points was shown in Fig 2. From the Geostatistical Analyst Extensions Histogram (Fig 3), Normal QQPlot (Fig 4), Trend Analysis (Fig 5), and Semivariogram (Fig 6) were explored. The Kriging and trend removal models from Geostatistical Analyst extension tool were performed and the results of cross validation statistics are shown in Table 2. As kriging was giving best results the Prediction map for the kriging was performed and shown in Fig 4. Standard error and Probability maps for the respective kriging map are shown in Fig 9 and Fig 10 respectively.

Date	CORE NO	X	Y	Top elevation	Mean (mm)	Sorting	Skewness	Kurtosis
5/4/2012	Core VB-PBC12-29	961773	955997	-37.8	0.12	0.43	-2.9	22.53
5/4/2012	Core VB-PBC12-30	958699	959192	-29.3	0.13	0.69	-4.29	27.58
5/4/2012	Core VB-PBC12-28	961281	951562	-27.6	0.13	0.54	-5.84	53.56
5/4/2012	Core VB-PBC12-26	962588	948466	-30.8	0.12	0.4	-4.2	49.36
5/4/2012	Core VB-PBC12-27	966188	949158	-68	0.24	0.89	-1.29	5.69
5/4/2012	Core VB-PBC12-25	962932	945903	-26	0.13	0.69	-5.64	43.75
5/4/2012	Core VB-PBC12-24	966531	944846	-61.8	0.21	1.67	-1.84	5.13
5/4/2012	Core VB-PBC12-23	964019	941277	-29.6	0.12	0.41	-3.16	26.9
5/4/2012	Core VB-PBC12-22	967083	940781	-59.9	0.12	0.46	-3.34	31.6
5/4/2012	Core VB-PBC12-21	967441	936793	-53.1	0.14	0.38	-3.1	34.33
4/4/2012	Core VB-PBC12-20	966436	932167	-31.3	0.13	0.61	-3.97	25.42
4/4/2012	Core VB-PBC12-19	969311	930154	-59.9	0.13	0.62	-3.75	23.08
4/4/2012	Core VB-PBC12-18	967554	927123	-29.3	0.13	0.55	-3.35	20.44
4/4/2012	Core VB-PBC12-17	970938	923505	-70.5	NA			
4/4/2012	Core VB-PBC12-16	969332	919478	-28.5	0.12	0.4	-2.88	24.57
4/4/2012	Core VB-PBC12-15	977731	914737	-82.7	0.73	1.07	-0.21	3.2
4/4/2012	Core VB-PBC12-14	972527	914459	-63.2	0.13	0.35	-1.03	8.7
4/4/2012	Core VB-PBC12-13	971417	910201	-32.2	0.12	0.5	-2.7	15.69

Table 1: Data points from ROSSI (http://rossi.urs-tally.com/Map).

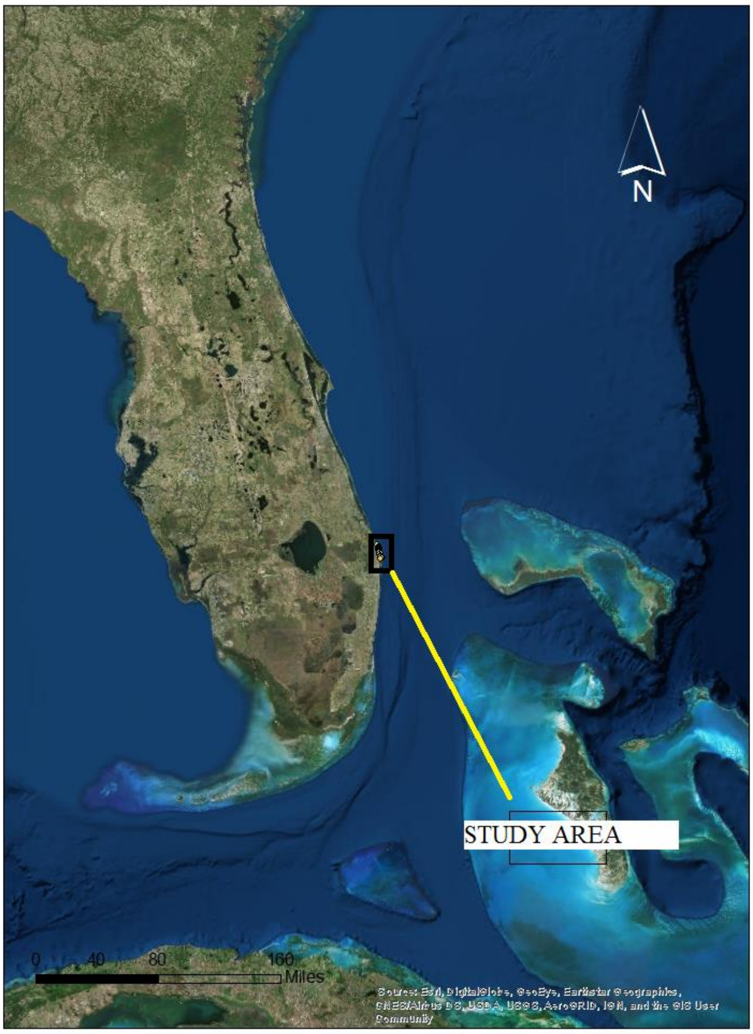

Fig 1 Study are in Palm Beach offshore region.

