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Guideline on the adaptive criteria for monitoring of the maritime activities

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1. Guideline for offshore environmental monitoring in the Black Sea

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Introduction

In Romania, one of the oldest oil and gas producers globally, discussions and prospects related to offshore oil and gas activities were first initiated in 1967- 1969 to enhance the national oil and gas production through potential offshore drilling and exploitation of the Black Sea continental platform. Consequently, in 1975, the first offshore drilling platform was installed, leading to the first Black Sea oil production in 1987. Despite this relatively long history of upstream offshore activity in shallow waters, it was only in 2012 that the first deep-water discovery was made in the Black Sea when Domino-1 well found an estimated 42 to 84 billion cubic meters (bcm) of potentially recoverable gas, thus becoming the largest single discovery in the Black Sea, as of today (Deloitte, 2018).

In 2016, around 8% of crude and condensate was produced offshore, and the rest - onshore (Eurostat, Supply, transformation and consumption of oil - annual data)[1]. Companies currently undertaking exploration activity offshore are OMV Petrom, Romgaz, Black Sea Oil and Gas (Carlyle), Petromar Resources, Petro Ventures, Gas Plus International, and international majors ExxonMobil or Lukoil (Romanian Black Sea Titleholders Association, www.rbsta.ro/en). Significant discoveries were made public in 2012 by OMV Petrom-ExxonMobil, with 42 to 82 bcm of natural gas estimated to be available in the Neptun Deep perimeter and 2015 by Lukoil, PanAtlantic and Romgaz with 30 bcm in the Trident perimeter. Romania's offshore perimeters are to be connected with the national transport system through the Tuzla-Podisor pipeline. The national gas transmission system operator, Transgaz, has applied for the environmental agreement's issuance. The pipeline will be linked to the BRUA corridor at Podisor and is expected to be completed by 2020[1].

Early in 2019, Black Sea Oil and Gas announced a final investment decision to develop its gas finds in the Black Sea. In 2020, Exxon Mobile announced its decision to withdraw from its Romanian offshore operations. The OMV Petrom-ExxonMobil venture's investment decision has been postponed for several years due to the negative impact on investment of the Offshore Law (Law 256/2018). In 2020, the government expressed that a revision of the Offshore Law (Law 256/2018) to accommodate some investor dissatisfaction can only be pursued once there is a "high consensus in Parliament"[1].

Monitoring programmes intend to show whether the environmental status is stable, deteriorating, or improving due to the operators' activities. In addition to identifying trends, the results should, as far as possible, provide a basis for projections for future developments. Environmental monitoring of offshore oil and gas activities includes monitoring the water column and benthic habitats (sediments and soft- and hard-bottom fauna). Operators and authorities use the monitoring results as a source of information and decide on new measures to be implemented offshore (KLIMA, 2011).

The Guideline on the adaptive criteria for monitoring the maritime activities impact deals with the required scope of the monitoring activities, the parameters to be analysed, the methods that should be used, the necessary accreditation, and the templates for reports.

The Guideline is a comprehensive GIS-based tool for the NW – W – S Black Sea region covering specific areas (substrate, habitat, Natura 2000, etc.) and carried out or potential activities. Each activity's potential impacts will be also delivered and, accordingly, the recommended monitoring and assessment programme. Suggested applicable monitoring methods for each of the identified sources which influence the marine habitats will be available.

The Guidance aims to improve the effectiveness of monitoring activities through the following topics:

- evolution of data needs throughout the lifecycle of an exploration or exploitation project.
- measurement variables and sampling techniques that may be addressed in monitoring programmes according to habitats, activities and impacts.
- data management and quality assurance methods to improve confidence in monitoring results and ensure the long-term usability of data.

1.1. National legislation and environmental concerns

The main pieces of legislation governing oil and gas exploration and production are the Petroleum Law (Law No. 238/2004, as amended) (Petroleum Law) and its implementation norms approved under Government Resolution No. 2075 of 24 November 2004. These reflect the implementation of Directive 94/22/EC on the conditions for granting and using authorisations for the prospection, exploration and production of hydrocarbons. Another important legislation recently adopted is Law 256/2018 on specific measures necessary for implementing petroleum operations by offshore block license holders (Offshore Law).

According to the methodological norms for the application of the Petroleum Law approved by Government Decision No. 2075/2004, exploitation works can only begin after obtaining the environmental agreement and providing the necessary conditions for the capture of petroleum, disposal of wastewater, and, if necessary, flaring of the associated gas.

Investors may be required to obtain certain environmental administrative acts issued by the Environment Protection Agency in connection with the development, construction and operation of petroleum infrastructure and facilities, as follows:

(1) the environmental permit is required for plans and programs which may have an impact on the environment; an environmental assessment (SEA) may be necessary;
(2) the environmental approval is required for construction of projects which may have an impact on the environment (as a prerequisite for obtaining the building permit for construction works); an environmental impact assessment (EIA) may be necessary;
(3) the environmental approval is required for construction of projects which may have an impact on the environment (as a prerequisite for obtaining the building permit for construction works); an environmental impact assessment (EIA) may be necessary; and
(4) the integrated environmental authorisation is required to carry out certain activities that have an environmental impact (such as energy, production and processing of metals, mineral, chemical and waste management).

The relevant legislation does not set out time limits for the issuance of the environment acts as an overall process, but only for specific stages – timing depends very much on the cooperation between authorities and the complexity of the project or plan. The mentioned environmental procedures are subject to public debate and may require an environmental study to determine potential issues deriving from the proposed plans or projects' environmental effects and impact.

For hydrocarbons exploration, the National Environmental Protection Agency decides, on a case-by-case basis, whether an EIA is required and if the activities are likely to have significant environmental effects. However, an EIA is mandatory for the extraction of petroleum when the extracted amount is of minimum 500 tons of oil/ day or 500,000 cubic meters of natural gas per day. Moreover, an EIA is mandatory for oil or gas transportation pipelines with a more than 800 mm diameter and a length of more than 40 km.

The Environmental Impact Assessment (EIA) procedure is governed under Law 292/2018 to assess public and private projects' impact on the environment. An EIA is mandatory in the following oil and gas-related projects:

- Crude-oil refineries (excluding undertakings only manufacturing lubricants from crude oil) and installations for the gasification and liquefaction of minimum 500 tonnes of coal or bituminous shale per day;
- Extraction of petroleum and natural gas for commercial purposes where the amount extracted is at least 500 tonnes per day of petroleum or 500,000 cubic metres per day of gas.
- Pipelines with a diameter of more than 80 cm and a length of more than 40 km for the transport of gas, oil and chemicals and the transport of CO_2 streams for geological storage, including related auxiliary stations;
- Installations for the storage of petroleum, petrochemical or chemical products with a capacity of at least 200,000 tonnes;

For other projects, the National Environmental Protection Authority (ANPM) must decide whether an EIA is required based on established thresholds/criteria or case by case examination. The EIA report is performed by authorised third parties, natural persons or legal entities that are acting independently of the titleholder of the project.

The EIA procedure is led by the central and territorial authorities for environmental protection and is achieved with other public central or local authorities' participation, organised under the Technical Analysis Committee.

EIA stages

The EIA process is preceded by a preliminary stage (initial evaluation stage) when the ANPM establishes the project's area concerning protected natural areas of community interest.

Within fifteen days of receiving the notice of the intention to develop the project, the ANPM evaluates whether the project needs to be subject to EIA procedure. If so, ANPM informs the project's titleholder of its decision on whether the EIA procedure is required and, if necessary, requests a presentation memorandum.

After the completion of the initial evaluation stage, the EIA procedure is carried out in three main phases:

1. Screening stage. At this stage, the ANPM may decide, either to:
   - conduct an EIA and an appropriate assessment;
   - conduct the EIA without the appropriate assessment;
   - perform the appropriate assessment only; or
   - continue the procedure required for issuing the development approval.
2. Defining the assessment domain and the environmental impact report. At this stage, ANPM provides the titleholder of the project with the guidelines on the main environmental issues that will be analysed in the environmental impact report, considering the proposals advanced by the public regarding the content of the report.
3. Analysis of the report. In this stage, the environmental impact report is made available to the public for consultation for a minimum period of 30 days and, afterwards, is subject to a public debate organised by the titleholder of the project.

After the environmental report is issued, ANPM must consider the Technical Analysis Committee's recommendations and grounded observations from the interested public. The term for completing the EIA procedure is about six months.

Other environment-related permits may be necessary for the construction and operation of petroleum infrastructure, such as a water management permit and authorisation (issued by the local or central water basin administrations).[1] These permits are accompanied by monitoring programs for compliance checking. The purpose of offshore environmental monitoring is to provide an overview of environmental status and trends over time due to oil and gas activities.

Monitoring programmes intend to show whether the environmental status is stable, deteriorating, or improving due to the operators' activities. In addition to identifying trends, the results should, as far as possible, provide a basis for projections for future developments. Environmental monitoring of offshore oil and gas activities includes monitoring the water column and benthic habitats (sediments and soft- and hard-bottom fauna). Operators and authorities use the monitoring results as a source of information and decide on new measures to be implemented offshore.

The results will also be used to develop and report national environmental indicators for the offshore oil and gas industry (KLIMA, 2011).

[1] https://www.volciucionescu.com/energy-oil-gas-in-romania/#section5

1.2. Environmental risks linked to offshore activities

There are many potential environmentally harmful processes during human activities, from physical/mechanical damage to pollution from contaminants and oil leakage to smothering by sedimentation and enhanced noise/vibration. By implementing risk-based environmental monitoring, work can be carried out efficiently at low risk for the environment. Thus, it is essential to monitor the different effects on the surroundings before, during and after the activity is closed. Environmental monitoring must be carried out within a clear framework to provide good results. The oil and gas industry is global, with operations conducted in every corner of the world since the worldwide increase of energy demand has raised the exploitation of non-renewable resources (Trabucco et al., 2012).

a) The offshore activities comprise different phases linked to the exploitation of gas and oil reservoirs: a) the exploration phase to probe the position and the geological characteristics of well and then to install a steel platform;
b) the production phase to extract oil and gas;
c) the decommissioning phase when the commercial life of the well is finished (Oil Industry International Exploration & Production Forum/United Nations Environment Programme, 1997)(Borthwick, 1997).

Oil and gas exploration and production operations have the potential for a variety of impact on the environment, depending upon the stage of the process, the nature and sensitivity of the surrounding environment, pollution prevention, mitigation, and control techniques. With regards to the aquatic environment, the principal problems are linked to the presence of the offshore structures and then to waste streams of drilling fluids, cuttings, well treatment chemicals and produced waters (Neff, 1987; Neff et al., 1992; Osenberg et al., 1992; Olsgard & Gray, 1995; Commission protecting and conserving the North-East Atlantic (OSPAR), 1999, 2009; Peso-Aguiar et al., 2000; Barros et al., 2001; Pinder, 2001; Cicero et al., 2003, 2004, Trabucco et al., 2006a, 2006b; Terlizzi et al., 2008; Manoukian et al., 2010).

In particular, produced water is water obtained along with oil and gas, and so it may include

a) naturally occurring water layer present in oil and gas reservoirs,
b) water that has been injected into the reservoirs to help force the oil to the surface, and
c) any chemicals added during the production and treatment process.

The positioning of a permanent structure and the discharge of produced water may generally modify environmental quality, causing effective changes of the water column's physical-chemical characteristics and sediment and perturbations on the marine living communities and the sea-bottom geomorphology.

Monitoring programs have been developed worldwide in all the areas characterised by an intense extraction and production activity (e.g. the North Sea, Gulf of Mexico and the Adriatic Sea), considering national and international sea protection policies and legislation. Among major international conventions, it is worth mentioning the Barcelona Convention (Barcelona Convention, 1979), with its Offshore Protocol, a regional regulatory framework for the Mediterranean basin, but it does not supply technical tools to manage environmental control activities. A good framework for the environmental monitoring of effluents resulting from offshore activities is provided by the OSPAR Convention (OSPAR, 1992; Stagg, 1998). It worked out the guidelines for monitoring the environmental impact of offshore oil and gas activities, representing a strategy adopted to assess the impact resulting from the different phases of offshore activities (exploration, production, and decommissioning) (OSPAR, 1999).

In the Black Sea, the Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea (2009) included a long-term ecological objective, EcoQO 4b - Reduce pollutants originating from shipping activities and offshore installations (Annex A).

1.3. Description of the environmental monitoring regime

Romanian offshore area covers 22 000 km^2 and reaches depths beyond 1 000 m. The whole area is divided into blocks of different sizes, some of them being awarded to operators for exploration, development and exploitation activities (Deloitte, 2018) (Figure 1.1).

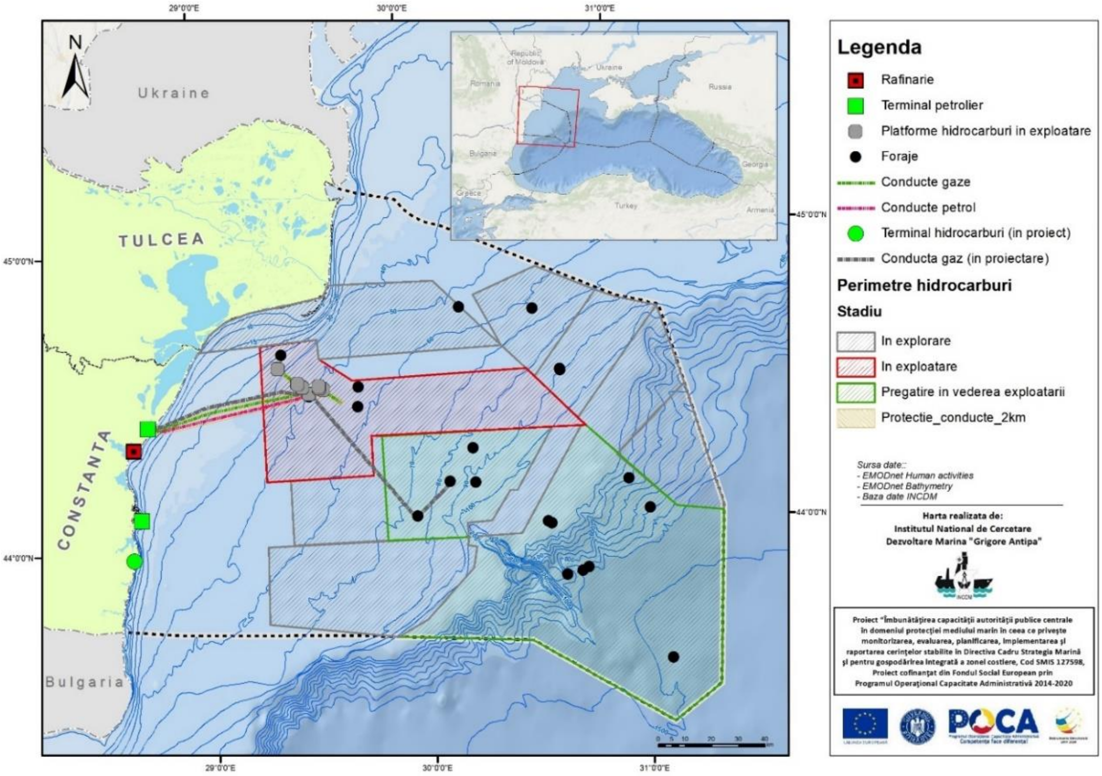

Figure 1.1 – Map of Romanian Black Sea's perimeters and offshore activities (source: SIPOCA – A3 - INCDM, 2021)

On the other hand, the Black Sea's ecosystem has specific characteristics and habitats in the overlapping area, mainly dominated by the infralittoral mixed sediments (Figure 1.2). Another essential feature is the Black Sea's natural anoxic layer.

