

## **Selection of the Dredged Material Disposal Sites in the Turkish Coastal Areas**

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### **Abstract**

Approximately  $5 \times 10^6$  cubic meter of sediment is removed annually from the harbours, ports, marinas and river mouths in Turkey. Uncontrolled dumping of these dredged materials might create contamination based on the assumption that this material is somehow polluted with the human activity related to the surrounding location. Selection of the disposal sites at sea is one of the important steps of dredge material management process described in most of the international conventions.

As part of the ongoing "Dredging Applications and Environmental Management of Dredge Material Project (DIPSTAR)" project, the dredged material disposal sites in Turkish Seas were determined by identifying: (i) the areas prohibited to disposal of dredged material, (ii) the coastal areas which have frequent dredging activities, (iii) behaviour of the dumped sediment and the area of impact determined by STFATE Model (Short-Term Fate of Dredged Material Disposal in Open Water), (iv) the scientific criteria which the candidate dumping sites should fulfil. The candidate dumping sites were separated into two main classes according to the dredged material volume (more or less than 100,000 cubic meters). Physical, chemical, and biological characteristics of the water column and the seabed properties were taken into account in determination of the limiting parameters for different seas of Turkey by the expert group. The scientific criteria about water currents (velocity, direction), distance from coastal area, depth, bottom slope, deep water oxygen, Dissolved Inorganic Nitrogen (DIN), Total Phosphate (TP), chlorophyll-a concentrations and Secchi disk depth were established by expert judgement, using scientific information about the oceanographic characteristics of each sea and recent monitoring/research project results.

Finally 54 dumping sites were determined on the coastal areas of Turkish seas (Aegean 11, Mediterranean 17, Marmara Sea 9, Black Sea 17 sites) for disposal of small and large volumes of sediments accumulated in the coastal sea by natural physical processes.

### **Introduction**

Dredging the excess sediment accumulated in time at locations like ports, harbours and marinas might be required. Dredging activities and resulted dredged material are required to be managed in accordance with the principles considering aquatic ecosystem and sea bottom integration (OSPAR, 2014). In this context, at first, the dredged material should be investigated for its beneficial use. If beneficial usage is not possible and the dredged material is uncontaminated, then it can be disposed/dumped at sea in certain conditions (OSPAR, 2014).

Uncontrolled dumping of dredged material in coastal and marine areas had been a common practice for a long time in Turkey. However, some of the dredged material is contaminated to an extent that major environmental constraints need to be applied when developing management options. Environmental Impact Assessment (EIA) legislation which is the only national legislation for the management of the dredge material for our country is simply inadequate since it does not include any scientific criteria for the limits of contamination, properties of the dumping sites and



monitoring of the dumping region. Selection of the dumping sites is an extensive and extremely complex issue. As it is strongly emphasized by the international guidelines (McIntyre *et al.*, 1982), the physical, sedimentological and biological characteristics of the dumping sites should be considered in order to minimize the possible negative impacts on the living marine resources. One of the conditions to be ensured is the similarity of the selected dumping site with the dredged material properties. Therefore, for example, dumping of the coarse material into the fine-grained biologically productive sea areas is not desirable. In selection of dumping sites "sediment stability" is another important condition that need to be considered (McIntyre *et al.*, 1982). The places where the slope and tectonic activities are high, are risky areas that can lead to massive sediment slips. Therefore such areas are not suitable for dumping.

"DIPtAR" Project aims to remedy the above pointed deficiencies and provide a basis to the Ministry of Environment and Forestry in the preparation of the "National Dredged Material Management Regulation". As a part of the DIPtAR project appropriate locations have been determined for uncontaminated sediments generated during dredging operations and decided to be dumped. The aim of this paper is to explain the dumping site selection methodology and present the proposed dumping locations at the marine and coastal areas of Turkey. Besides different marine features, European regulations, directives, regional conventions (Barcelona, Bucharest, OSPAR and London) and related protocols and guidelines were considered in selection of the disposal areas.