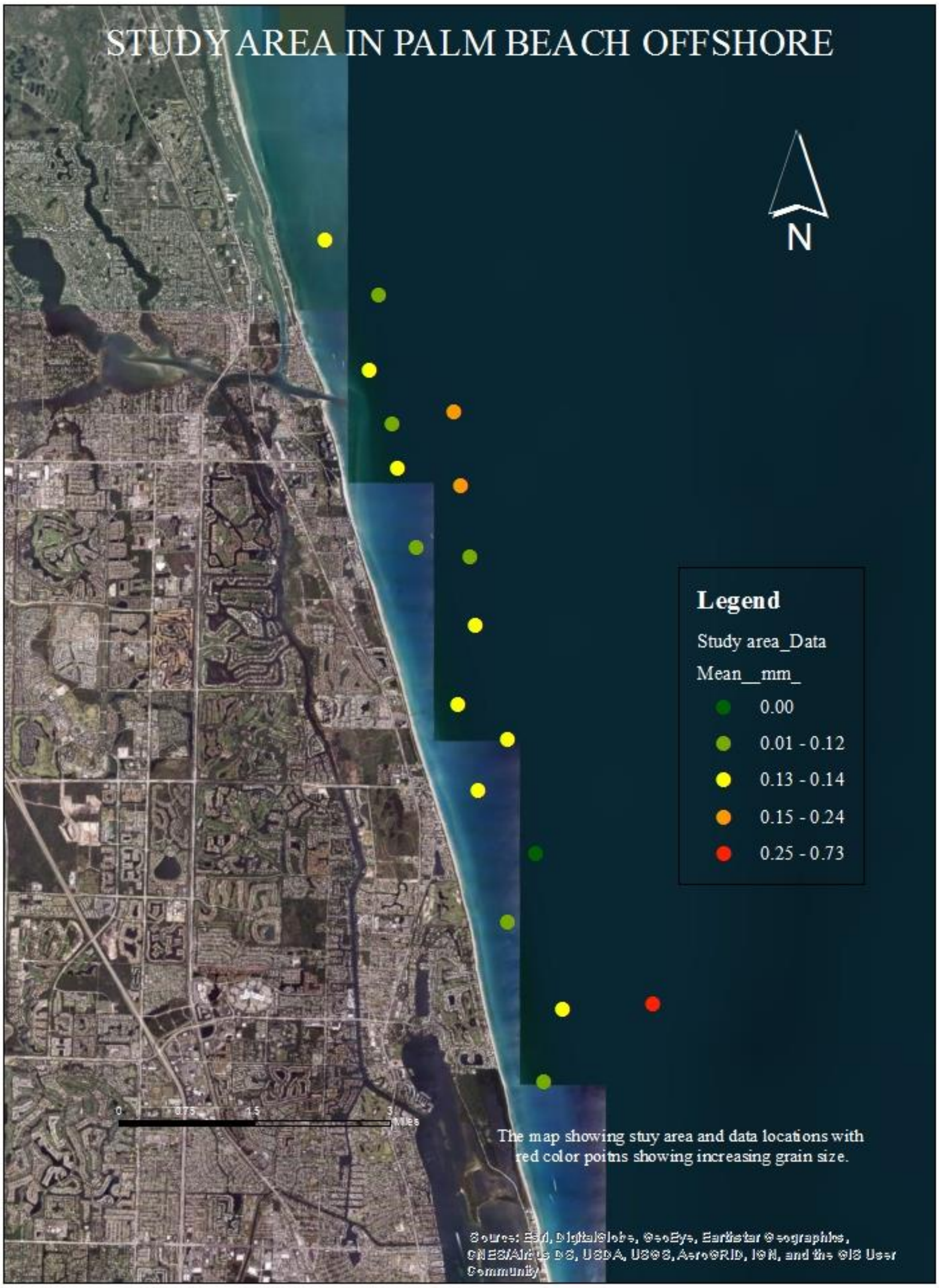

Fig 1: Study area and sample locations showing mean grain size(mm).