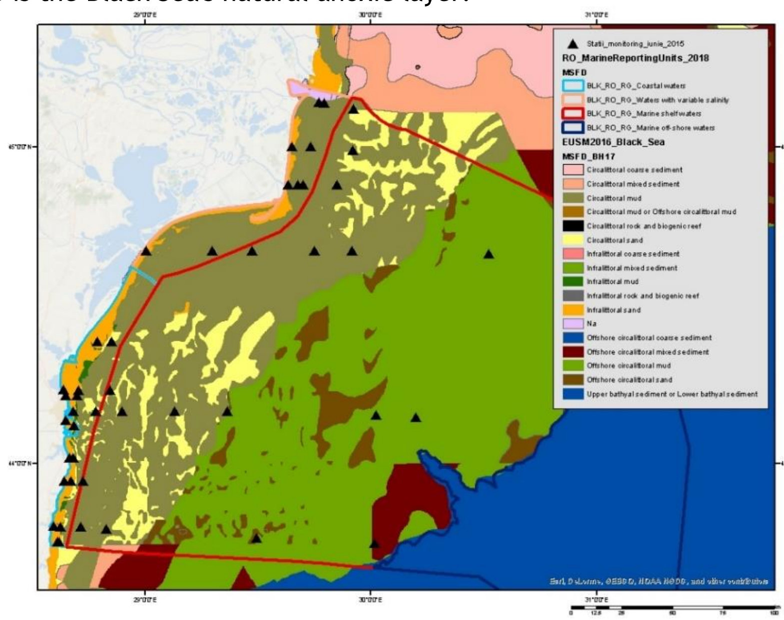

Figure 1.2 – Map of Romanian Black Sea's habitats (source: SIPOCA – A3 - INCDM, 2021)

Pelagic habitats

Monitoring of the water column consists of two main elements, condition monitoring and impact monitoring. Monitoring activities must be carried out in a way that makes it possible to verify the risk that pollutant discharges from oil and gas activities will impact the pelagic environment. The scope of the monitoring programme must be proportional to the expected risk.

Condition monitoring applies to fish, and surveys are required every three years. The monitoring is intended to document to what extent fish are affected by pollution from the oil and gas industry. The analyses are required to include hydrocarbons (TPH and PAHs) measurements and selected biomarkers in fish (Table 12). However, priority will be given to those areas believed to be most heavily polluted and to attractive nursery areas for fish where there is also substantial oil and gas activity with higher discharges.

Impact monitoring must, as a minimum, include fish and mussels. As part of the environmental monitoring regime, the operators are required to take part in the development of methods for impact monitoring in the water column (KLIMA, 2011). Impact monitoring is based on exposing organisms to produced water The preferred species is the blue mussel, but fish may also be appropriate in some cases. Biomarkers for assessing exposure and possible impacts are constantly being developed. A set of key methods should be included in the impact monitoring programmes, but the adaptation of the methodology to take account of new knowledge should be taken into account during the planning process. Table 10gives an overview of current methods.

Benthic habitats

Monitoring of benthic habitats consists of two main elements:

- Baseline surveys, which are required before exploration drilling in new areas and before production drilling.
- Field-specific and regional monitoring programmes, which normally begin after production has started. (Field-specific monitoring programmes form part of the regional programmes, and are carried out at the same time.)

The Romanian continental shelf has been divided into geographical regions for monitoring of benthic habitats (Figure 1.2). As a general rule, each region should be surveyed every third year, and the surveys should alternate between regions. The scope of the monitoring programmes must be related to the level of offshore activity in the region. Monitoring of new activities is additional to and must be adapted to existing monitoring activities. If large variations in-depth and/or type of sediment indicate that it is necessary, regions should be divided into subregions. The subregional divisions established in regions that have already been surveyed should not be changed without good reason.

Samples from the regional and field-specific stations in one region are to be taken during the same survey. The regional stations are intended to provide information on general background levels in the area for the parameters that are monitored and to function as reference stations for the expected normal situation. The field-specific stations are intended primarily to be analysed for petroleum hydrocarbons, metals, naturally occurring radioactive substances and fauna composition.

In addition to investigating the horizontal extent of any impacts around oil and gas installations, vertical sectioning of the sediment samples should also provide an estimate of how deep into the sediment drill cuttings and drilling fluid are present and whether a natural recovery process is taking place.

As a general rule, an approved grab type sampler must be used to collect samples of sediments and the benthic fauna. However, in some cases, a grab may not be suitable:

- in areas where the seabed habitat is heterogeneous – a mixture of rock, stones and gravel with some soft-bottom areas;
- when monitoring discharges from the top-hole section after drilling; in such cases, there is so little dispersal that traditional sampling methods cannot convey the extent of the impacts.

In such areas, visual surveys will be needed, using remotely operated or towed observation gear. Remotely operated vehicles (ROV) are preferable because they provide more flexibility during a survey. In addition, visual surveys will be needed as a supplement to traditional methods of environmental monitoring in areas that are defined as vulnerable (e.g. the Barents Sea).

The overall purpose of environmental monitoring is to describe whether and to what extent releases from oil and gas activities have had impacts on a sampling station, a larger area around an installation, or a region. The environmental monitoring results can be used to verify the predictions and conclusions of the environmental impact assessments (EIAs) for individual fields and the region as a whole.

Quality Assurance

Documentation of the requirements below should be obtained before oil and gas companies award contracts in connection with environmental monitoring.
• All suppliers of services for monitoring programmes (analyses, fieldwork) must have ISO 17025/OECD accreditation for the methods they use. Suppliers must also document their quality assurance routines.
• The operating companies' reports to the authorities must confirm that the requirements above are fulfilled, concerning the qualification system, certificates and approval date.

1.4. Environmental monitoring

The riparian country shall ensure that the features of the project and/or measures envisaged to avoid, prevent or reduce and, if possible, offset significant adverse effects on the environment are implemented by the developer and shall determine the procedures regarding the monitoring of significant adverse effects on the environment (European Parliament, 2014).
The type of parameters to be monitored and the duration of the monitoring shall be proportionate to the nature, location and size of the project and the significance of its effects on the environment. Existing monitoring arrangements resulting from Union legislation other than this Directive and national legislation may be used if appropriate, to avoid duplication of monitoring.
A description of the measures envisaged to avoid, prevent, reduce or, if possible, offset any identified significant adverse effects on the environment and, where appropriate, of any proposed monitoring arrangements (for example the preparation of a post-project analysis). That description should explain the extent, to which significant adverse effects on the environment are avoided, prevented, reduced or offset, and should cover both the construction and operational phases
The riparian country should ensure that mitigation and compensation measures are implemented, and those appropriate procedures are determined regarding the monitoring of significant adverse effects on the environment resulting from the construction and operation of a project, inter alia, to identify unforeseen significant adverse effects, to be able to undertake appropriate remedial action. Such monitoring should not duplicate or add to monitoring required according to EU and national legislation.
Final programmes for condition monitoring of the water column must be carried out in autumn, and always outside the spawning period for the fish species in question, preferably in October (JAMP Guidelines for Monitoring Contaminants in Biota, 1997). The timing of fieldwork for impact monitoring of the water column depends on the analyses that are to be carried out and is decided for one year at a time.
However, the environmental monitoring programme should be “fit for purpose”. Oil and gas projects differ in size, complexity and environmental sensitivity and these factors should be taken into account when deciding on a monitoring programme (OGP, 2012).

1.4.1. Assessment of Impacts and Effects

Although not an exhaustive list, several impacts associated with typical offshore oil and gas activities have been listed below (UNEP/MED, 2019).

Seismic survey:

- Underwater noise generation on marine mammals and fish;
- Physical presence (e.g. survey vessel, streamers etc.) on other users of the sea and marine animals.

Exploration drilling:

- Physical presence on other users of the sea and the seabed and associated communities (e.g. benthos);
- Drilling discharges (e.g. drilling muds, cement etc.) affecting the seabed and associated communities (e.g. benthos), water column and associated communities (e.g. fish);
- Atmospheric emissions (e.g. power generation, flaring etc.) on the atmosphere (local,

transbondary and cumulative);
- Underwater noise generation on marine mammals and fish;
- Unplanned/accidental events (e.g. hydrocarbon spills) may affect plankton, benthos, coral reefs, fish, shellfish, marine mammals, marine turtles, seabirds, seagrass beds, designated sites, coasts and inshore habitats and other users of the sea.

Production:

- Physical presence on other users of the sea and the seabed and associated communities (e.g. benthos);
- Oily discharges (e.g. produced water) on the water column and associated communities (e.g. fish);
- Atmospheric emissions (e.g. power generation, flaring etc.) on the atmosphere (local, transboundary and cumulative);
- Unplanned/accidental events (e.g. hydrocarbon spills) on plankton, benthos, coral reefs, fish, shellfish, marine mammals, marine turtles, seabirds, seagrass beds, designated sites, coasts and inshore habitats and other users of the sea.

Recognition of potential cumulative and transboundary impacts from the proposed activities should also be considered when assessing impacts and effects and included within the EIS.

1.4.2. Mitigation and Monitoring

Mitigation measures are predominantly applied at source, to reduce impacts, with the intention of a corresponding reduction in residual effects upon the receptors in question to acceptable levels. However, mitigation may also be applied directly at the receptor level, to reduce effects, without any influence on the source or the impact.

Countries with mature oil and gas industry and well-developed regulatory frameworks, such as the UK, Norway, The Netherlands and the US have incorporated comprehensive mitigation measures within their permitting and consenting regime. These mitigation measures are often informed and/or augmented with good industry practice guidance from organisations and institutions such as OSPAR, IFC/World Bank and IOGP.

As many oil and gas operators are multinational companies, which operate in different countries under multiple regulatory regimes, which are typically managed through their global corporate management systems to ensure all regulatory standards are met wherever they operate, many offshore oil and gas operations do have many inherent mitigation measures in place, as part of their "normal" operational procedures and practices.

All environmental mitigation and monitoring requirements should be stated within the EIS and should be taken forward in an Environmental Management Plan (EMP). In line with the requirements set out in the IMAP, regular Operator Environmental Performance assessments should be carried out by an independent/third party to assess and evaluate the operator's environmental performance throughout the operations against that stated within the EIS.

Special attention should be given to the receptors typically affected by offshore activities, including (UNEP/MED 2019):

- Benthos;
- Fish and shellfish;
- Marine mammals;
- Plankton;
- Seabirds;
- Seagrass beds;
- Nature Conservation Areas
- Other users of the sea e.g. fishing, shipping, tourism, oil and gas activities, renewable energy, submarine cables, military activity, aquaculture, archaeology etc.

1.4.3. Survey frequency and sampling pattern

Condition monitoring

As a general rule, condition monitoring surveys are recommended at three-year intervals.

Impact monitoring

Impact monitoring is required in at least one region a year.
To improve the monitoring methodology and the basis for result interpretation, operators may be permitted to replace one year's water column monitoring programme with laboratory studies or literature studies on individual substances or groups of substances.

Sampling areas and station network

As a basis for condition monitoring, operators must obtain up-to-date information on the distribution and migratory patterns of the fish populations in the target area. The choice of station network design for impact monitoring in each region must be based on knowledge of the physical conditions in the area and calculations of concentration fields for relevant pollutants. Dispersion modelling may also be useful in selecting sampling sites. A typical sampling programme should include at least one reference station, stations that reflect presumed gradients and impacts (OGP, 2012).
There is no requirement for baseline surveys for water column monitoring.
The sampling pattern for condition monitoring must be such that it gives a representative picture of the most important fish species in the region.
The number and location of the instrument rigs deployed for impact monitoring must be such as to provide the best possible picture of the situation of the selected field in the region. Any need for changes or an expansion of the station network must be discussed in the report following each survey.
Measurements such as turbidity, temperature, salinity and dissolved oxygen may be carried out on discrete samples but can also be measured using multiparameter probes.
Water, sediments and biota sampling plans should specify the type of container, storage conditions and maximum holding times for each type of analysis. Sample containers should be clean and properly stored to avoid contamination.

Analytical parameters

Biological parameters

The fish species to be included in condition monitoring are determined in consultation with authorities and must be listed in the monitoring programme. Representative species from areas where there is oil and gas activity, are to be collected and analysed. In addition to the chemical parameters (see below), analyses should include a selection of biomarkers that are indicative of exposure to pollutants and any adverse effects on fish.
The organisms to be used for impact monitoring will be specified in the monitoring programme. Experience shows that mussels should be used. So far, the only fish species used has been *Lisa aurata*.
The monitoring programme must also specify which biomarkers and other biological parameters are to be included (Annex B - Table 12).

Chemical parameters (Annex B - Table 10 and Table 11)

Condition monitoring must include analyses of regulated PAHs' content in fish fillet because of the food safety implications of these pollutants. Even though levels above the detection limit have seldom been found, analyses for these compounds are still required in areas where the impacts of oil and gas activities are believed to be greatest.
Measurements of various biomarkers are also required to determine whether fish in areas where there is oil and gas activity have been exposed to pollutants released from these activities. Specifications are to be drawn up in the draft programme, discussed at the annual planning meeting and documented in the final monitoring programme.

The chemical parameters to be investigated under impact monitoring must be specified in the draft programme, discussed at the annual planning meeting and listed in the final monitoring programme.

Other investigations

If authorities consider it necessary, further water column investigations regarding environmental status and impact of pollutants may be required near oil and gas fields.

Sample collection

Procedures for sample collection and processing for condition monitoring are described in the *JAMP Guidelines for Monitoring Contaminants in Biota* (1997).

Sample processing

Fish that are investigated as part of condition monitoring must be kept alive until samples are taken for biochemical analysis. Working surfaces used for sample processing must be clean, and the samples must be handled in a way that minimises the risk of sample contamination onboard the vessel. The procedures followed must be documented and reported. More specific procedures are described in the monitoring programme.

Sample preservation

Samples taken for chemical analysis as part of condition monitoring surveys must be frozen to at least -20°C as soon as possible and stored at this temperature until analysis. All other samples for both condition and impact monitoring must be treated according to the specifications in the monitoring programmes.

Analytical methods

All analytical methods must be documented. The programmes for condition and impact monitoring must include detailed descriptions of the analytical design, methods and reporting forms.
Key factors affecting the impacts of oil and gas activities in the water column are (OGP, 2012):

- Physical – winds, currents, turbidity, salinity and temperature;
- Chemical – suspended solids, organic compounds and additional substances resulting from other activities;
- Biological – number and distribution of fish and other pelagic organisms, toxicity ro or more general health variables of marine organisms

The sediment compartment is a sink for many contaminants in the marine environment. Solids that enter the water column, through either disturbance of seabed sediments or the discharge of waste solids, may be transported from the site of discharge. Soluble materials may precipitate from the water column due to chemical changes or adsorb to natural sediment particles present in the water column. Precipitated materials or sediment particles with adsorbed contaminants then settle on the seabed where they may have direct effects on benthic communities or indirect effects on water column organisms. Although marine processes can redistribute and dilute solids that settle to the seabed, particularly in shallow water, the sediment compartment has a strong tendency to accumulate particles and associated contaminants over time.