### Material and Methods

IMO Waste assessment guideline and GESAMP reports and studies (no 16) were mainly considered. The dumping site selection processes carried out in this project was summarized in Fig. 1. In this context, the paths followed in determining the dumping sites were listed below:

- Preparation of the national dredged material inventory and the amount of dredged material
- Identification of the marine areas which will be prohibited for the dredged material dumping
- Determination of the boundary conditions the dredged material to be discharged into disposal sites
- Determination of criteria according to the specific physical, chemical and biological conditions of our seas
- STFATE (Short Term FATE of dredged material) model was used in order to simulate horizontal and vertical behaviour of the dredged material in different conditions.
- Revision of the designated areas with outer experts (marine biology, chemistry, geology and physics, experts on benhos and fisheries) and stakeholders (NGOs, harbour managers, fishermen, municipalities etc.)

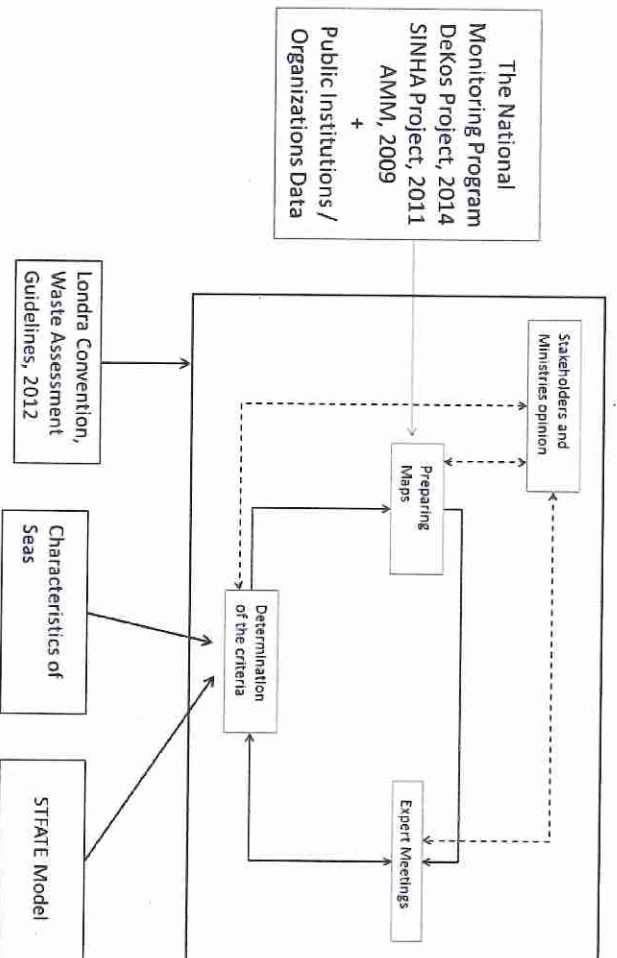


Fig. 1: Dumping site selection process for marine areas (DIPTAR project)

### GIS Data Layers

GIS (Geographical Information System) is a preferable and widely used technology for decision-making process especially in site selection problems requiring spatial analysis. The data layers used in this study were created within the framework of the following projects, "Determination and Classification of Quality Status of Marine and Coastal Waters", "Urban Wastewater Management Along Coastal Areas of Turkey", "Constitution of the Emergency Response Centres and Determination of the Present Situation of the Turkish International Waters for the Feasibility Works" and the ongoing "Dredging Applications and Environmental Management of Dredge Material Project (DIPTAR)", Table 1 list the data provided from institutions/organizations and Ministries (The Ministry of Food, Agriculture and Livestock, the Ministry of Energy and Natural Resources, the Ministry of Transport, Maritime Affairs and Communication, General Directorate of Mining (MIGEM), Department of Navigation, Hydrology and Oceanography,) and the GIS layers created for the identification of prohibited areas for disposal of dredged material. ESRI ArcGIS v. 10 software was used for creation, analyses and mapping the results.