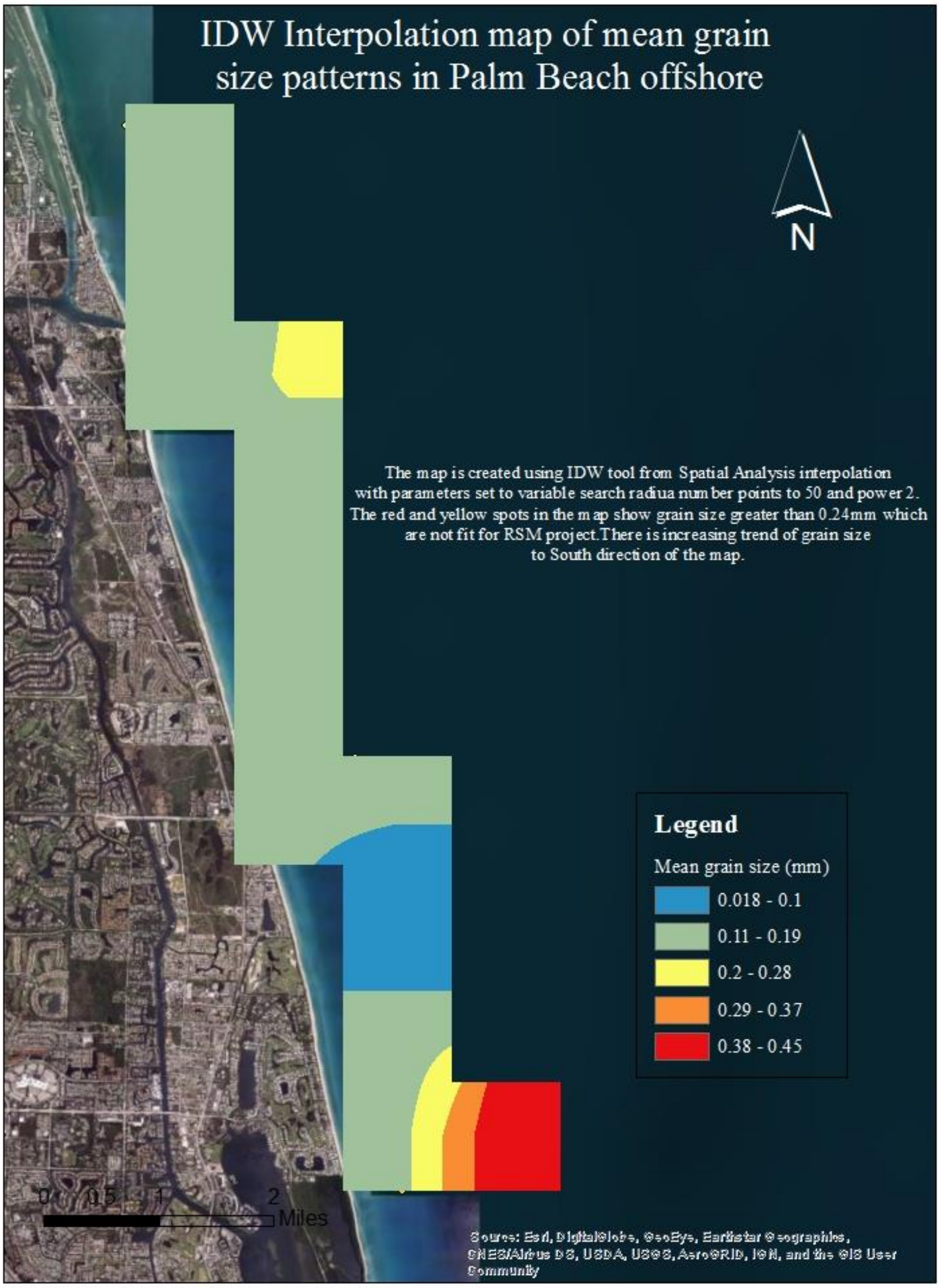

Fig 2: IDW interpolation map (nnp) of mean grain size patterns in Palm Beach Offshore region.

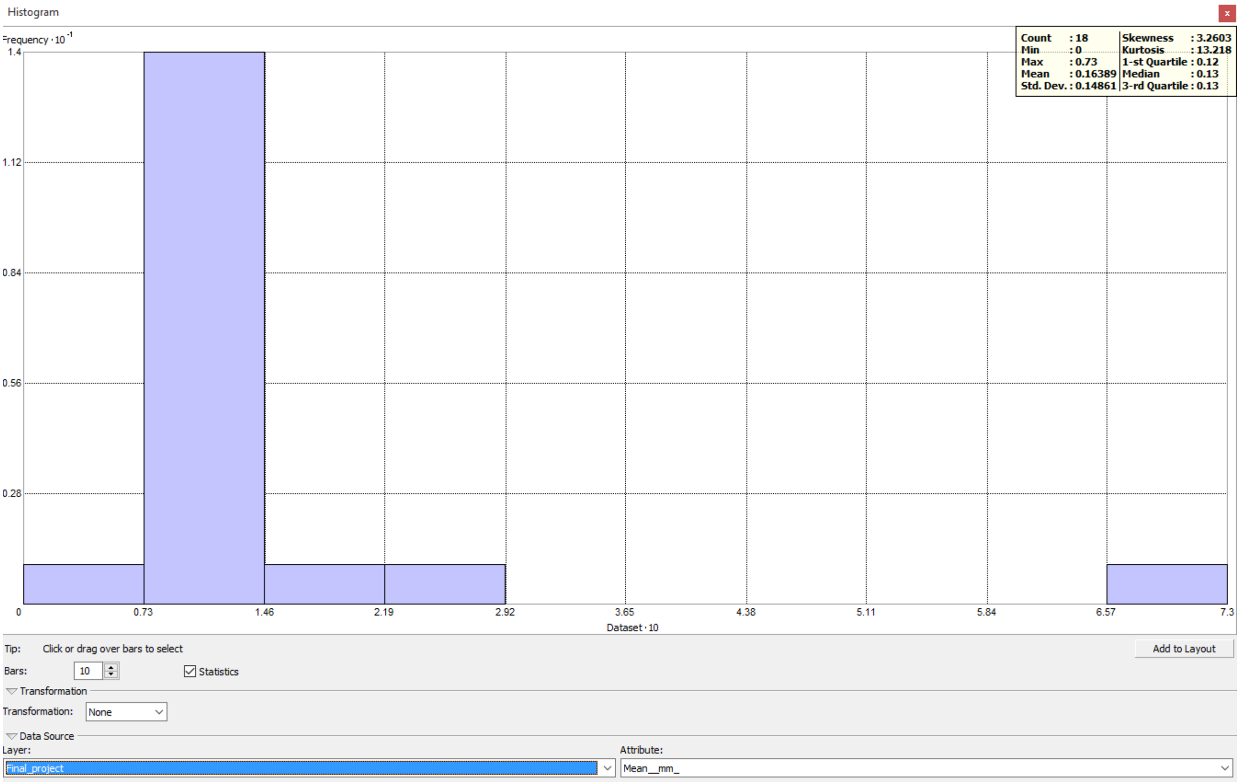

Fig 3: Histogram plot of mean grain size showing right tail indicating right skewed and have positive skewness.