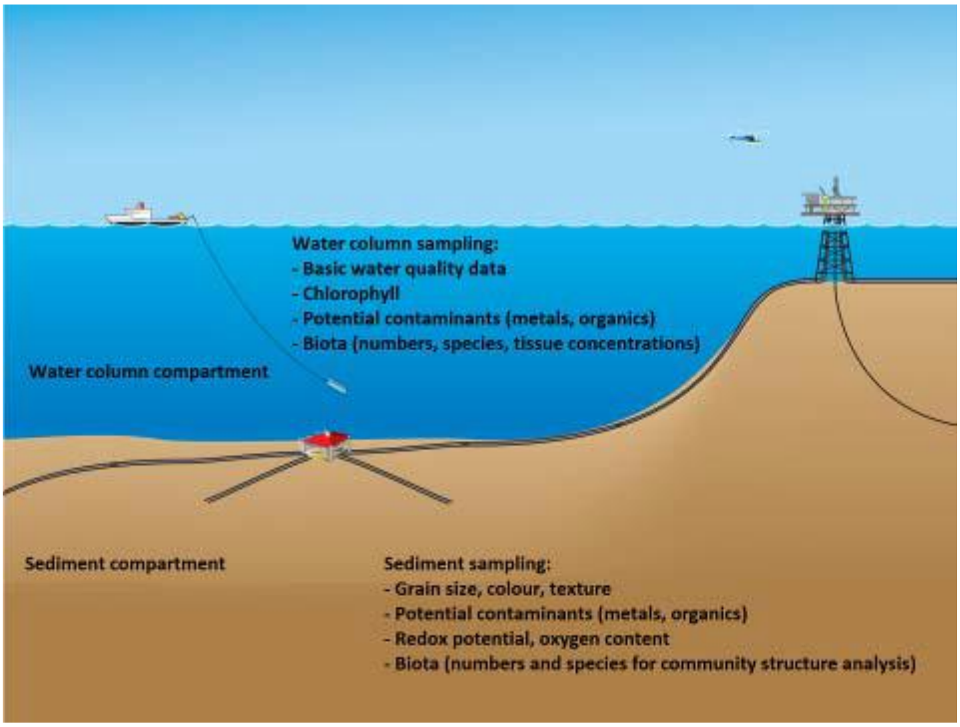

Figure 1.3 - Environmental compartments sampled in offshore environmental monitoring surveys (OGP, 2012)

1.4.4. Environmental modelling tools

Technology advances in modelling allow greater accuracy in the prediction of the fate, effects and risk of offshore discharges and emissions. While models do not substitute for site-specific environmental data, they often reduce the amount of field data necessary to make a sound technical assessment. Discharge modelling of produced water and drilled cuttings models estimate the vertical and horizontal distribution of the produced water outfall and cuttings on the seafloor respectively. Several models are presently available for evaluating the dispersion of produced water discharges. Among these are the Dose-Related Risk and Effect Assessment Model (DREAM; SINTEF, Norway; Johnsen et al., 2000; Reed and Hetland, 2002), the Offshore Operators Committee (OOC) model (Smith et al., 2004), PROTEUS (BMT-Cordah, UK) (Sabeur and Tyler, 2004), MIKE 3 (DHI, 2009) and the CORMIX model (Jirka et al., 1996).
The models referred to previously, except the MIKE model, are all capable of estimating the vertical and horizontal distribution of cuttings on the seafloor. In addition, there is MUDMAP (ASA, US), which was developed to predict the transport and dilution of drill fluids. Though performed less frequently, air dispersion models have been used for estimating the concentrations and atmospheric dispersion of air emissions from offshore facilities.
Models have generally focused on the relative concentration and exposure of a waste stream or chemical constituents in the marine environment. The DREAM model, used particularly in Europe, has integrated probabilistic risk processes and estimates exposure and ecological risk levels (SINTEF, Norway; Johnsen et al., 2000; Reed and Hetland, 2002).

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Introduction

The Contracting Parties of the Bucharest Convention need to take all appropriate measures and cooperate in preventing, reducing and controlling pollution caused by dumping in accordance with the Protocol on the Protection of the Black Sea Marine Environment Against Pollution by Dumping.
The Marine Strategy Framework Directive consider the activities which have impacts on sea (including disposal of dredged material) through establishing a framework within which EU Member States shall take the required necessary measures to achieve good environmental status. The initial assessment step of the MSFD includes the essential characteristics, the current environmental status, the predominant pressures and impacts (including disposal of dredged material at sea), the economic and social analysis of the use of the sea and estimates of the cost of degradation. The monitoring step considers the knowledge gaps related with these information.
Having a common understanding of the important terms for sediment and dredged material management is important. Also, using similar approaches will benefit the sustainability of dredging activities in the region.

Background

Dredging is needed to maintain navigation in ports, harbors and marinas for development of port facilities. Sediment management is a key issue in marine coastal policy due to the large amount of material excavated during maintenance dredging from harbors, estuaries and channels. The annual volume of dredged material in the marine environment is estimated at 200-250 million tons/year for the E.U (EuDA/05/0271). The dredging activity takes place at the interface of the water bottom formed by sediment and the water body. This may lead to fairly unique problems with the regulation of dredging and dredged material disposal. The appropriate rules are also influenced by the specific environmental conditions and the history of dredging in a particular region.
Dumping is defined in London Convention (1972) and its Dumping Protocol(1996as: "The deliberate disposal in the maritime area of wastes or other matter from vessels or aircraft, from offshore installations, and any deliberate disposal in the maritime area of vessels or aircraft, offshore installations and offshore pipelines". The term does not include disposal in accordance with MARPOL 73/78 or other applicable international law of wastes or other matter incidental to, or derived from, the normal operations of vessels or aircraft or offshore installations (other than wastes or other matter transported by or to vessels of offshore installations for the purpose of disposal of such wastes or other matter or derived from the treatment of such wastes or other matter on such vessels or aircraft of offshore installations). Dredged material is the most important category of waste or other matter that can still be dumped in seas in certain conditions.
Dredging and dumping activities may cause physical disturbance and may result in the redistribution, and possibility of changing the form, of contamination. Physical disturbance includes increases in suspended matter, which affects primary production and growth of filter-feeding organisms, burial of benthic organisms and changes in substrate character, which may affect benthic communities (*Ref: OSPAR 2009., Chen et al. 2018, Zimmerman et al. 2003, Crow et. al. 2010).*
The main potential impacts of the dredging and disposal practices on marine environment are related to:

- change in benthic structure
- increased turbidity (flora and fauna)
- nutrient and organic matter increase in the water column and sediment
- chemical disturbances due to release of the harmful contaminants
- enhanced sedimentation of the suspended solid matter (TSS) on deep flora and fauna (burial and smothering);

Harbour areas in particular have been found to contain high levels of contaminants in bottom sediments due to wastes from urban, industrial, and riverine sources, as well as navigation. 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 location.
Due to the reasons explained above, the problem of dredged material has emerged as an environmental issue of global importance.

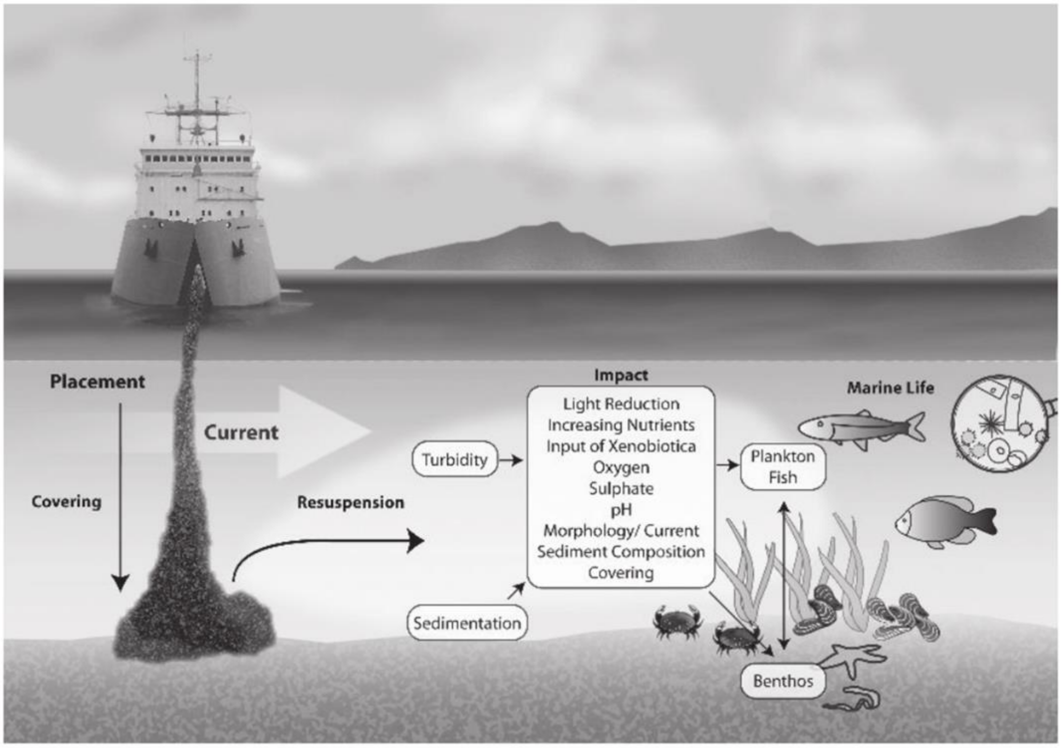

Figure 2.1 - Potential Impact on ecosystem (ref: CEDA/IADC)

2.1. Management of Dredge Material and Dumping Decision

The greater proportion of the total amount of material dredged worldwide is, by nature, similar to undisturbed sediments in coastal waters. A smaller proportion of dredged material, however, is contaminated by human activity to an extent that major environmental constraints need to be applied when considering disposal or use of these sediments (LC.52 (18) art.1.2).
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, MSFD, 2008, IMO 2007, Bucharest Conv.,1992; Barcelona Conv., 1995).
The updated version of the LC (the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972), the London Protocol (LP 1996) provides an instrument which outlines eight steps for the assessment dredged material. The OSPAR Convention (1992), derived from the London Convention and being followed by the Barcelona and HELCOM Conventions has similar approach. 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 (IMO 2007, 2009, OSPAR 2014).
All these conventions use almost the similar framework provided by DMAF outlined below (Figure 2.2), to define whether dredged material is suitable for specific application or should be disposed off at sea. OSPAR guidelines specify best environmental practice (BEP) for managing dredged material, with the most recent version adopted in 2014 (OSPAR Agreement 2014-06). In a general flow (OSPAR 2014, IMO 2007), the following stages are considered: (1) characterization of dredged material before any excavation work, (2) evaluation of the potential dumping/disposal options, (3) selection of the most appropriate disposal site if the dredged material is clean or low contaminated, (4) anticipation of any negative impacts of dumping process on the marine environmental and socioeconomic

activities in the relative region, (5) issue of a specific permit for the dumping activity from the authorities, (6) monitoring of environmental effects caused by dumping operations, and (7) possible modifications or permit cancellation based on the findings of field monitoring (Figure 2.1).

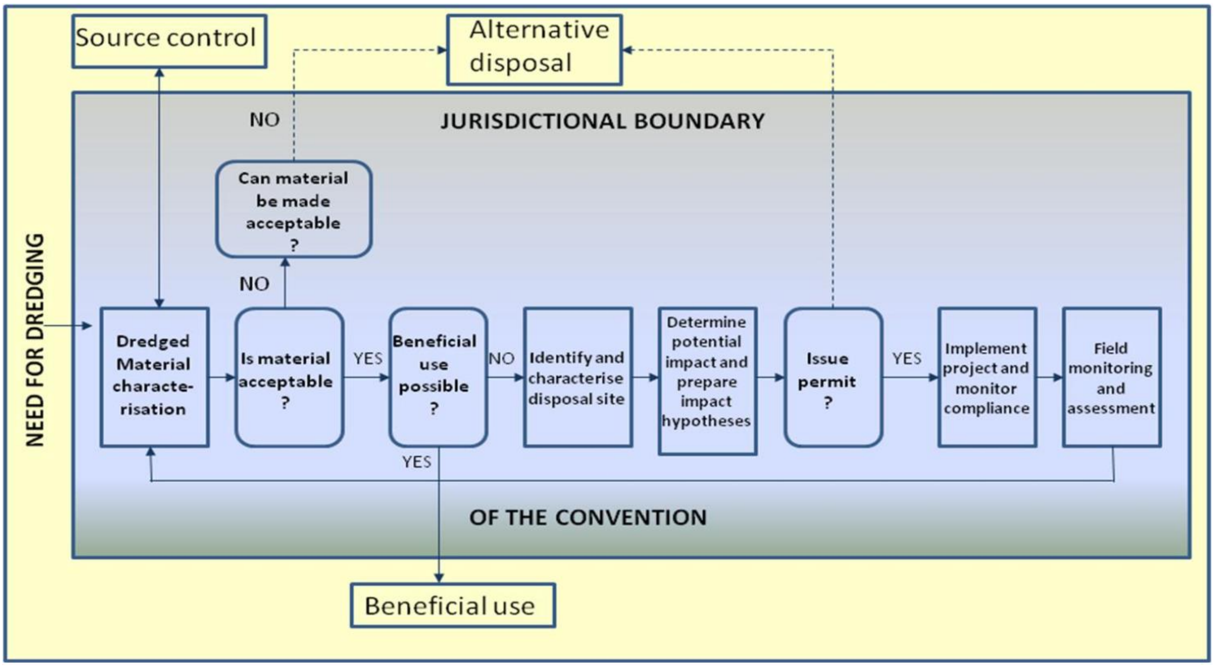

Figure 2.2 - The Dredged Material Assessment Framework (adopted from OSPAR 2014 by EuDA)

Pursuant to the Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention 1994), and its Protocol on the Protection of the Black Sea Marine Environment Against Pollution by Dumping, it is essential to obtain permission for the discharge of the dredging material from the seabed and to make a report by creating a database. However, within the scope of the protocol, the necessary criteria for the decision/permission to dumping the dredge material into the sea are not defined and the monitoring strategy for assessing the effects in the dumping sites have not been determined. The development of an objective/implementable framework for the region is needed in order to support decision-making in planning the re-use or remediation of collected materials. It will also allow a clear improvement in environmental management in the light of sustainability as requested in the SDG and the MSFD (Directive 2008/56).

Dredged material Characterization: sampling and analysis plan

Both removal and deposit of dredged sediments may cause harm to the marine environment. Therefore contracting parties of the above mentioned Conventions are encouraged to use a Best Environmental Practice (BEP) approach designed to minimise both the quantity of material that has to be dredged and the impact of the dredging and deposit activities in the maritime area (OSPAR 2014). The Contracting Parties of the London Convention are required to use the Guidelines for the Sampling and Analysis of Dredged Material Intended for Disposal at Sea (IMO, 2005).
In order to get sufficient and meaningful information about the material to be dredged, tests and analysis are required. However, some information about the area should be obtained beforehand in order to decide the number of samples and parameters to be analysed at minimum cost and effort. Number of grab samples can be decided using the information on pollution history and the amount/area to be dredged (WAG IMO 1997). If the area is regularly monitored under the monitoring program and/or there is no any pollutant source around, lesser number of samples may be sufficient. For both number and location of samples, the goals of the study, the size of the area, the heterogeneity of the sediment, and how contaminants segregate in the sediment matrix need to be considered (IMO 2005). The volume of sample should be a function of: the sample depth(s); the number and types of the samples analysis; the sample volume or weight required to satisfy the method and QA/QC programme for all analytical and biological tests selected.