### *Inventory of the Dredging Operations*

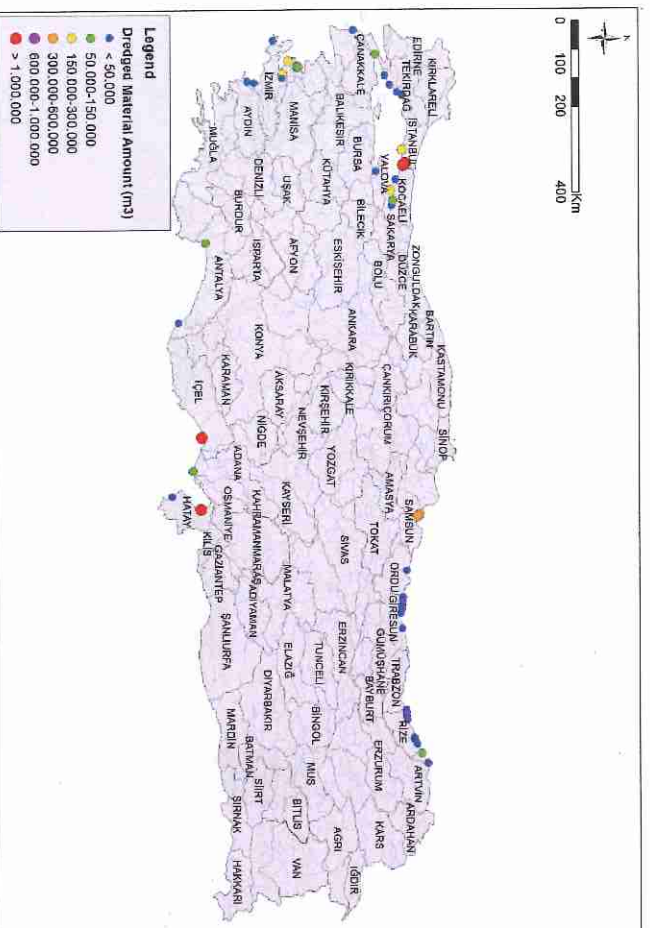
Information about the dredging operations on the coasts of Turkey (up to 2012) was obtained from the Ministry of Transport, Maritime Affairs and Communication. It is clear that the most intense dredging works are operated on the Eastern part of the Black Sea, Northern Shelf of the Marmara, and mostly in the gulfs of the Aegean and Mediterranean Seas (Fig. 2).

**Table 1:** CBS Data Layers Information

Data	CBS Data Layer Created
Areas of fishery and shellfish (commercial and recreational purposes)	Fish Farms
Spawning, feeding and reproduction areas and important fishery migration routes	Prohibited Areas for Fishing
Migration routes of sea mammals	Not provided
Protected Areas (Coral Reef areas, sea grass areas, etc.)	Sea Grass
Renewable Energy Areas	Not provided
Seabed Usage (mineral resources, etc.)	Seabed Pipelines/Cables
Coastal Areas	Petroleum Platforms
Courses	AIS data
Military and Archeological Areas	Training and Exercise Areas

Maintenance dredging and dredging at fishing ports constitute the major part of the dredging operations performed in our country. Besides, significant amount of sediment material have been dredged during the enlargement works at the harbours and the establishments of new maininas.

However amounts of dredged material generated from maintenance dredging works and dredging at fishing ports are generally at low levels. Disposal ways and frequency values obtained from the inventory of dredging works performed in our



**Fig. 2:** Amount of the sediment material generated from dredging operations at the coastal area of Turkey



## **Results and Discussion**

Dumping operations may harm environment, especially when they take place near recreation or commercial districts. Dumping causes an irreversible biological impact on the benthic organisms which are important for the marine food chain or leads to the release of major pollutants such as heavy metals and hydrocarbons.

In order to define the conditions under which a permit for the dumping of dredged material may be issued, a process for evaluating the physicochemical characteristics and toxicity of that material in relation to the protection of marine environment and human health should be followed with a parallel consideration of the amenities and economical and commercial human activities which could be affected (Kapsimalis *et al.*, 2010). Within the scope of the study, the selection of dumping sites in the Turkish coastal and marine areas are principally based on the following principles; they should have limited space and hydro-dynamical, typological and bio-geo-chemical properties that be influenced at the lowest levels from disposal of dredged materials having varying non-toxic geochemical properties. In order to select adequate dumping sites in the coastal area, the determined criteria (Tolun *et al.*, 2015) should be ensured based on quantitative measurement data obtained in the sea.