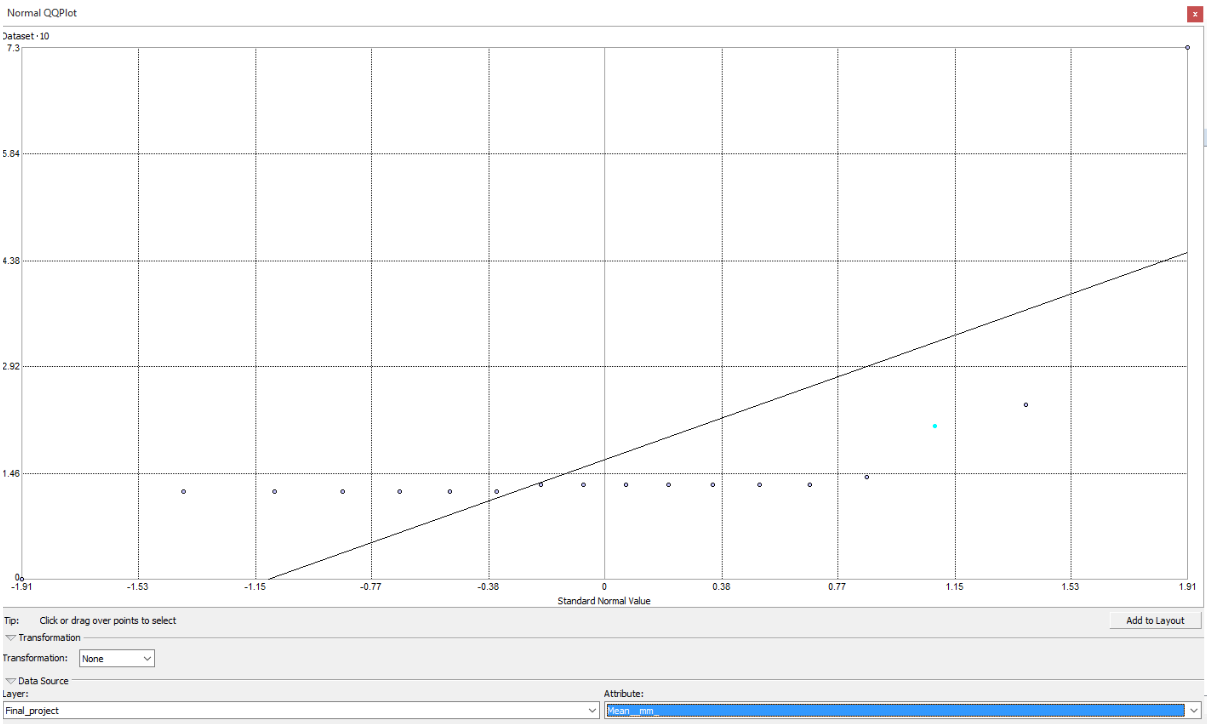

Fig 4: Normal QQ plot showing that the distribution of grain sizes is not normal.

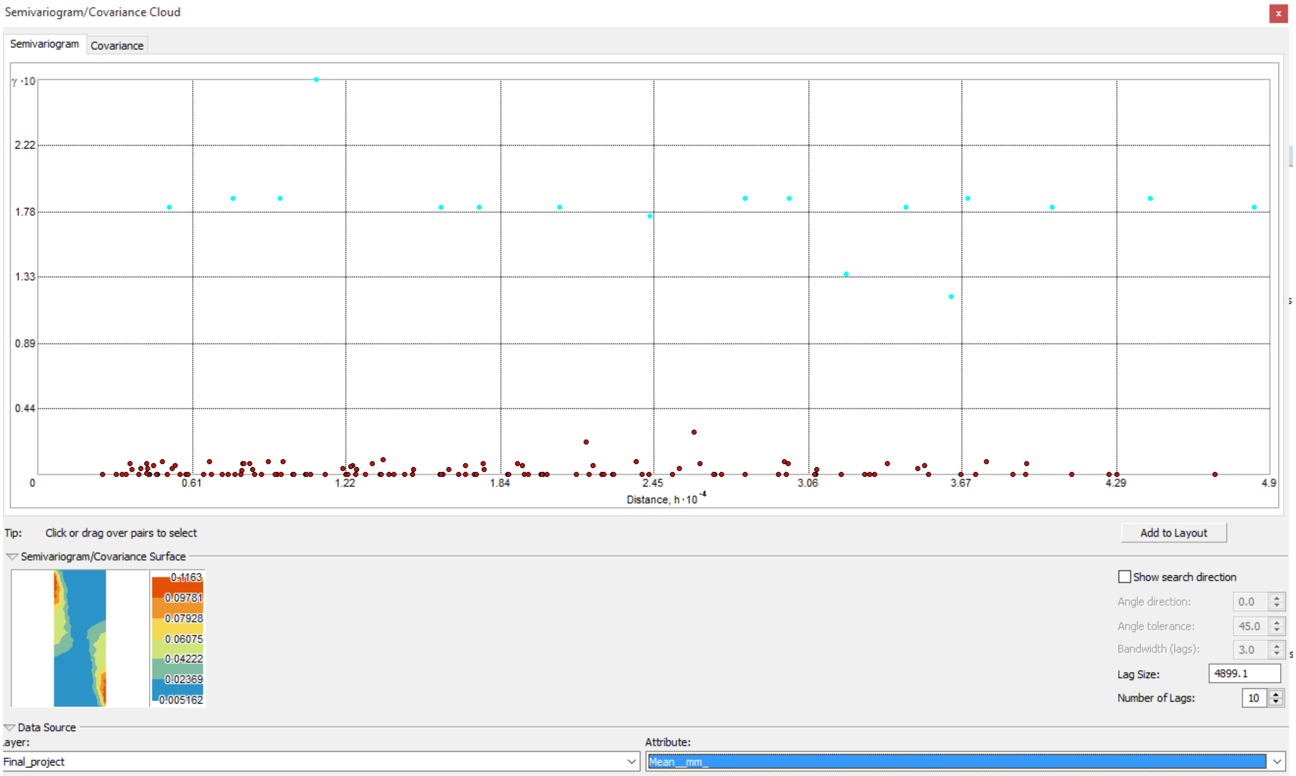

Fig 5: Semivariogram plot for grain size patterns (blue color points indicating negative spatial auto correlation).