The Table 1 gives an indication of the number of separate sampling stations required to obtain representative results, assuming a reasonably uniform sediment distribution in the area to be dredged (OSPAR Guideline 2014):

Table 1 - Number of samples required for dredge material characterization (OSPAR 2014)

Amount dredged (m^3)	**Number of Stations**
Up to 25 000	3
25 000 - 100 000	4 – 6
100 000 - 500 000	7 – 15
500 000 - 2 000 000	16 – 30
>2 000 000	extra 10 per million m^3

In addition to surface sediments it is recommended to take core samples which can also be used to estimate the vertical distribution of the physicochemical characteristics.

Analytical requirement for dredged material characterization

Characterisation should take into consideration physical, chemical and biological characteristics. Comprehensive and detailed investigations of geo-chemical properties of organic/inorganic pollutants in dredged materials and principal physical and bio-geo-chemical properties of the selected disposal sites are commonly a prerequisite for any planned dredging activity. The sequence named “tiered approach to testing” is recommended to determine whether sufficient information exist to allow a management decision to be taken or whether further analysis is required. Further information determined by local circumstances can be added at each tier (OSPAR 2014).

1. **the physical properties** includes, the amount of material to be dredged, sediment grain size properties (clay/sand/silt/grave/boulder) and organic carbon content. Results are considered to estimate sediment behavior during the dredging and dumping operation. This information is also important to decide the subsequent analysis requirement for chemical and biological properties.
2. **the chemical properties** includes; the redox status, potential contamination sources such as industrial or/and municipal discharges, activities such as agricultural, maritime and spills. Considering these information a primary list of possible contaminants are listed. As an example, Primary list of the OSPAR 2014 guideline includes: Arsenic, Cadmium, Copper, Chromium, Lead, Mercury, Nickel and Zinc. The determination of PCBs, PAHs and Tri-Butyl tin compounds and its degradation products will be necessary in circumstances where the sediments are likely to be contaminated with these substances. Further information may also be useful in interpreting the results of chemical testing.
3. **the biological properties and effects** includes: acute and chronic toxicity tests and bioaccumulation potential. If the potential impacts of the dredged material to be deposited cannot be adequately assessed on the basis of the chemical and physical characterisation, biological measurements should be carried out.

Assessment of habitats communities and populations may be conducted in parallel with chemical and physical characterisation. It is important to ascertain whether adequate scientific information exists on the characteristics and composition of the material to be deposited and on the potential impacts on marine environment and human health (OSPAR 2014).

Criteria(Action Levels) and dredged material management decisions

The European Commission has not set any specific limit for dredged material this is left to the member states. However the Conventions such as London and OSPAR recommends to the Contracting parties to set certain conditions (citeria/action levels) considering their marine/coastal areas and European directives such as WFD, MSFD.

OSPAR guideline (OSPAR 2014) is summarized below:

The Action List is used for dredged material management decisions as a screening mechanism for assessing properties and constituents of dredged material with a set of criteria for specific substances. Action List levels (upper and lower) should be derived from studies of sediments that have similar geochemical properties to those from the ones to be dredged and/or to those of the receiving system. Thus, depending upon natural variation in sediment geochemistry, it may be

necessary to develop individual sets of criteria for each area in which dredging or deposit is conducted. Material which contains specific contaminants (posing risks to the aquatic ecosystem) above the limit values (upper levels) should be generally considered unsuitable for dumping. The material with intermediate quality (below the upper levels but higher the lower levels) needed further analysis such as toxicity tests before the dumping decision(London Convention and Protocol-Guidance for the development of Action Lists and Action Levels 2009) .
It is important, recognizing the value of sediment as a resource. Depending on the physical and chemical characteristics of the material the management options include beneficial use (beach nourishment, habitat restoration, shoreline stabilization etc.), unrestricted, open-water deposit, confined aquatic disposal or confined disposal facilities. In some cases the best option may be to leave the material in-situ (OSPAR 2014).

2.2. Management of disposal at sea option and potential impacts

The London Protocol (LP) guideline for the Assessment of Potential Impacts are similar to the guideline of the OSPAR and HELCOM Conventions (London Protocol 1972, OSPAR 2014, HELCOM 2015). The points specified in the relevant sections of the LP are summarized below.
Evaluating the potential environmental consequences associated with dredging and dredged material disposal is a complex issue. Assessment of potential impacts should lead to a clear statement on the expected results of discharge options to be carried out on land or at sea. The assessment should be as comprehensive as possible. Primary potential effects should be determined at the stage of selecting the dumping site.
Scientific advancements have made possible the collection of large amounts of complex technical information such as; the characteristics of the material, conditions in the probable dumping area, changes and foreseen dumping techniques, and should indicate potential impacts on human health, living resources, the facilities offered by the environment and other legitimate uses for the marine area.
Expected impacts (Impact hypothesis) on ecosystem should be described based on reasonable conservative assumptions in spatial and temporal scales. When describing an impact hypothesis, sensitive areas (spawning, breeding and feeding areas), habitats (biological, chemical or other functions), migration routes and resources will be of particular interest, but not limited to these.
Analysis of each dredged material disposal option should be evaluated in the light of comparative analysis (weight of evidence decision-WOE) of the following issues: risks threatening human health, environmental losses, hazards (including accidents), loss of some of the economic and future uses in the future.
Tiered approach provides for the efficient utilization of resources while ensuring that sufficient information is collected to make technically sound decisions. In each of the tiers, data are collected to assess the potential for exposure and effects. In the earlier tiers (Tiers I and II: Initial and Primary Assessments) existing information and simple screening tools are used, while in the later tiers (Secondary Assessment) more sophisticated effects-based laboratory bioassays are employed (Figure 2.3).

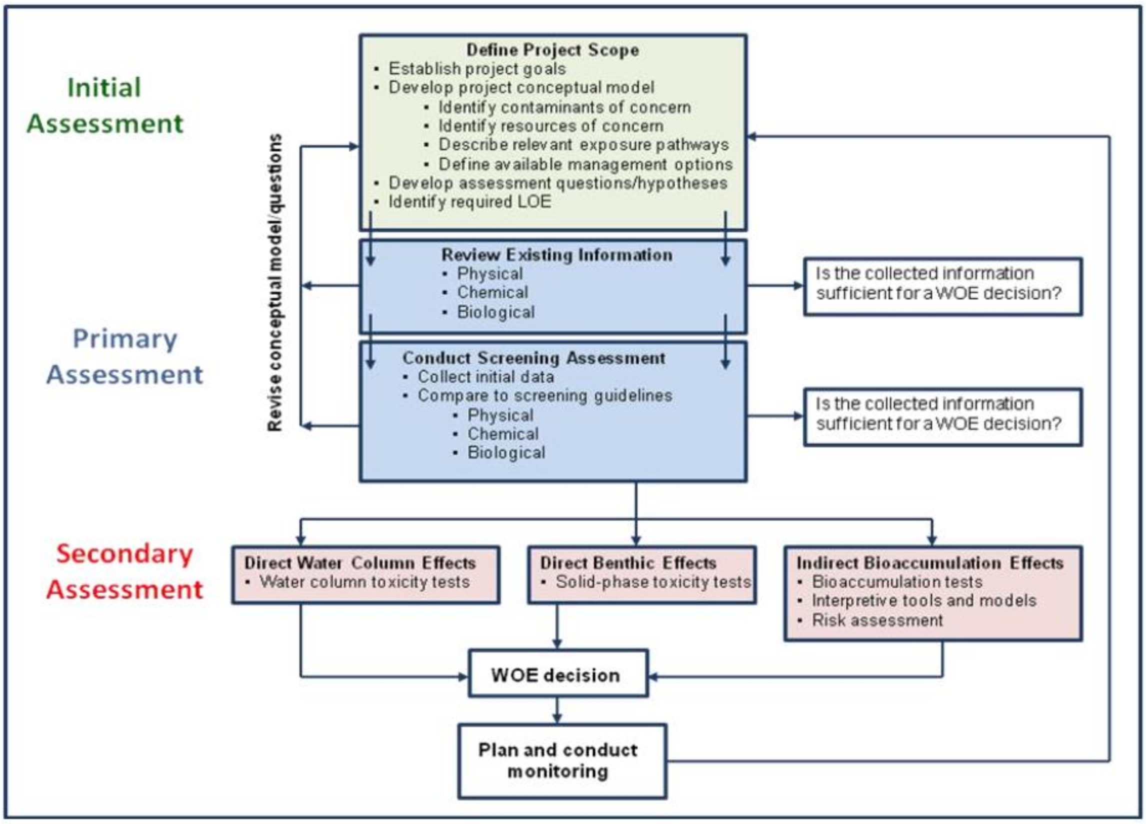

Figure 2.3 - Generalized assessment and decision-making framework (SMOCS Report 2011) (ref. PIANC WG ENVICOM 8 Assessment Guidance for DM 2005)

The results of the physical/chemical/biological characterisation will indicate whether the dredged material, in principle, is suitable for disposal at sea. Where sea disposal is dentified as an acceptable option, it is nonetheless important, recognising the potential value of dredged material as a resource, to consider the availability of beneficial uses.
It is also possible to use other risk based approaches or procedures in development national regulations/strategies (EPA 1998, UNEP-IMO 2000, CEDA 2008, PIANC 2009) for sediment sampling and analysis in the dredged material management framework. Selection of substances of concern and effects needed to be determined.

Dump Site Selection

In some circumstances it may be desirable to confine the dredged material to a limited area of the sea. It is also needed to identify and avoid particularly sensitive areas in all operations (IMCO 1982-GESAMP).
A basin wide dumping site selection methodology should be applied in order to propose dumping locations at the marine and coastal areas of Black Sea. Besides, different marine features, European regulations, directives, regional conventions (Bucharest, OSPAR and London) and related protocols and guidelines should be considered in selection of the disposal areas. Information about frequency of dredging operations, amount of dredged material, and location of the dredging operations are important in determining the disposal sites. GIS (Geographical Information System) is a preferable and widely used technology for decision-making process especially in site selection problems requiring spatial analysis (London Convention, Waste Assessment Guidelines, 2012).
For the evaluation of a sea disposal/dumping site information should be obtained and assessed on the following, as appropriate (OSPAR 2014):

1. the physical, chemical and biological characteristics of the seabed (e.g., topography, sediment dynamics and transport, redox status, benthic biota);
2. the physical, chemical and biological characteristics of the water column (e.g., hydrodynamics, dissolved oxygen, pelagic species);
3. distance to:

- areas of natural beauty or significant cultural or historical importance and/or specific scientific or biological importance (e.g. Marine Protected Areas);
- recreational, subsistence, commercial and sport fishing areas;
- spawning, recruitment and nursery areas;
- migration routes of marine organisms;
- shipping lanes;
- military exercise zones;
- engineering uses of the sea such as undersea cables, pipelines, wind farms

Size of the dump-site is an important issue to be considered in selection process (IMCO 1982- GESAMP; LC/LP IMO 2003). In order to assess the capacity of a site, the following should be taken into consideration (LC-LP 2013):

- the anticipated loading rates per day, week, month, or year;
- the degree to which the site is dispersive;
- the allowable reduction in water depth over the site because of mounding of material;
- volume changes as a result of water introduced into the material during dredging operations and consolidation of both the dredged material and the underlying sea floor.

2.3. Monitoring strategy for dumping sites and operations,

Monitoring plays an important role in preventing pollution of the marine environment from dredged material disposal operations. It should be conducted with a clear purpose and the information should be used to assess and modify management actions (future project evaluations, ongoing project operations, or site management policies) and future permitting decisions, as appropriate (LC/LP 2007, IMO 2009, LC/LP 2011). The strategy of monitoring in relation to disposal of dredged material includes three main purpose such as compliance, impact-status and permit decision assessment. It can provide valuable information before (surveillance), during (feedback) and after a dredging and dumping project (compliance). It is used to verify that permit requirements have been met and to give the contractor/authority the opportunity to check before/during their operations weather the assumptions made during the site selection process are correct and sufficient to protect the environment and human health (IMO 2003, OSPAR 2014). It can also increase knowledge about environmental conditions and the effects of an activity which can then serve as a basis for better assessment of environmental effects during future disposal projects (LC Dredged material Guideline 2013).

Compliance monitoring needed to provide assurances that (1) the material to be disposed is the same as the material authorized under the permit; (2) the material is loaded, handled, and transported in accordance with the permit; (3) the volume is consistent with the permit; and (4) the disposal location and method are the same as specified by the permit.

Field monitoring involves sample collections at or near the disposal site and measurements made over different spatial or temporal scales. What is monitored will depend directly on the Impact Hypotheses that were constructed during the assessment of potential effects.

Long-term monitoring may also uncover impacts that the project has had on habitats and species, some of which may not be visible until years after the project's completion. Compiling this data can provide useful information for future projects (IADC 2009) and:

- modify or terminate the field-monitoring programme;
- modify or revoke the permit;
- redefine or close the dump-site;
- modify the basis on which applications to dump wastes are assessed.

Sampling design needs to consider the number of samples necessary to statistically test the hypotheses. The amount and type of testing necessary to support the decision will vary from project to project. It is important that the scale of the monitoring relates to the extent of the perceived problem and that the physical, chemical, or biological components of the monitoring programme relate to the cause of interest or concern (PIANC 2006a; CEFAS 2003; LC 2013). Physical fate observation should be directed mainly at evaluating dispersion characteristics and should be include observation of wind, vertical density distribution, currents and bottom properties. Measurement of

light penetration may also be relevant. Furthermore chemical measurements are also required according to the dredged material originate, structure and contents (GESAMP 16. report 1985). The results of monitoring (or other related research) should be reviewed at regular intervals.
The monitoring activities described above require significant interaction between program designers, project managers, and regulators.

Recommended Parameters and Frequency

Monitoring strategy including indicator variables and parameters (physical, chemical and biological) to be monitored are determined according to the potential impacts of the dredged material characteristic and physical structure/location of the dumping area. Table 2 and Table 3 gives an idea for compliance monitoring strategy (DIPTAR Project report 2016) for the lowest potential impact case.