The enclosed seas surrounding Turkey have different hydrographic, biological and geo-chemical properties. Moreover, dredged materials have different geo-chemical properties and with various chemical pollutants of different origins. In order provide the above requirements in the selection of disposal sites, the criteria listed below have been taken into account: Total volume and geo-chemical properties of non-toxic dredged materials (sediments) are considered to be the first criteria in selecting disposal sites in the sea. Dredging material with more than 100,000 m<sup>3</sup> of total volume are evaluated in a different category.

- Dredged materials with volume lower than 100,000 m<sup>3</sup>, exhibiting natural geo-chemical properties with low levels of contaminants and greater sand content (> 40%) are adequate for dumping to coastal sea areas with similar surface sediment properties with dredged materials
- All the disposal areas should not have rocky and sloping base in order to keep dumped material within limited area and similar bottom properties. Disposal site to be determined should be at a distance to prevent dumped materials to reach the coast by currents and waves (minimum distance: at least 1 mile)
- The upper layer hydro-dynamical and bio-chemical properties of the selected dumping sites are preferred to have low levels of nutrients and thus algal production (low nutrients, chl-a) and fisheries (low fish stock, low organic matter for feeding). The oxygenated lower layer properties should be within seasonal mixing zone for seasonal ventilation of water column having seasonally varying temperature (with the expectation of two-layer system such as Marmara Sea).
- In the Black Sea near-bottom waters are preferred to anoxic (total depth >200m) to minimize effects of dumping on the thermocline properties of the shelf waters (< 150-200m) where copepods inhabits under low-level oxygen conditions.

- The total depth should be greater than 2-fold Seki disk depth ( $>2 \times \text{SDD}$ ) measured in dry season (the period of low production and greater rates of light penetration) to save the areas covered by all seabed plants needing sufficient solar light to grow.
- According to the results of STFATE- spreading-sedimentation model applications in the two-layer marine system, the upper layer current should be less than 50-60 cm/s in the dumping sites to prevent dispersion of small-grain size solid materials (sediments) to transport distant points. The near bottom circulation should be strong enough to keep the bottom water oxygenated (short renewal time), where the total depth is preferred be less than 250m to keep the dumped material in the dumping site and reduce dispersion of sediments in the water column after dump. Distance of at least 3 mile criteria is applied for non-toxic dredged materials over 100,000 m<sup>3</sup>, with low % of sandy materials and moderate levels of chemical pollutants. In this areas total depth should be greater than  $2 \times \text{SDD}$ .

In the selection of dumping sites in Turkish coastal sea, the above criteria have been taken into account. In the two-layer Marmara Sea, dumping dredged materials should be possible only to the oxygen deficient lower layer. Therefore, the dumping sites were determined in the coastal zone having much shorter residence time compared to the deep basin.