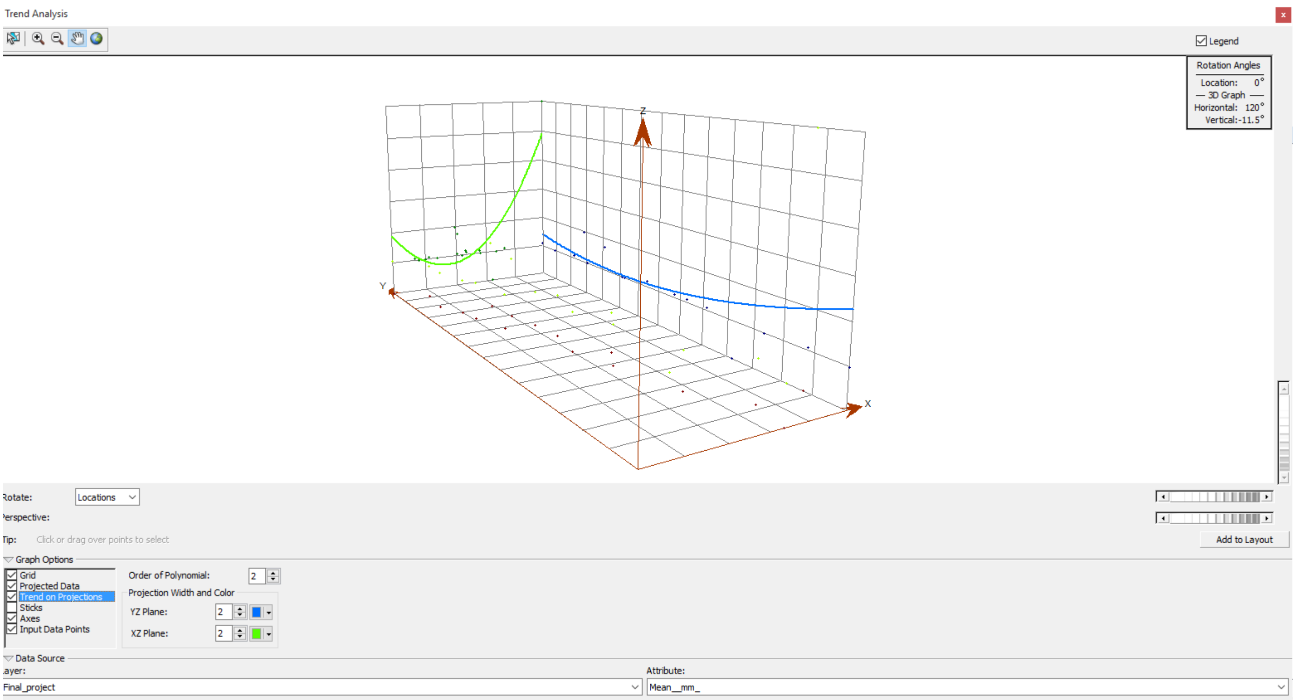

Fig 6: Trend analysis plot: blue line showing YZ plane which is N-S direction anf green line is XZ which is E-W direction showing a polynomial second order and having high trend in E-W direction.