Table 2 - Frequency of Parameters /Variables to be monitored

Parameters and Variables	Before Dumping	During Dumping	After dumping (6 month -1 year later)
Bathymetric structure	1	1	1
Side scan sonar-sub bottom profiler	1		1
Geochemical and geological characteristic (Size distribution, TOC, Metals and organic substances-determine according to the pollution history and risks)	1	1	1
Zoo-benthos (ecological quality)	1	1	1

Table 3 - Recommended Parameters indicating water quality

Parameters (At least 3 depth of the water column)	Before Dumping	During Dumping	After dumping
pH	1	1-3	1
Temperature (ºC)	1	1-3	1
Salinity (%o)	1	1-3	1
Stratification status (sigma-t)	1	1-3	1
Dissolved Oxygen Concentration (mg/L) and Saturation (%)	1	1-3	1
TOC (mg/L)	1	1-3	1
Chlorophyl-a (µg/L)	1	1-3	1
Nitrate +Nitrite (µg/L)	1	1-3	1
Total Phosphorus (µg/L)	1	1-3	1
Total Suspended Solid(mg/L)	1	1-3	1

Templates for decision makers

All disposal of dredged material in the sea, requires a dumping permit issued by the authorized organization (for example ministriy of environment or state agencies such as EPA in USA). Monitoring results will be used for making decisions, preventing unacceptable adverse effects beyond each site's boundary.
During the project initialization phase the permittee shall complete and submit to the auhority a Project Plan/set Up Form prior to the beginning of a dredging cycle or project disposal. The form may include the following information (Adopted from TR National Regulation):

A. General Information about
- Name and address and other info. of the operation company and port/harbor
- Dredging purpose and time
- Geographical location of the site and amount to be dredged
- Dredging activities in the last 5 years at the site

B. Characterization of the Dredged material
- Amount, size composition, sampling points, analysis results (physical, chemical and biological/ecological)

C. Methods and Equipment
- Bathymetric map
- Dredging/dumping methods and precautions for environmental impacts
- Ecological report

D. Beneficial Usage options (additional analysis required by the waste directive and other regulations)

E. Information about the possible dumping site
- Length from the coast and depth
- Coordinates of the monitoring locations and bathymetric map
- Monitoring program
- General flow regime
- Initial monitoring results (pre dumping)

F. Environmental impact assessment (impact hypothesis)

2.4. National regulations and principles/practices of dredged material management in ANEMONE Partner Countries

Turkey

Approximately $5x10^6$ m^3 of sediment is removed annually from the harbours, ports, marinas and river mouths in Turkey (Tan *et al.*, 2015). Uncontrolled dumping of dredged material in coastal and marine areas had been a common practice for a long time in Turkey. This is especially an important problem for the harbour areas in particular have been found to contain high levels of contaminants in bottom sediments due to wastes from urban, industrial, and riverine sources, as well as navigation. The DIPTAR Project (Dredging Applications and Environmental Management of Dredged Material in Turkey) was carried out between 2013 and 2016 in order to establish the management principles for seafloor dredging and dredging material, which constitutes an important risk of eutrophication-based pressures in terms of causing nutrient transport from the sediment to the water column. Under the DIPTAR project, an ecosystem based management procedure (including beneficial usage option) were formed and tested in the pilot sites with different activities in each marine areas of Turkey including Samsun port and fishery in the Black Sea (DIPTAR Project, 2016). The results of the project were partially used as the basis for the preparation of the national regulation.
Disposal of dredged material requires a "Dumping at Sea" permit from the Ministry of Environment and Urbanization while the sediments with unacceptable levels of contaminants are not disposed at sea according to the national regulation(Regulation No 31008/2020: Dredging and Environmental

Management of Dredged Material). The upper and lower limit values of the chemical contents of dredge material to be dredged and possible dumping areas with their capacity and frequency of dumping are specified in the Regulation for the seas around Turkey (including Black Sea, Marmara Sea and Mediterranean-Aegean Seas). Permitting procedure for dredged material and action levels are defined in the regulation such as: If the chemical analysis shows concentrations of parameters (Cd, Pb, As, Cr, Cu, Ni, Zn, Hg and PCBs) between the two action levels a more comprehensive study and evaluation has to be carried out, based on the amount to be dumped and the concentrations of contaminants. If the chemical analysis shows concentrations above the upper action levels dumping at sea will normally not be permitted, pending a throughout evaluation of the case, and the material must be deposited at land. Besides the evaluation based on chemical concentrations an evaluation on the amount of material to be dredged and its size distribution are also considered. The "Ecological report" prepared and evaluated by marine scientists is also important to decide dredging permission and dump site selection. The ecological report includes benthic macro flora and fauna species compositions (specific sensitive habitats etc) in the region of the dredging or dumping. The other criteria considered in the dump site selection are: Water depth (>40m), length form the coast line (>3 nm), SDD (>6m), total phosphorus (<20ug/l) (at several locations). Monitoring is also required at the dredging and dumping sites before, during and after the operations. pH, temperature, salinity, turbidity (as SDD), Dissolved Oxygen, Total Organic Carbon, Total Phosphorus and Total Suspended Solids are the desired parameters to be monitored in the dump sites. A web based national data and information flow system was established in order to support the decision makers and users (applicants). The system provides information about before, during and after the dredging/dumping operations (such as amount, location, characterization results). It is also helpful for the decision makers to estimate the remaining capacity of the dump sites for further operations.

Ukraine

In Ukraine, dredging is divided into capital and operational.
Capital dredging - dredging works performed during new construction and reconstruction of hydraulic structures.
Operational dredging - dredging works performed during the maintenance of port waters and canals in order to ensure the safety of navigation and maintain the design (passport) dimensions.
Capital dredging and organization of underwater dumps of dredging soils requires design with subsequent construction expertise and environmental impact assessment (EIA) procedures with positive conclusions.
Operational dredging requires the development of EIA materials.
The decision to carry out activities on capital, operational dredging and organization of underwater dumps will be a permit for work on the lands of the water fund, issued by the Ministry of Environmental Protection and Natural Resources of Ukraine.

Dredging in Ukraine is carried out in the following ports, which are subordinate to the State Administration of the Sea Ports of Ukraine (SA "SPU"):

- Odessa port.
- Port "Yuzhny".
- Port "Chornomorsk".
- Belgorod-Dnestrovsky port.

Also, the dredging of the navigable canals through the "Bystry" arm of the Danube and Dnieper-Bug canal is carried out on a regular basis, under the direction of the branch "Delta-Pilot".
Dumping of dredging materials is carried out into the Black Sea.
Port "Yuzhny" carries out dumping of dredging materials at 4 dumps.
Odessa port, Port "Chornomorsk", Belgorod-Dnestrovsky port have one place each for dumping of dredging materials.
Branch "Delta-Pilot" have two places for dumping of dredging materials.
Information about the places of dumping of dredging materials in the Black Sea is given in Table 4.

Table 4 - Marine underwater dumps of dredging materials SA "SPU" and Branch "Delta-Pilot" in the Black Sea

	№ п.п.	№№ places of dumps	Coordinates (dump configuration)	The distance from the entrance to the port to the center of the dump,
Port "Yuzhny"	1	1	46°24'48" 31°00'00" (circle with a diameter of 2400 m)	20,0 km
	2	2/1	46°33'17" 31°02'15" 46°33'43" 31°03'50" 46°33'18" 31°03'50" 46°32'52" 31°02'15" (quadrangle)	8,7 km
	3	2/2	46°32'32" 30°59'20" 46°32'48" 31°00'01" 46°32'00" 31°00'30" 46°31'10" 31°00'07" (quadrangle)	7,3 km
	4	2/3	46°28'34" 31°00'00" (circle with a diameter of 1850 м)	13,8 km
Odessa port	5		46˚21'40" 30˚49'00" 46˚21'40" 30˚50'00" 46˚20'40" 30˚50'00" 46˚20'40" 30˚49'00" (quadrangle)	17,5 km
Port "Chornomorsk"	6		46˚19'28" 30˚46'48" (circle with a diameter of 1100 м)	8,0 km
Belgorod-Dnestrovsky port	7	901	46˚04'74" 30˚25'08" 46˚03'08' 30˚26'47" 46˚02'51" 30˚27'23" 46˚01'22" 30˚25'58'’ (quadrangle)	3,6 km from the entrance to the Dniester estuary
Deep-water navigation through Dnieper-Bug canal	8		46˚27'11" 31˚23'55" (circle with a diameter of 1 mile)	18 km from the entrance to the Dnieper-Bug canal
Deep-water navigation through the "Bystry" arm of the Danube	9		45˚19'13" 29˚51'58" The radius of the dump is 926 m	8 km from the "Bystry" arm

The issuance of a permit for the discharge of dredging materials to sea dumps is carried out only after, after establishing their quality, by special units of the Ministry of Environmental Protection and Natural Resources.

With a positive conclusion, mandatory monitoring of the dumping area is carried out.

In the area affected by dumping of dredging materials, the following set of indicators is monitored:

- organic pollutants: full complex, surface, bottom layer, bottom sediments;
- trace metals: full complex in water surface and bottom layer, bottom sediments;
- pH, oxygen: observations on all standard horizons;
- hydrogen sulfide (if any): bottom layer;
- nutrients: full complex, on all standard horizons;
- total suspended solids: surface and bottom and on standard horizons at reference stations;

2.5. References

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PIANC EnviCom(2008) Working Group Reports
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IMO Waste Assessment Guidance (WAG)
UNEP MAP Guidelines for the Management of Dredged Material (www.unepmap.org)
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WODA World Organization of Dredging Association (www.woda.org)
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3. Case study - Impact of fisheries and the physical pressure from fisheries on the fish diversity and the seabed habitats

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Introduction

Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 established a framework for community action in the field of marine environmental policy (hereafter Marine Strategy Framework Directive or MSFD) [1] that requires that "Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected". Commission Decision (EU) 2017/848 defines five criteria for the determination of Good Environmental Status (GES) in relation to a set of broad habitat types [2]. Two of those criteria relate to physical disturbance as follows:
D6C2: Spatial extent and distribution of physical disturbance pressures on the seabed.
D6C3: Spatial extent of each habitat type which is adversely affected, through change in its biotic and abiotic structure and its functions by physical disturbance.
Fisheries with mobile bottom-contacting gears (MBCG) are identified as a key human activity that causes significant physical disturbance to the seabed in EU waters, including in the Black Sea [3].
The Bulgarian Black Sea fisheries featured the following characteristics in 2017: the fishing fleet consisted of 1295 active vessels, 95 % of which with length < 12 m [4]. All of the 99 fishing vessels with length ≥ 12 m were equipped with satellite tracking devices and another 77 vessels < 12 m were equipped with GSM/GPRS tracking devices connected to the Fisheries Monitoring Center servers in Varna. Days at sea in 2017 were 25 071, 70 % of which were for boats < 12 m. The top three target species with the highest catches were Rapa whelk (*Rapana venosa*) – 3653.2 t, European sprat (*Sprattus sprattus*) – 3188.9 t, and White clam (*Donax trunculus*) – 819.0 t. The typical fishing gears for each of them are respectively beam trawl, mid-water otter trawl (operated near the bottom due to sprat aggregation) and dredge (illegal gear). Red mullet, horse mackerel and turbot catches were also sizeable and could have contributed to the overall physical disturbance by near bottom or bottom trawling.
The present study provides the first assessment of the physical disturbance from fisheries in the Bulgarian Black Sea in 2017: its extent, distribution and intensity over MSFD benthic broad habitat types and its impact on benthic invertebrates assemblages and fish.

3.1. Material and Methods

All pressure and impact estimates were done for the Bulgarian Black Sea shelf area under 200 m depth, as there is no aerobic macrofauna present or fisheries occurring in deeper Black Sea regions due to naturally anoxic conditions.
Vessel Monitoring System (VMS) data for 2017 was analysed to reconstruct the trawling lines of 86 vessels equipped with MBCG, distributed by fleet segments as follows: 18 with overall length between 6 and 12 m, 47 – between 12 and 18 m, 11 – between 18 and 24 m, and 10 with overall length above 24 m. Only pings with fishing specifics speeds (1.6-3.6 kn) were extracted. Start and end points of fishing operations were converted to lines, buffered with the average gear width and aggregated to calculate the swept area in GIS. The physical disturbance intensity was estimated using the swept-area ratio (SAR) [5, 6], calculated in grids with cell sizes 0.5x0.5 km, 1x1 km, 2x2 km and 5x5 km by dividing the sum of the swept area within each cell to the cell area. The SAR value indicates the theoretical number of times the entire grid cell has been swept if effort was evenly distributed within the cell. For example, a SAR of 2 means that each location within the grid cell is fished 2 times over

the year, while a SAR of 0.5 means that each location within the grid cell is fished once in two years. The pressure estimates were aggregated for all gear types (métiers) due to the fact that VMS data was decoupled from logbooks data. Actual gears widths were unknown, therefore averaged to 11 m based on expert evaluation of the available information on the predominant gears used, thus swept area could be either under- or over-estimated. Absence of tracking devices on boats with length < 12 m (the major segment with the most days at sea) represents a critical limitation resulting in pressure underestimation, especially in the shallow coastal area.

The use of seabed habitats map was required to estimate the extent and proportion of each habitat that was physically disturbed. A predictive map of MSFD broad habitat types (Figure 3.1 a) was obtained from the Seabed Habitats data portal of the European Marine Observation and Data Network (EMODnet) [7]. The predominant broad habitat types on the shelf are circalittoral mud (4201.8 km^2), offshore circalittoral mud (3024.4 km^2) and offshore circalittoral mixed sediments (2972.7 km^2), and infralittoral sand (197.1 km^2) in the coastal area.

Zoobenthic communities ecological status (indicative of the habitat condition) was assessed using the normalized multivariate marine biotic index M-AMBI(n) [8]. Habitat type specific thresholds are established for the constituent indices S, H' and AMBI [9], while common good status threshold is set using the ecological quality ratio (EQR) approach at EQRM-AMBI(n) ≥ 0.68, allowing for inter-habitat comparisons [10]. Sampling for macrofauna from the shelf sediments was carried out in October 2017 on board RV "Akademik" at 73 monitoring sites (147 samples) (Figure 3.1 a).

To derive an ecologically meaningful low/high pressure intensity threshold in relation to the ecological status of benthic macrofauna, Receiver Operating Characteristic (ROC) analysis [11] was run on two classes of SAR: "low" and "high" pressure, which were assigned corresponding to "good" and "not good" habitats status according to EQRM-AMBI(n). SAR values used were taken only from the cells, where macrofauna assemblages data was available.

$EQR_{M\text{-}AMBI(n)}$ was tested for significant difference of the mean at low-high pressure using t-test: two-sample assuming unequal variances, alpha=0.05.

Fish diversity and status assessment was based on the sampling executed during the period 5.10 – 15.11.2017 by OTM trawl gear over 40 stations, distributed in the Bulgarian Black Sea shelf area. All hauls have meridional direction with duration of 30 min and trawling speed between 2.4 – 2.5 knots. For the assessment, the indicators under the following criteria (COMMISSION DIRECTIVE (EU) 2017/845) are applied:

D3C2 — Primary: The Spawning Stock Biomass of populations of commercially-exploited species are above biomass levels capable of producing maximum sustainable yield. Appropriate scientific bodies shall be consulted in accordance with Article 26 of Regulation (EU) No 1380/2013.

State indicators:

- survey abundance indices.

D3C3 — Primary: The age and size distribution of individuals in the populations of commercially-exploited species is indicative of a healthy population. This shall include a high proportion of old/large individuals and limited adverse effects of exploitation on genetic diversity.

State indicators:

- the proportion of fish larger than mean size of first sexual maturation – Lm.
- the 95th percentile of the fish-length distribution of each population, as observed in research vessel or other surveys (L95).
- mean length of fish of each population, as observed in research vessel or other surveys (Lмean).

The threshold values used are according to the Bulgarian national monitoring program for Descriptor 3 (Table 5).

Table 5 - Threshold values used for the assessment.