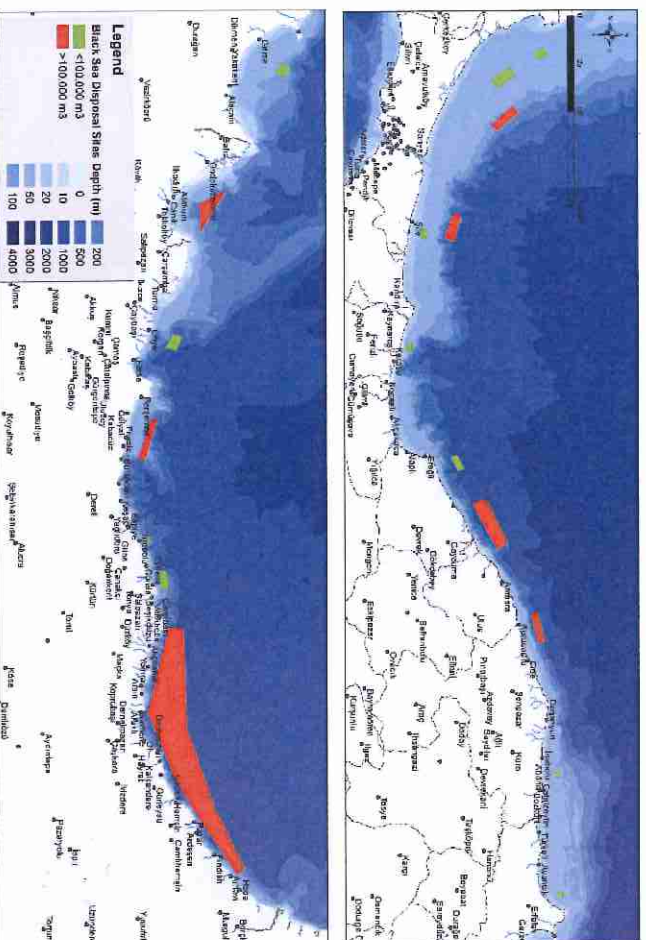


Fig. 5: Designated Disposal Site of Turkey Black Sea



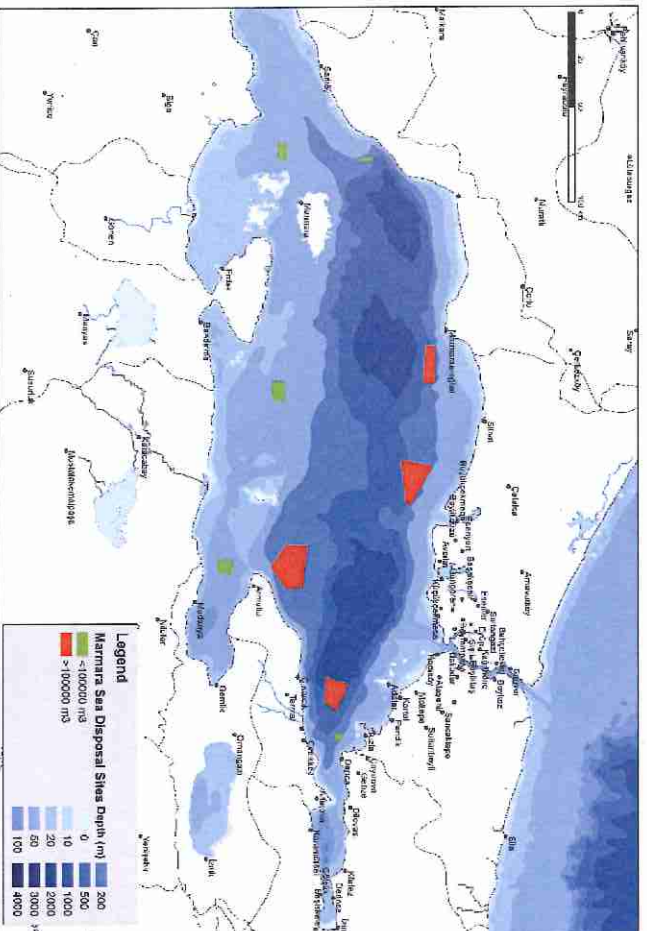


Fig. 6: Designated Disposal Site of Turkey Marmara Sea

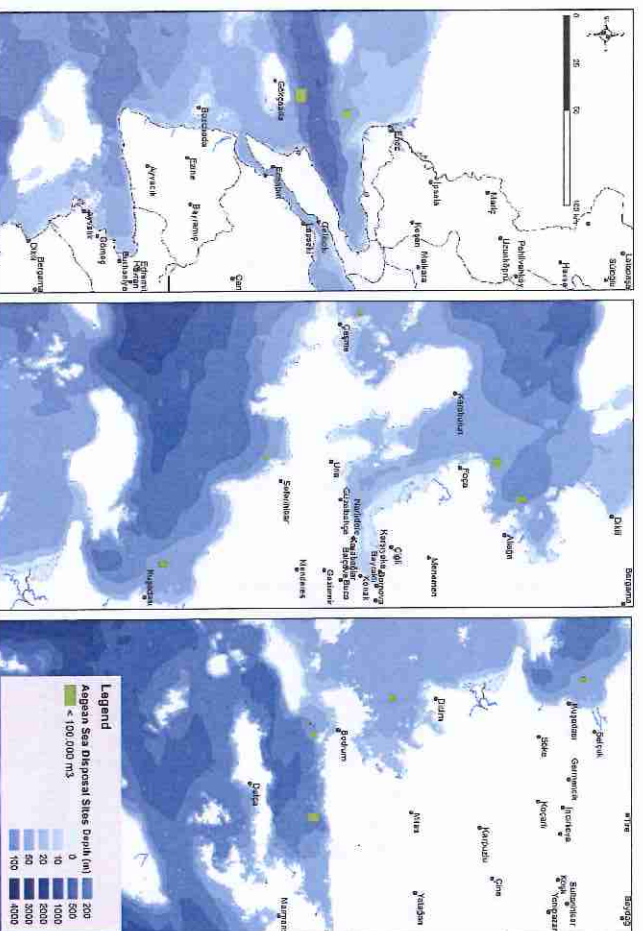


Fig. 7: Designated Disposal Site of Turkey - Aegean Sea



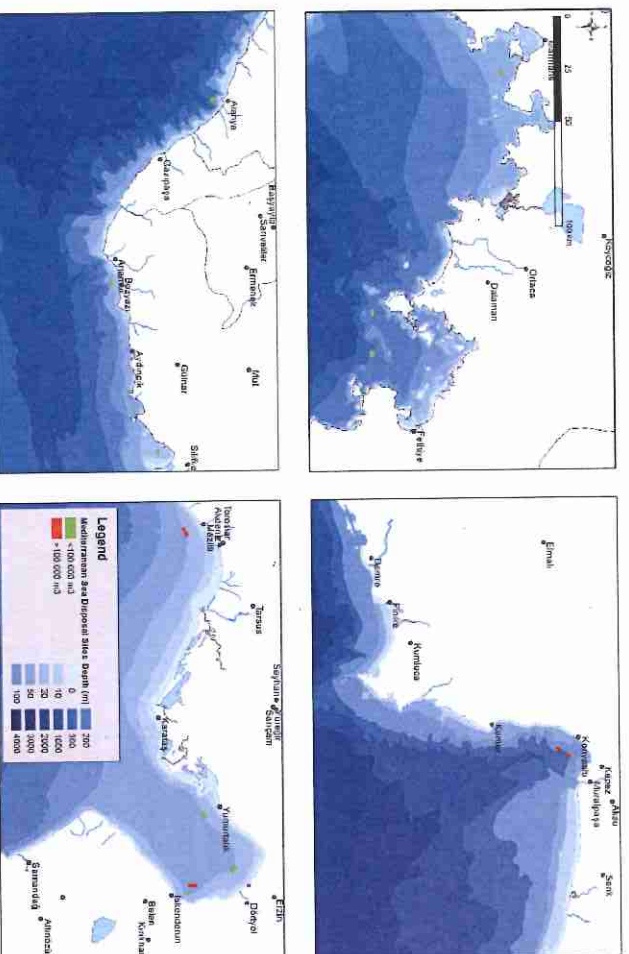


Fig. 8: Designated Disposal Site of Turkey - Mediterranean Sea

## Conclusion

Coastal line length of Turkey is 8484 km. In proportion to the length of the coastal line and the number of marinas and harbours, dredging operations take place at coastal areas increase in the last years (Tolun *et al.*, 2015). Specifically at harbours, fishing ports and river deltas, accumulations should be regularly moved away by dredging.

Within the scope of this study, adequate disposal sites for dumping non-toxic dredging material with low/moderate levels of pollutants to seas were selected principally based on the criteria defined in GESAMP Guide.

This study illustrates the preliminary results of the selection of possible dumping sites of sediment materials dredged from harbours and marinas located in Black Sea, Marmara Sea, Aegean Sea and Mediterranean Sea of Turkey. The selection criteria defined for new dumping sites are hopefully to save natural resources and reduce chemical pollution in our seas.

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