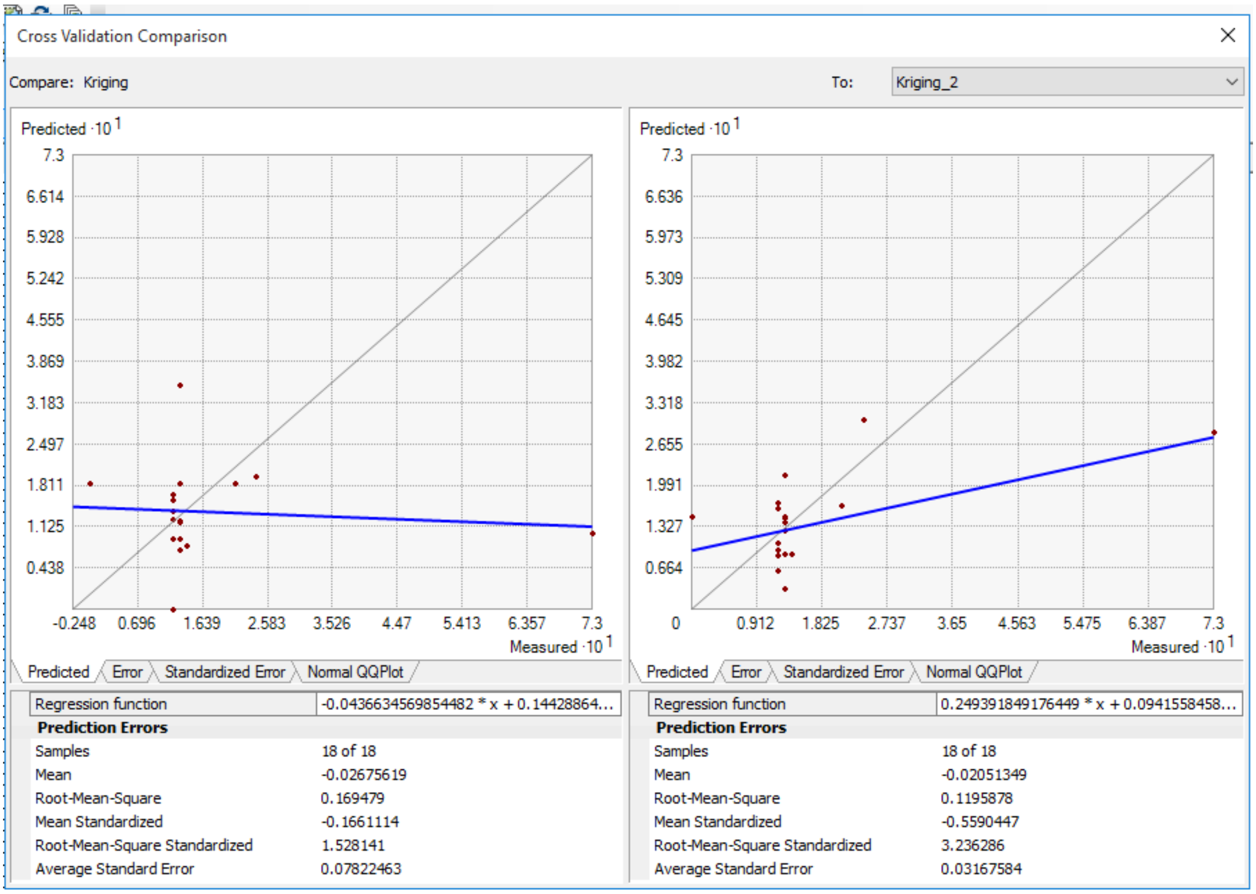

Table 2: Summary of cross validation statistics. The best fit model fo spatial interpolation is ordinary kriging. Mean (-0.026756) standardized mean (-0.1661114) and root mean square standardized (1.528142) for kriging shows values which are close to 0 and 1 respectively. The average standard error is smaller in trend removal but the root mean square and average standard error are close in ordinary kriging. So, ordinary kriging was used as best fit model for the interpolation.

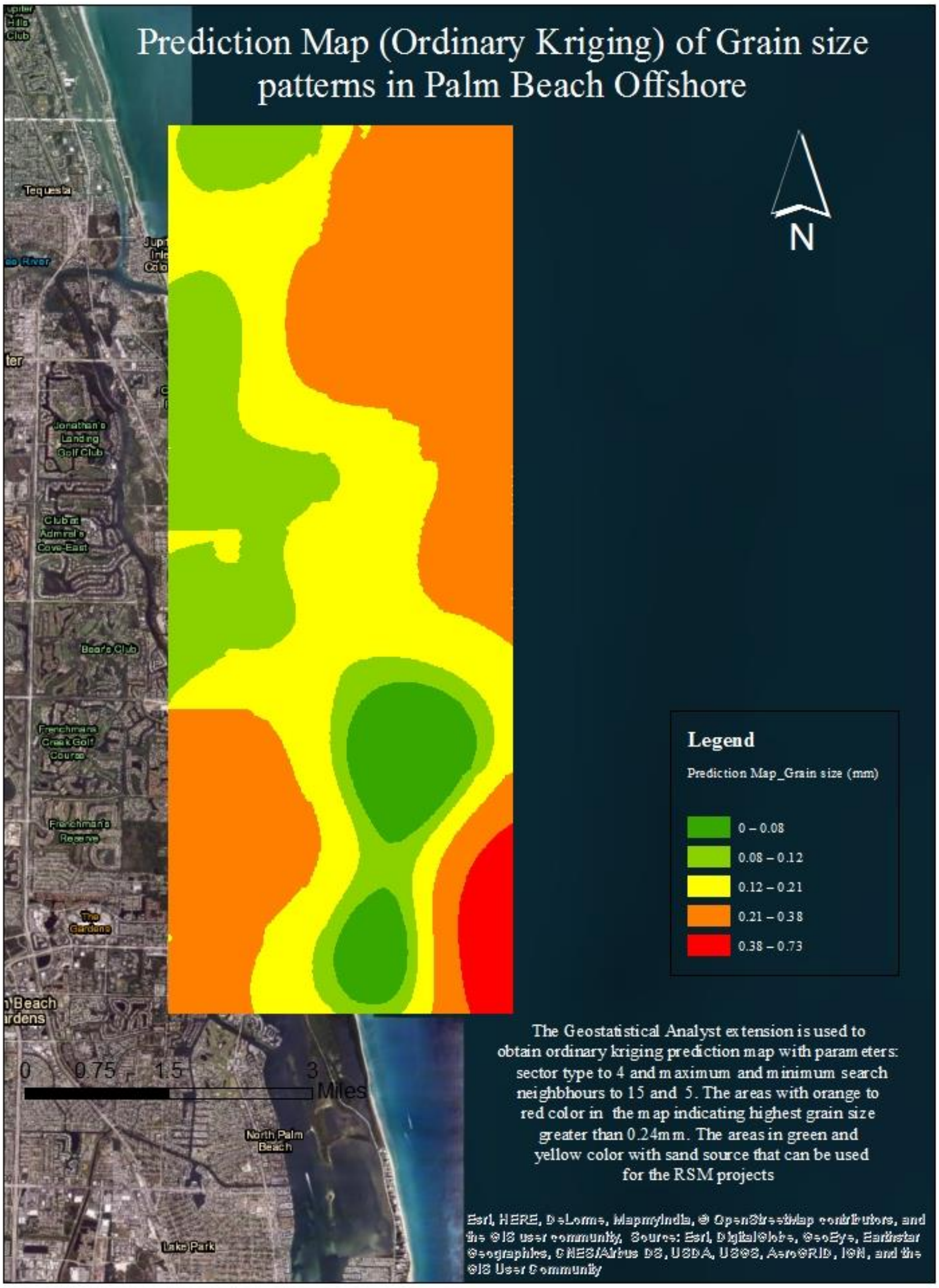

Fig 7: Prediction Map (kriging) of mean grain size patterns in Palm Beach Offshore region.