Feature	Element, Element Code	GES component	Parameter Related Indicator	Threshold Value
Commercially-exploited fish and shellfish	**Squalus acanthias Linnaeus, 1758[Picked dogfish]**	D3C1	Ratio catch/Biomass	Not yet set
		D3C2	Abundance index	Not yet set
		D3C3	L95	Not yet set
		D3C3	ML	Not yet set
		D3C3	Lm	Not yet set
	Raja clavata Linnaeus, 1758 [Thormback ray]	D3C1	Ratio catch/Biomass	Not yet set
		D3C2	Abundance index	Not yet set
		D3C3	L95	Not yet set
		D3C3	ML	Not yet set
		D3C3	Lm	Not yet set
	Sprattus sprattus (Linnaeus, 1758)[European sprat]	D3C1	Ratio catch/Biomass	0.082
		D3C2	Abundance index	55000
		D3C3	L95	10.17
		D3C3	ML	7
		D3C3	Lm	68
	Alosa immaculata Bennett, 1835 [Pontic shad]	D3C1	Ratio catch/Biomass	Not yet set
		D3C2	Abundance index	Not yet set
		D3C3	L95	Not yet set
		D3C3	ML	Not yet set
		D3C3	Lm	Not yet set
	Merlangius merlangus (Linnaeus, 1758) [Whiting]	D3C1	Ratio catch/Biomass	Not yet set
		D3C2	Abundance index	Not yet set
		D3C3	L95	15.3
		D3C3	ML	16
		D3C3	Lm	16
	Pomatomus saltatrix (Linnaeus, 1766) [Bluefish]	D3C1	Ratio catch/Biomass	Not yet set
		D3C2	Abundance index	Not yet set
		D3C3	L95	Not yet set
		D3C3	ML	Not yet set
		D3C3	Lm	Not yet set
	Trachurus mediterraneus (Steindachner, 1868) [Horse mackerel]	D3C1	Ratio catch/Biomass	Not yet set
		D3C2	Abundance index	Not yet set
		D3C3	L95	13
		D3C3	ML	10.44
		D3C3	Lm	30
	Mullus barbatus Linnaeus, 1758 [Red mullet]	D3C1	Ratio catch/Biomass	Not yet set
		D3C2	Abundance index	Not yet set
		D3C3	L95	13.43
		D3C3	ML	14.04
		D3C3	Lm	53
	Scophthalmus maximus (Linnaeus, 1758) [Turbot]	D3C1	Ratio catch/Biomass	0.033
		D3C2	Abundance index	1700
		D3C3	L95	62
		D3C3	ML	50.4
		D3C3	Lm	74

The assessment under D3C2, indicator Abundance index is estimated for the whole shelf area, and for D3C3 – by species and MRU.
The approaches for integration of the individual indicators, criteria and final evaluation of D3 is made, as follows:

- The integration of individual indicators by species and MRUs for each criterion is carried out under the “One Out All Out (OAAO)” rule.
- The integration of the MRUs for each criterion and type - under the “One Out All Out (OAAO)” rule;
- the integration between criteria for each species - under the “One Out All Out (OAAO)” rule;
- The final assessment for the species is formed by the percentage of species in “Good” status. The threshold value is 100%.
- The final assessment for the Descriptor 3 Exploited fish species – “One Out All Out (OAAO)”

rule applied to all fish species.

3.2. Results and discussion

The total length of the reconstructed trawling lines from MBCG was estimated to 89823.0 km (Figure 3.1 b). No fisheries occurred beyond 100 m depth.
The physical pressure estimates in a grid with cell size 0.5x0.5 km amounted to spatial extent of 7110.3 km^2, 59 % as proportion from the total shelf area and maximum intensity of SAR = 3.5 (Figure 3.1 c). The grid resolution had a significant effect on the estimated values: the spatial extent of the physical disturbance increased to 82 %, while the maximum intensity decreased to SAR = 1.4 as the cell size increased to 5x5 km. The finest grid was used in the subsequent assessments.
Nineteen sites (26 %) rated as "not good" with regards to zoobenthic community status according to $EQR_{M\text{-}AMBI(n)}$ results. The majority of "not good" sites occurred in the circalittoral mud (Figure 3.1 a). The ROC analysis on the "low" and "high" pressure classes, corresponding to "good" and "not good" macrofauna status, resulted in optimum SAR = 0.19550 at which the sensitivity/specificity pair was maximized. Therefore, low/high pressure threshold was set at SAR ≥ 0.2, which is an ecologically meaningful threshold related to the benthic macrofauna status. The average $EQR_{M\text{-}AMBI(n)}$ was significantly different (p=0.006) at "low" and "high" pressure. Moreover, "good status" (mean EQR=0.81) was associated with low pressure (SAR < 0.2), while "not good" status (mean EQR=0.66) was estimated at high pressure (SAR ≥ 0.2).
Areas of high pressure intensity (SAR ≥ 0.2) comprised only 12 % of the shelf (Figure 3.1 d). The extent and proportion of the broad habitat types under overall pressure and high pressure from MBCG is summarized in Table 6.

Table 6 - Spatial extent and proportion of the broad habitat types subject to physical disturbance and high intensity disturbance in the Bulgarian Black Sea shelf in 2017. *Predominant habitat types in infralittoral, circalittoral and offshore circalittoral zones.

Habitat type	Total area	Trawled area		Intensively trawled area (SAR ≥ 0.2)	
	(km2)	(km2)	%	(km2)	%
Infralittoral mud	9.5	2.4	25	0.0	0
Infralittoral coarse sediment	62.9	18.2	29	2.7	4
Infralittoral sand*	197.1	61.4	31	23.3	12
Infralittoral mixed sediment	55.3	31.4	57	3.8	7
Circalittoral coarse sediment	189.7	98.7	52	43.2	23
Circalittoral mixed sediment	853.3	603.4	71	181.4	21
Circalittoral sand	108.1	64.3	59	29.1	27
Circalittoral mud*	4201.8	3466.1	82	876.3	21
Offshore circalittoral coarse sediment	4.5	0.0	0	0.0	0
Offshore circalittoral mixed sediment*	2972.7	1812.4	61	162.2	5
Offshore circalittoral mud*	3024.4	866.3	29	89.9	3
Offshore circalittoral sand	5.3	5.2	98	0.0	0

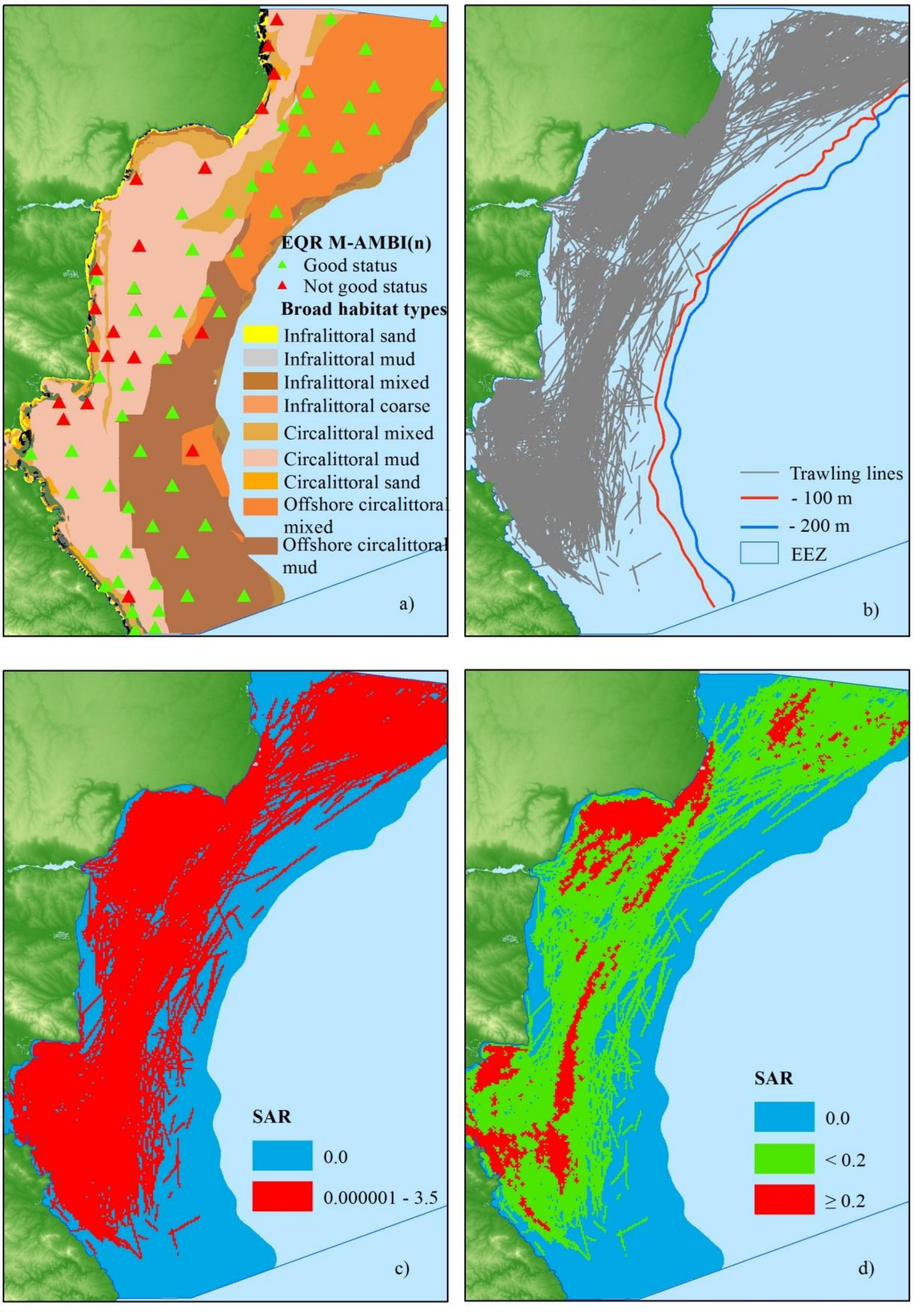

Figure 3.1 - Maps of: a) MSFD benthic broad habitat types in the Bulgarian Black Sea shelf area and zoobenthos ecological status at the monitoring sites in 2017; b) reconstructed trawling lines from VMS data; c) distribution of the physical disturbance from MBCG; d) distribution of high and low physical disturbance pressure.

G.

The distribution of physical disturbance intensity in the Bulgarian Black Sea in 2017 had a considerable spatial variation (Figure 3.1 d). While the overall fishing pressure occurred over 59 % of the shelf under 200 m depth, the areas of high pressure intensity (SAR ≥ 0.2) encompassed only 12 % of the shelf and occurred either closer to the coast or in the circalittoral zone at depths typical of the main target species: 15-30 m for *Rapana venosa* and 50-70 m for *Sprattus sprattus*. Areas with lower intensity occurred offshore in the deeper parts of the Bulgarian shelf. There was no pressure observed beyond 100 m depth where hypoxic/anoxic conditions in the Black Sea prevent the distribution of fish stocks. Since the assessment area was aligned with the shelf boundary at 200 m, the proportion of intensively disturbed areas from the actual fishing grounds may be underestimated.

The proportion of area subjected to fishing pressure varied among the broad habitat types and was highest in the circalittoral mud (81 %), circalittoral mixed sediments (71 %) and offshore circalittoral mixed sediments (61 %). However, the respective proportion of intensively disturbed area was higher (21%) for both circalittoral habitats and decreased to only 5 % in the offshore sediments. The proportion of infralittoral sand physically disturbed (overall 31 %, intensively 12 %) was probably underestimated due to absence of tracking devices on small boats.

The results of the ROC analysis established low/high physical disturbance pressure threshold at SAR ≥ 0.2, associated with significant difference in the macrofauna ecological status and therefore suitable for evaluation of the extent of the habitats at risk to be adversely affected by physical disturbance from fisheries under GES criterion D6C3.

The intensively fished areas identified in this study could be qualified as “core fishing grounds”. However, the fishing effort and landings may have non linear relationship. Maps of the landings distribution in the Bulgarian Black Sea for the period 2015-2019 are provided by the Scientific, Technical and Economic Committee for Fisheries (STECF) at 0.5 x 0.5 degree resolution [12]. A visual comparison of the pressure map developed in this study with STECF landings map for 2017 revealed that some of the intensively fished grounds (Cape Kaliakra area) obtained ample landings, while other (Southern shelf area) were not as productive. These observations suggest possible spatial management measures: e.g. closure of non-core fishing grounds could reduce the physical disturbance pressure in favour of habitat protection but at minimal loss of revenue from fisheries. Optimization approaches have been developed to define the minimum area where a given proportion of the effort is guaranteed [13]. Ban and Vincent [14] demonstrated that strategically allocated small reductions in fisheries could result in large unfished areas and have the potential to achieve important environmental targets and benefits.

Future work shall be done to analyze the temporal variation in fishing intensity in a six-year management cycle under MSFD to determine the spatial variation in core fishing grounds and physical disturbance from fisheries over time. Trade-off analysis is required to explore the consequences of different management scenarios to the fisheries sector and to the marine ecosystem.

3.3. Fish

The collected data contain information on a total of 28 species of fish that were registered during the survey, of which 11 species are subject to exploitation. Because some of the species were registered in low numbers and at a few stations, the indicators were calculated for only eight of them. The obtained results are given below.

Criteria D3C2, indicator „Abundance index“(kg/km^2; ind/km^2)

Estimated abundance indices (ind.km^{-2}) are presented on Figure 3.2.

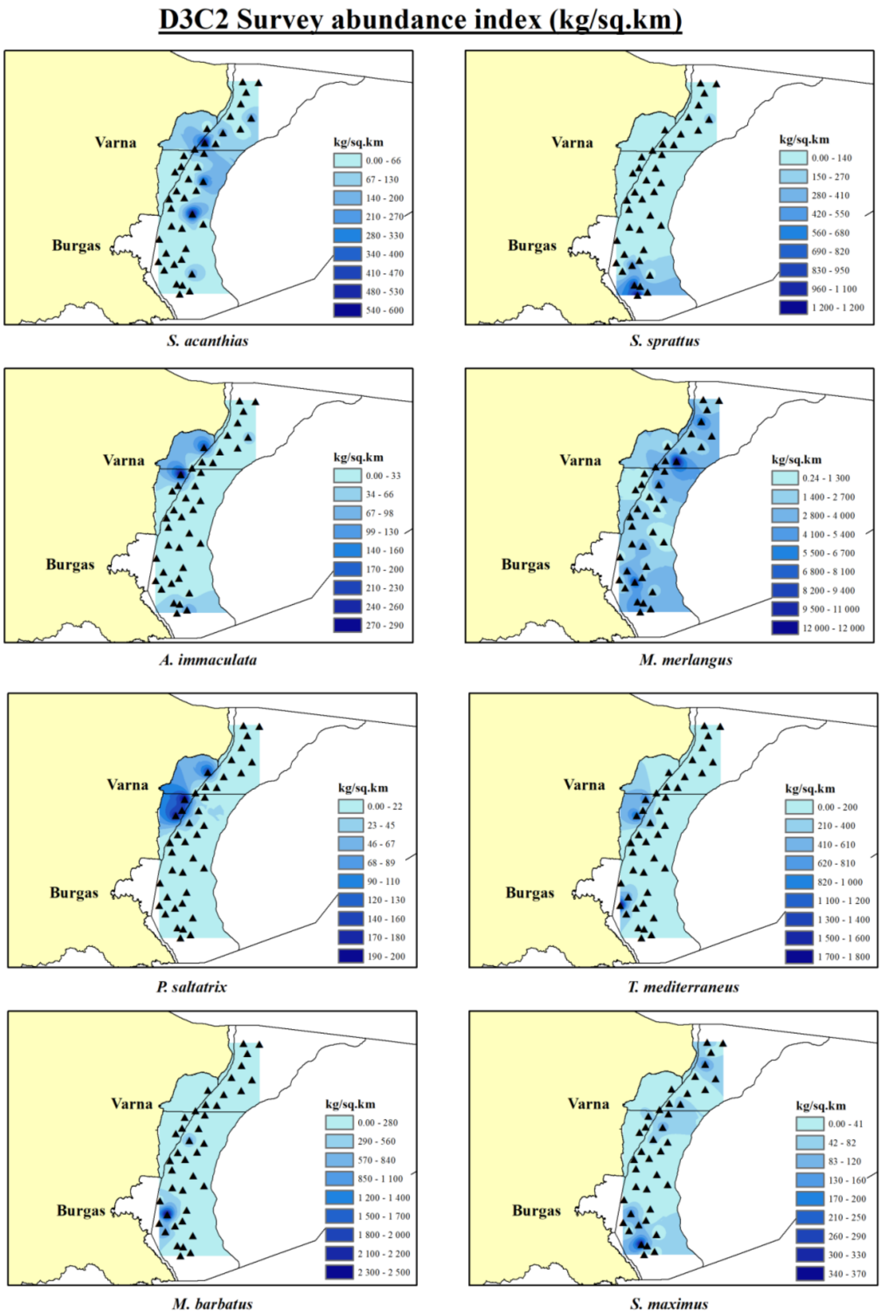

Figure 3.2 - Abundance indices by biomass (kg.km-2) for exploited fish species.