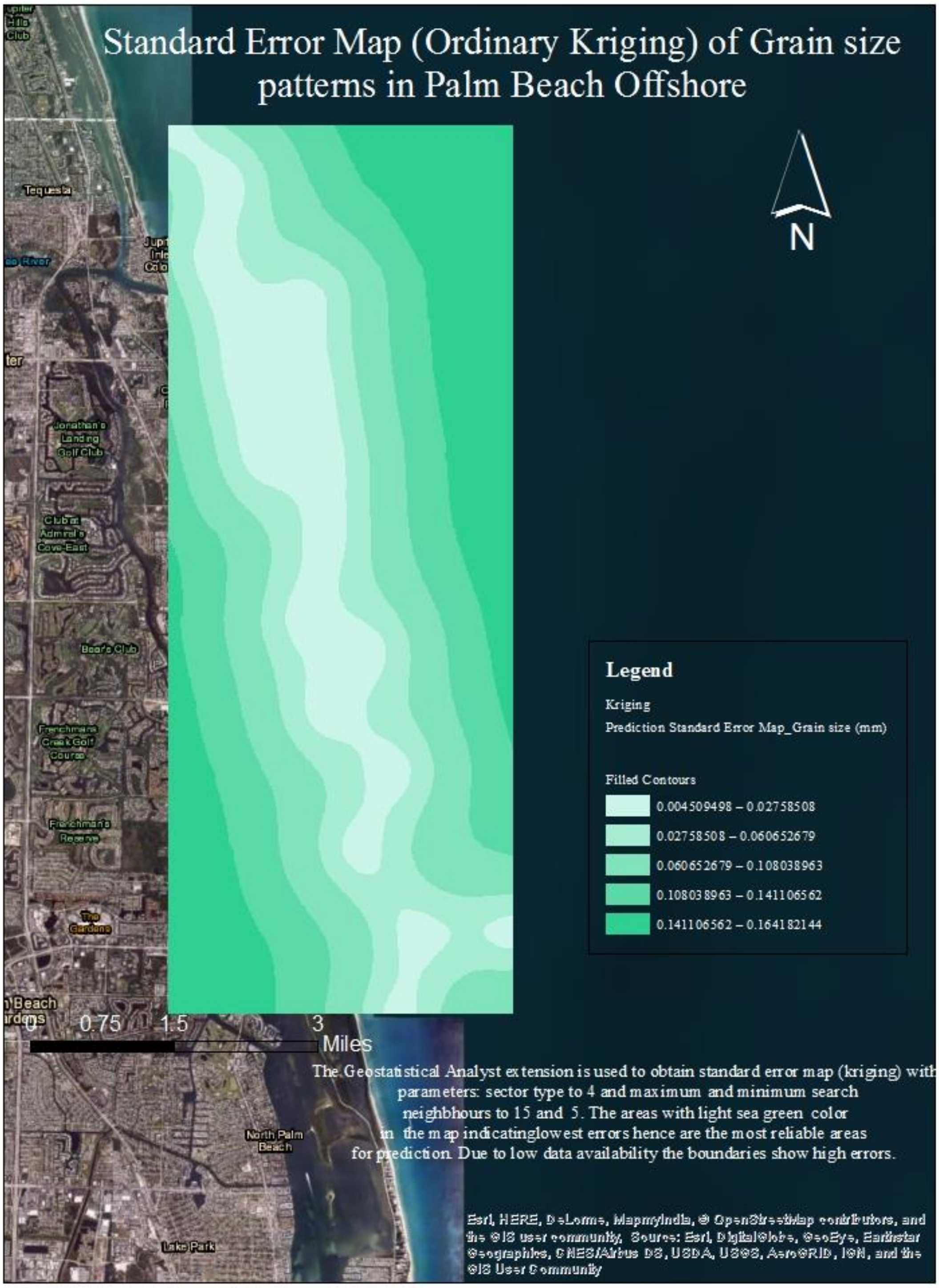

Fig 8: Standard error map (kriging) of mean grain size pattern in Palm Beach Offshore region.