<u>Criiteria D3C3, indicators:</u>

- the proportion of fish larger than mean size of first sexual maturation – Lm – Figure 3.3.
- the 95th percentile of the fish-length distribution of each population, as observed in research vessel or other surveys (L95) - Figure 3.4.
- mean length of fish of each population, as observed in research vessel or other surveys (LMean) - Figure 3.5.

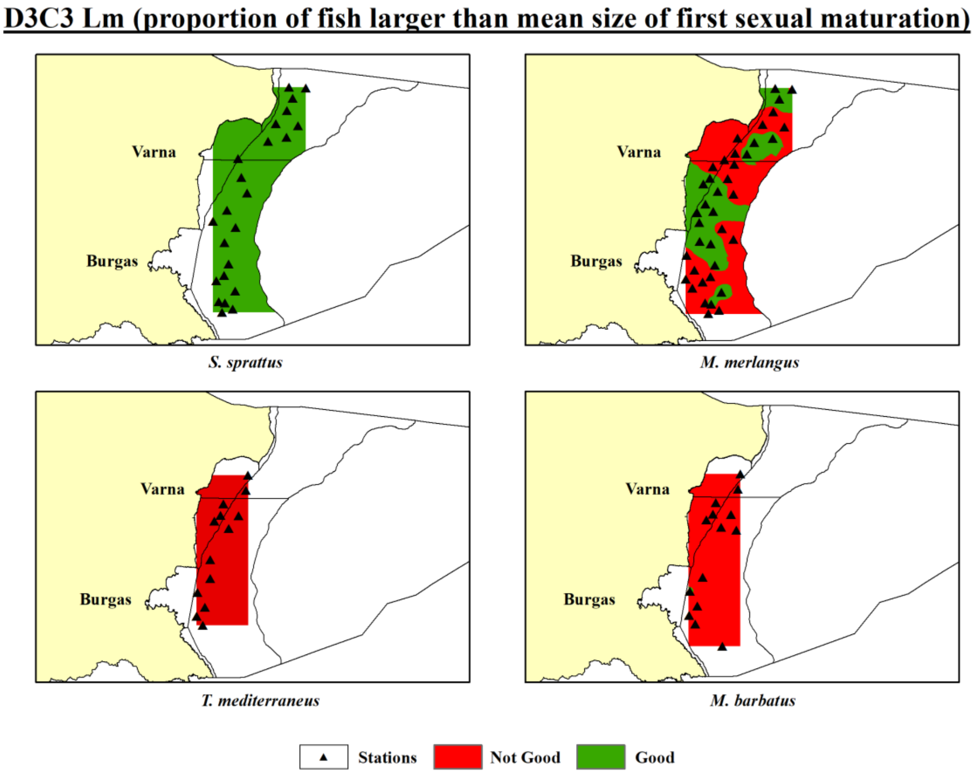

Figure 3.3 - Proportion of fish larger than mean size of first sexual maturation – Lm for 2017.

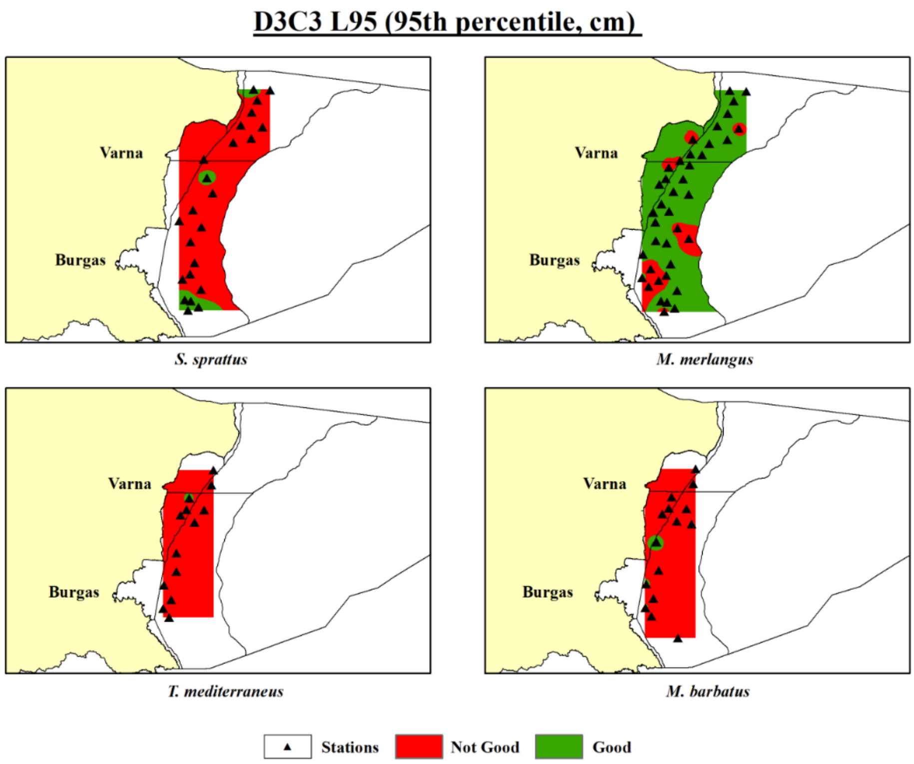

Figure 3.4 - The 95th percentile of the fish-length distribution of each population, as observed in research vessel or other surveys (L95) in 2017.

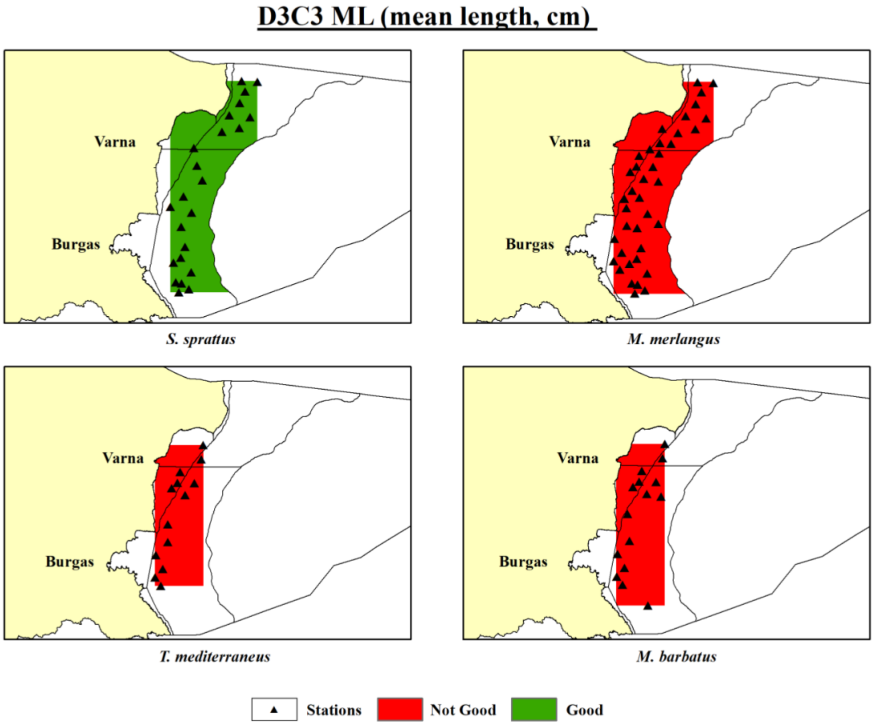

Figure 3.5 - Mean length of fish of each population, as observed in research vessel surveys (Lmean) for 2017.

The assessment of the state of the exploited fish species (Descriptor D3) in the MRU areas in 2017 shows that there are no species in “Good” state, four species have not been assessed and the rest are in “Not Good” state. The possible reason could be related to intensive fishing pressure over the Bulgarian shelf area.
Correlations between SAR (in 5 km grid) and fish diversity indices, abundance and Criteria D3C3 indicators were investigated. Results are presented on Table 7, Table 8, Table 9 and on Figure 3.6, Figure 3.7 and Figure 3.8.

Table 7 - Correlations (non-parametric, Spearman) between the physical pressure (SAR) and fish diversity indices. Values in bold are different from 0 with a significance level alpha=0.05.

Diversity indices	SAR
S	**0.446**
d	**0.444**
J'	-0.022
H'(loge)	0.054
1-Lambda'	0.011

Statistically significant moderate correlations were observed between SAR (in 5 km grid) and species richness (S) and Simpson’ diversity index (d). Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of and each species.

Table 8 - Correlations (non-parametric, Spearman) between the physical pressure (SAR) and fish abundance. Values in bold are different from 0 with a significance level alpha=0.05.

Abundance	SAR
S. sprattus Abun	**-0.410**
M. merlangus Abun	-0.148
P. saltatrix Abun	**0.379**
T. mediterraneus Abun	**0.352**
M. barbatus Abun	**0.313**

Moderate negative correlation was observed between SAR and sprat abundance. Positive correlations were observed for bluefish, horse mackerel and red mullet. The positive correlation with SAR for these migratory species probably is due to attraction of fishing vessels to the areas, where mass migration occurs. The intensive fisheries, represented by high SAR values, exerted negative impact on sprat abundance.

Table 9 - Correlations (non-parametric, Spearman) between the physical pressure (SAR) and L95 and Lmean. Values in bold are different from 0 with a significance level alpha=0.05.

Abundance	SAR
S. sprattus L95	**-0.453**
M. merlangus L95	0.120
T. mediterraneus L95	-0.134
M. barbatus L95	-0.342
S. sprattus Lmean	0.038
M. merlangus Lmean	0.094

Moderate negative correlation was observed only between SAR and indicator L95 for sprat size structure For the other species and for mean lengths (Lmean), the correlations are not statistically significant.
Our results showed, that further studies on relationships between state of fish communities and size structure of populations should be carried out, but based on longer data series.

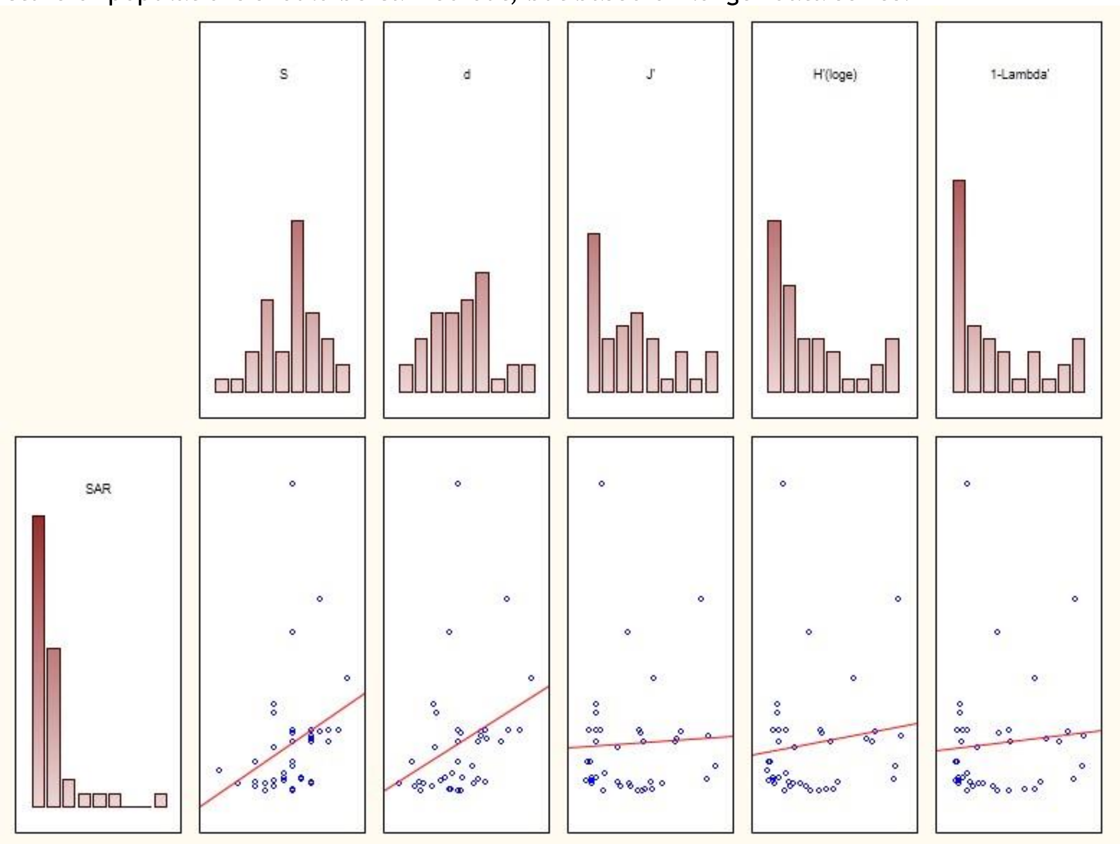

Figure 3.6 - Correlations between the physical pressure (SAR) and fish diversity indices.