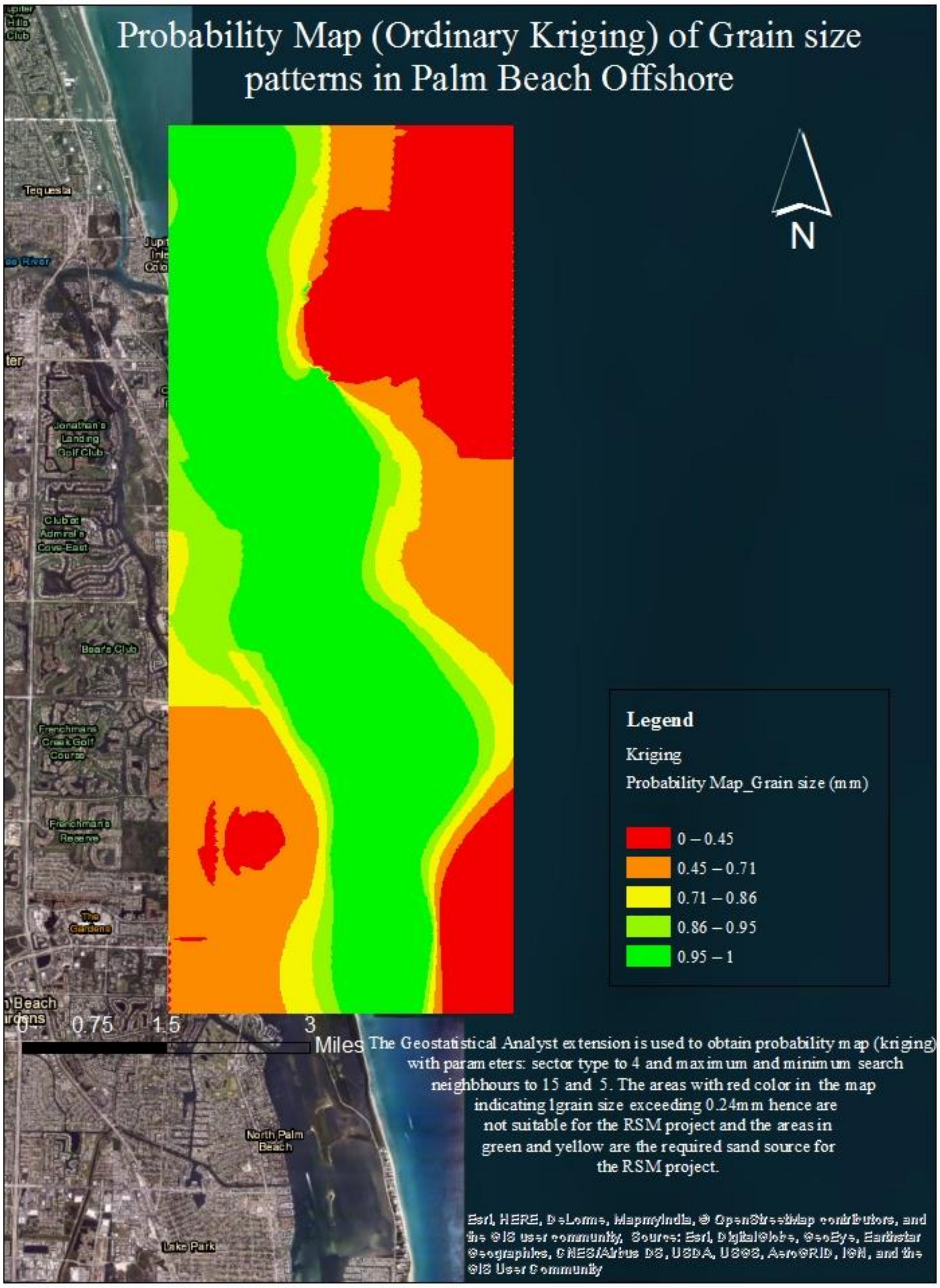

Fig 9: Probability map (kriging) of mean grain size patterns. The region in green are showing the regions not exceeding 0.24mm grain size and potential sand source for the RSM project.

6. DISCUSSION

The IDW interpolation surface shown in Fig 2 shows an increasing pattern of grain sixe towards South in the study. The trend globally in the grain size distribution shows an increasing size patterns towards South from the center as the red hotspots are seen in Fig 2. Histogram (Fig 3) show that the distribution is not normal for the higher values in the data as suggested by the right tail of histogram indicating right skewed and having a positive skewness of 3.2603. Skewness when rounded to decimal one it is 3.2 which is exceeding +/- 0.5 showing that the distribution is not normal. The dynamic linking shows that the lower grain size points are located in the North part of the map. The Normal QQ plots provide another way to examine the normality of a data distribution. The closer the points are to the straight line the closer the distribution is to be normal. In the NQQ Plot (Fig 4) shows that most of the points are farther to line showing not normally distributed. The semivariogram and covariance cloud shown in Fig 5 shows the empirical semivariogram values for all pairs of locations within a dataset and plots them as a function of the distance that separates the two locations, shows the relation between spatial distances and attributes grain size. Each point in the cloud represents a pair of points in the dataset, so the number of points in the cloud will increase rapidly as the number of points in the dataset increases. The points which are above 1.78 in blue color in the Fig 5 indicate a negative spatial auto correlation. The trend analysis provides a three-dimensional perspective of the data as shown in Fig 6. The locations of sample points are plotted on the X-Y plane. Above each sample point, the value is given by the height of a stick in the Z-dimension. In use of Trend Analysis tool provides the values that are then projected onto the X-Z plane and the Y-Z plane as scatterplots. As shown in Fig 6 there are two trend lines blue line showing YZ plane which is N-S direction and green line is XZ plane which is E-W direction. The trend lines show high trends in both directions. The E-W trend line in XZ plane shows highest grain size in East and decreasing towards West which is in “U” shape shows that the best fitting function is a second order polynomial function. The prediction map for the ordinary kriging map is shown in Fig 7. The map shows that there is increasing trend of grain size trend towards NE, SW and SE from centre which is in yellow, orange to red color. The prediction standard error map shows the quality of prediction in each location. The standard error map in Fig 8 shows that the more reliable and trustworthy area to predict is central area of study area as the values of errors are low in the area showing light sea green color. The boundary areas of the study are not reliable due to low data available in the which is the reason for high standard error values and thus are low reliable areas for the prediction. The probability map is shown in Fig 9. The threshold value is set to not exceeding 0.24mm, the area in red color in the map shows areas with exceeding the threshold value of 0.24mm which has low range of grain size and not potential sand source. The regions in green color indicating grain size less than 0.24mm are the potential regions of sand source for Regional Sediment Management projects.

7. CONCLUSIONS AND RECOMMENDATIONS

The spatial interpolation and by analysing fields using IDW and kriging shows the potential sand source for the RSM projects. The overall project shows the regions of center of the study area are the potential sand source with grain size less than 0.24mm, there is more probability to obtain the sand that can be utilized for the RSM projects. Further analysis on kurtosis, skewness and sorting will provide much detailed and refined results to understand the potential sand sources for many other projects. The elevation of the core has also to be taken consideration in further studies to obtain results to estimate the volume hence to prepare a budget plan for the projects based on the potential availability of the sand.

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