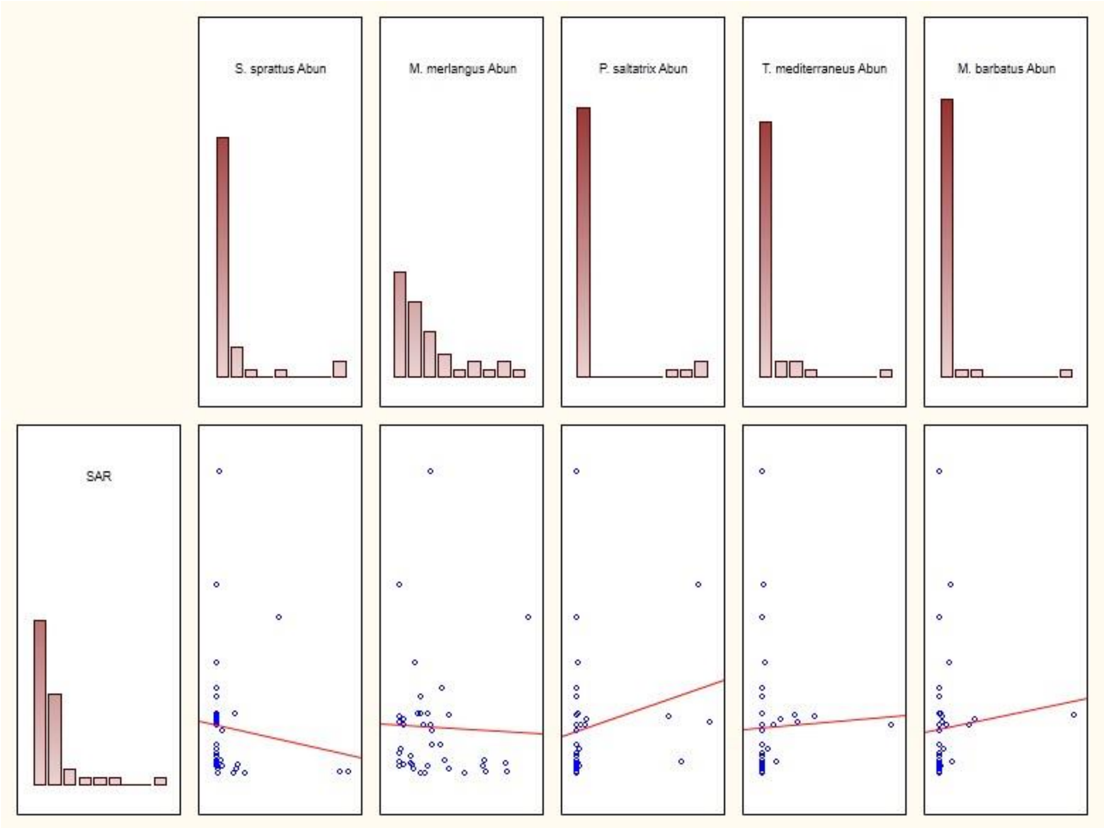

Figure 3.7 - Correlations between the physical pressure (SAR) and fish abundance.

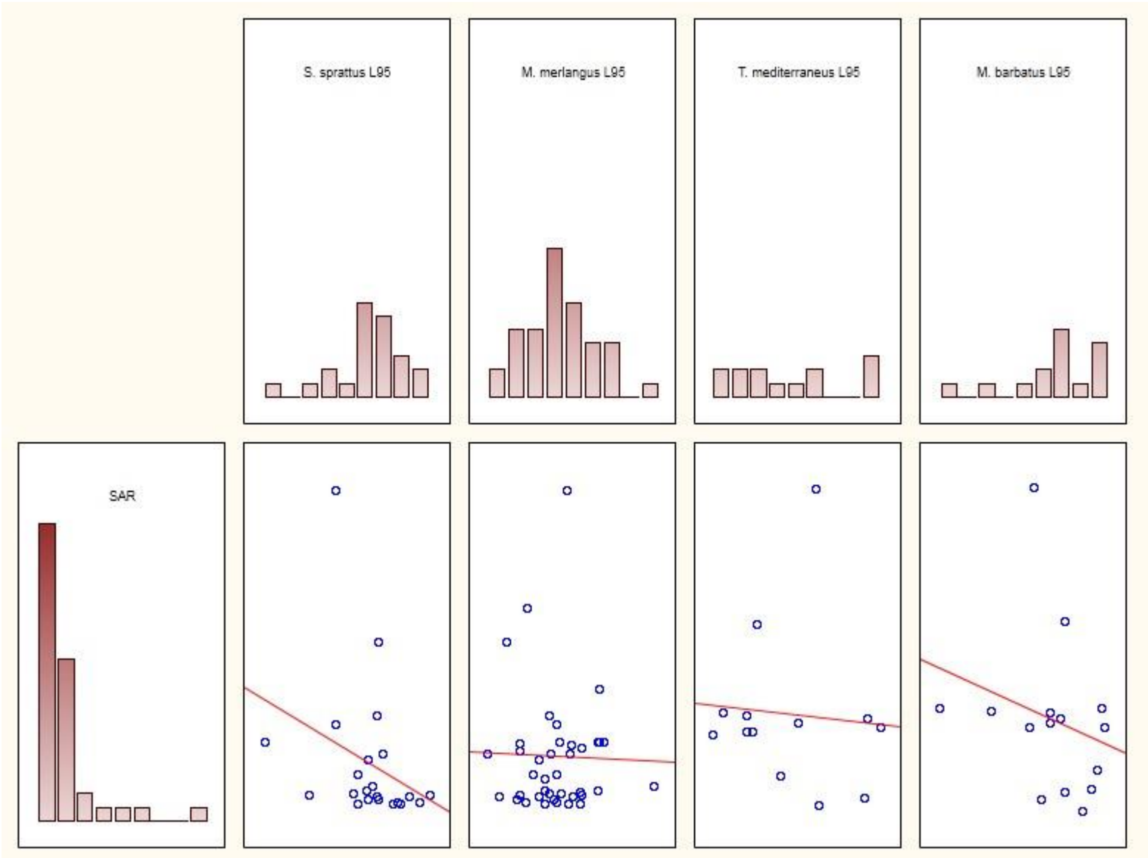

Figure 3.8 - Correlations between the physical pressure (SAR) and indicator L95.

3.4. Conclusions

Nearly 60 % of the Bulgarian Black Sea shelf was physically disturbed by MBCG in 2017. However, only 12 % of the seabed under 200 m depth was subject to high physical disturbance pressure from fisheries.

The predominant benthic habitat types exposed to the most extensive trawling pressure were circalittoral mud and mixed sediments, followed by offshore circalittoral mixed sediments. The habitats exposed to the highest pressure intensity were those in the circalittoral zone. The physical disturbance on the infralittoral sands was probably considerably underestimated due to lack of tracking systems on the predominant fleet segment boats < 12 m length.

Significant difference was demonstrated in benthic habitats condition according to macrofauna status at low and high physical disturbance pressure intensity. The established low/high pressure threshold (SAR ≥ 0.2) allows for evaluation of the extent of habitats at risk to be adversely affected by physical disturbance from fisheries under GES criterion D6C3.

The negative relationships between fisheries intensity and sprat abundance and size structure indicators was observed.

Future analysis of the spatio-temporal variation in the physical disturbance from fisheries and landings weight/value can provide the evidence base for optimization of the fishing grounds to protect the benthic habitats and fish populations and achieve the environmental targets at minimal loss of revenue from fisheries.

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ANNEX A Management targets for reducing pollutants originating from shipping and offshore installations - Black Sea

Black Sea Commission EcoQO 4b: Reduce pollutants originating from shipping activities and offshore installations matrix consisting of short-, mid- and/or long-term management targets that address the concerning root causes.

For regional level interventions, the Black Sea coastal states and the international partners shall work collectively to take the required steps to fulfil the intervention. The national level supporting interventions will be the responsibility of the individual states. The targets are listed below, including outputs, time to implement, legal, institutional and policy reforms required, indicators of success, priorities and uncertainties[2].

[2]http://www.blacksea-commission.org

Management target	Anticipated outputs	Time	Reforms	Indicators	Priority	Uncertainties
Policy/legislation						
Adopt the Black Sea Contingency Plan to the Protocol on Cooperation in Combating Pollution of the Black Sea by Oil and Other Harmful Substances in emergency situations (Part I - Response to oil pollution)	Adoption of the Plan by all 6 Black Sea Countries	1-2 years	Georgia, Ukraine and Russia	Adoption of the Plan at national levels	High/ Medium	Political acceptance
Develop and adopt Part II (Chemical Plan)of the Black Sea Contingency Plan to the Protocol on Cooperation in Combating Pollution of the Black Sea by Oil and Other Harmful Substances in Emergency Situations Short-term target. Development of Part II of the Black Sea Contingency Plan (response to pollution from harmful substances) Mid-term targetAdoption of Part II of the Black Sea Contingency Plan (response to pollution from harmful substances)	Part II developed, agreed and adopted by all BS countries	2-3 years 4-8 years	Yes	Part II of the Plan finalised and sent to countries for adoption Part II of the Plan is adopted by all 6 Black Sea Countries	High	Political acceptance Financing
Establish an inter-state ministerial mechanism to enable a quick response to major pollution events	National Contingency Plans, covering both vessels and offshore installations in place and coordinated between the Black Sea Countries		Yes	National authorities/ institutions/stakeholders involved in contingency and emergency situations response identified in all BS Countries The mechanisms for intervention, information exchange, etc., in place National/regional contingency action plan published and operational Scheduled oil spills preparedness and response exercises, including bi-annual DELTA exercises, agreed by countries	High/ Medium	Financing Lack of operational equipment
Adopt and enforce relevant international legal instruments for safety navigation, pollution prevention, limitation of liability and compensation Short-term	Ratification/accession/ adoption of MARPOL 73/78 (Annexes III, IV&VI), AFS by all six Black Sea Countries	3-5 years 5-10 years	Yes	Assessment of ratification and effective application and enforcement of relevant legal instruments All 6 Black Sea Countries are	High/ Medium	Political acceptance Financing Inter-institutional cooperation

Management target	Anticipated outputs	Time	Reforms	Indicators	Priority	Uncertainties
target Cooperate and access relevant international legal instruments for safety navigation, pollution prevention, limitation of liability and compensation (MARPOL, BWM, London Protocol added in glossary etc.) Mid-term target Enforce relevant international legal instruments for environmentally safe navigation, pollution prevention, limitation of liability and compensation (MARPOL, BWM, London Protocol etc.)				parties to the relevant legal instruments and apply an harmonised system of enforcementRatification of legal instruments Documented enforcement of legal instruments		
Improved regulations/ management of dredging/ dumping activities	Reduced transfer of dangerous pollutants into the marine environment by dumpingImproved reporting to the BSC of the dredging operations and deposit sites	5-6 years	Yes	Number of permits for dredging/disposal to the Sea; Number and locations of official deposits for dredged sediments	Medium	No standardised analytical methodologies for analysis of sediments No internationally agreed guidelines for the identification of appropriate dumping sites
Waste management						
Provide adequate port reception facilities for ship-generated wastes according to MARPOL 73/78, Annex I, IV, V.	Reduction of illegal discharges of ship-generated waste, including oily mixtures, noxious liquid substances, sewage, garbage and cargo residues into the Black Sea marine environment	3-10 years	Yes	Increased disposal and treatment of ship-generated wastes and cargo residues in full compliance with MARPOL 73/78 Management Plans for Ship Generated Waste and cargo residues published/ implemented in all BS Ports Investments Annual Report to the BSC on ports ship waste management 3 Years assessment report of the Black Sea State of Environment	High/ Medium	Financing; Low cooperation between authorities and shipping industry Low level of involvement of stakeholders in the decision-making process
Establish a harmonised fee/cost recovery system on ship-generated waste	Reduction of illegal discharges of ship-generated waste	1-3 years	Yes	Regionally harmonised cost recovery/fee system in place.	High/ Medium	Political acceptance
Surveillance/Monitoring						
Develop systems for the	Reduced illicit chemical	5-10	Yes, a	VTOPIS or equivalent systems	Medium	Financing availability

Management target	Anticipated outputs	Time	Reforms	Indicators	Priority	Uncertainties
identification of illegal pollution sources from vessels and offshore installations Mid-term targetSystem for monitoring oil pollutionLong-term targetSystem for monitoring solid waste disposal	and solid waste discharges	years for oil pollution 10+ years for solid waste	change in policy at least	implemented and operational in all Black Sea countries to support national Governments in surveillance of vessels traffic and in reducing/eliminating the pollution originating from vessels, including offshore installationsSystem operationalSystem operational		Link to remote sensing data sources for real-time monitoring. Radar required to identify source locations, but satellite remote imagery required for the identification of pollutants themselves. Unclear whether flotsam and jetsam can be viewed using satellite remote imageryMay be necessary to use aircraft for marine litter identification , which is likely to be prohibitively expensive.
Economic mechanisms/instruments						
Develop/establish a harmonised enforcement system in cases of illegal discharges from vessels and offshore installations, including technical means and fines	Infringement of discharge regulations as well as aiding, abetting or inciting an illegal discharge is punishable	3-5 years	Yes	A harmonised system of penalties established and enforced Effective, proportionate and dissuasive	High/ Medium	Political acceptance Financing Limited effectiveness of economic incentive mechanismsInter-ministry cooperation needed.
Develop a common system for claims management for pollution damages compensation	Common and effective policy on claims management	1-3 years	Yes Ukraine - CLC 92 Protocol	Common procedures and panel of experts, databases, etc.	Medium	Political acceptance Inter-institutional cooperation needed
Assess the need to develop a legal framework for assessment of the transportation of hazardous wastes in line with Basel Convention	Regional Studies of the movement of Transboundary hazardous waste.Decision on the necessity of development of the Protocol on Hazardous Waste.	3-6 years	Yes, a change in policy at least		High/Medium	Inter-institutional cooperation needed Political acceptance

ANNEX B Methodologies used for offshore environmental monitoring

Table 10 - Physycal-chemical analysis (water)(after OGP, 2012) – pelagic habitats, up to 100m

Parameters	Method
Total suspended solids	Filtering then weighing
Nutrients (nitrate, nitrite, ortophosphate)	Spectrophotometry Ion Chromatography
Chlorophyll pigments and phaeopigments	Extraction then spectrophotometry
Dissolved oxygen – pH – temperature-salinity	Multiparameter probes
Metals – Ba, Cd, Cr, Cu, Pb, Ni, Co, Sn, Zn	AAS; ICP-AES
Total Petroleum Hydrocarbons	GC/FID
Polycyclic Aromatic Hydrocarbons	GC/MS
Mono Aromatic Hydrocarbons (BTEX)	GC

Table 11 - Chemical analysis (sediments) (after OGP, 2012) – benthic habitats, up to 50m

Parameters	Method
Total organic Carbon	Loss on ignition (LOI) Analyzer
Grain size distribution	Silting through different meshes of sieves
Total Petroleum Hydrocarbons	Extraction then GC/FID
Polycyclic Aromatic Hydrocarbons	Extraction then GC/MS
Metals – Ba, Cd, Cr, Cu, Pb, Zn	AAS; ICP-AES
Total Petroleum Hydrocarbons	GC/FID
Polycyclic Aromatic Hydrocarbons	GC/MS

Table 12- Overview of relevant methods for the impact of offshore activities on biota (KLIMA, 2011)

Parameter	Tissue type/ matrix	Substance/ group of substances	Organisms
PAH metabolites (FF/GCMS)	Bile	PAHs	Fish
Alkyl phenol (AP) Metabolites	Bile	APs	Fish
PAHs (body burden)	Soft tissue	PAHs	Mussels
Histology	Gills	Different sources of stress	Fish
DNA adducts	Liver	PAHs (+)	Fish
CYP 1A	Liver	PAHs (+)	Fish
Vitellogenin (VTG)	Blood plasma	Xenoestrogens	Fish
Pyrene hydroxylase	Digestive gland	PAHs	Mussels
Micronucleus formation	Cells	Genotoxic stress	Mussels
Lysosomal membrane stability	Haemocytes (blood cells)	Metals and organic contaminants	Mussels
Lipofuscin	Histological sections	Different sources of stress	Mussels
Neutral lipid	Histological sections	Different sources of stress	Mussels

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