Ritmare

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"The Ionian and Adriatic Region: energy resources and environmental sustainability"

Workshop

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THE RITMARE PROJECT, OIL AND GAS RESEARCH ACTION

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Ritmare (La Ricerca Italiana per il Mare, www.ritmare.it) is one of the Flagship Projects of the National Research Program funded by the Ministry of Education, University and Research in the five-year period 2012-2016 and has so far provided funding of nearly 100 million euros to the overall Italian community of marine scientists. The project is coordinated by CNR, the National Research Council and involves more than 1200 scientists from research organizations and universities in the field of marine and maritime research and innovation. Ritmare is divided into 7 topics:

1. Maritime Technologies. More efficiency and safety at sea, less environmental impact (including noise) of watercrafts.

2. Technologies for Sustainable Fishery.

3. Marine Spatial Planning of the Maritime Space in Coastal Waters.

4. Marine Spatial Planning of the Deep Marine Environment and the Open Sea, including hazard mitigation and initial assessment of the marine resources in the Italian Seas.

5. Observation System for the Marine Mediterranean Environment.

6. Research, Training and Dissemination Structures to promote the use of shared laboratories, infrastructures, workshops.

7. Interoperable Infrastructure for the Marine Data and Observatories Network. Distribution, reuse and re-analysis of open marine data.

RITMARE has been supporting the training of a new generation of marine scientists by funding innovative projects selected through calls for proposal in order to strengthen the strategic presence of Italian marine research in Europe and in the Mediterranean area.

The project furthermore aimed at revitalizing the domestic nautical sector, with particular focus on the developed of new environmentally sustainable technologies and has leveraged the establishment of a permanent forum between researchers, decision makers and stakeholders, with the aim to foster the integration and transfer of scientific progress into the decision making process.

The key issues of the project can be summarized in the need of protecting the health of the sea and mitigating its natural impacts on human activities in the frame of a marine production system.

During 2016, all the activities concentrated on strategic themes of greater socio-economic impact, in the light of the Bluemed initiative for Blue growth and jobs in the Mediterranean and the EUSAIR strategy in the Adriatic and Ionian region. A second intent aimed to reinforce the network of collaborative efforts established in the previous years and facilitate the surfacing, reuse and innovative interpretation of relevant existing marine data.

Within this broader scope, on May 19th 2017, a workshop entitled "The Adriatic Ionian Region: energy resource exploration and exploitation and environmental sustainability" disclosed the results of activities carried out by the research action called "oil & gas".

The action aimed to provide an independent scientific standpoint on the controversial issue of exploration and exploitation of hydrocarbons in the Italian seas.

The Italian offshore hydrocarbon production is entirely located in the Adriatic and Ionian Region, where the EUSAIR strategy is in force. The EU Strategy, endorsed in October 2014 by the European Council, is the third EU macro-regional strategy after the EU Strategy for the Baltic Sea Region (2009) and the EU Strategy for the Danube Region (2011). The EUSAIR covers eight countries: four EU Member States (Croatia, Greece, Italy, Slovenia) and four non-EU countries (Albania, Bosnia and Herzegovina, Montenegro, Serbia). Fourteen Italian Regions (Friuli Venezia Giulia, Veneto, Lombardia, Autonomous Provinces of Trento and Bolzano, Emilia Romagna, Marche, Umbria, Abruzzo, Molise, Apulia, Calabria, Basilicata and Sicily) adopted the agenda.

Four thematic pillars are at the base of the strategy: 1. Blue growth; 2. Connecting the region (transport and energy networks); 3. Environmental quality; 4. Sustainable tourism. The area hosts a busy shipping lane, the hub for the offshore oil & gas industry in the Mediterranean, the southern gas corridor that links natural gas supplies to Europe and meets the strategic goal of enhancing Europe's energy security and diversity.

More recently and sadly, the region is also the only perilous passageway to Europe left for economic migrants, asylum seekers and refugees. All these activities occur in very narrow marine regions, where the boundaries of national jurisdiction are not entirely defined, and a crumbled legal framework makes it difficult the decision making process and the implementation of measures in terms of environmental protection in the common marine area.

The workshop has been an opportunity to share the scientific perspective with stakeholders, to hear from them some lessons learnt on the ground (Regione Abruzzo), to learn about their environmental monitoring programs (e.g. Offshore safety network by Ministry of Economic Development and Marine Strategy Framework Directive by Ministry of Environment). In a nut shell, the workshop was an attempt to explain to the audience what are the scientific evidence, arising from independent studies, of possible indirect impacts or unexpected synergies of the oil & gas exploration and exploitation activities on the marine system.

Session 1 – Offshore oil & gas exploration and exploitation in the Italian seas: environmental safety and regulations

THE NETWORK FOR OFFSHORE SAFETY

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ABSTRACT

The “Network for offshore safety” is the name of the partnerships with major Italian Research Centres, Universities and other State Institutions (e.g. Italian Navy and Port Authority) started by the Italian Ministry of Economic Development, Directorate-General for Safety of mining and energy activities (DGS-UNMIG) in order to assure safety of the mining and energy activity also by the improvement of control and monitoring of the offshore mining activities.

The DGS-UNMIG initiatives started in 2014 according to the art. 35 of the Legislative Decree n.83/2012 are focused on the development of high specialist scientific and technological issues managed in 6 main research projects.

This paper deals with the DGS-UNMIG activities and is aimed to show the results obtained by the "Network" during the last three years.

KEY-WORDS

offshore safety; Network; oil & gas; monitoring; dialogue and transparency

INTRODUCTION

The transposition of Offshore Directive (30/2012/EU), through the Legislative Decree n. 145/2015, brought to the rearrangement of the competences in the mining and energy sector between two Directorates of the Ministry of Economic Development:

- The Directorate General for safety of mining and energy activity (DGS-UNMIG), which assumed the role of safety Authority;
- The Directorate General for security of supply and energy infrastructures (DGSAIE), which assumed the role of the Licensing Authority.

The DGS-UNMIG must ensure compliance both with the work programs and the occupational safety regulations during the prospecting, exploration and exploitation phases of the life cycle of a hydrocarbon license. The DGS-UNMIG activities are implemented thanks to the Central body, in Rome, to the mining and chemical Laboratory and to the associated Offices (UNMIG) placed on the Italian territory in Bologna, Rome and Naples.

The Offices carry out:

- Tests and controls of safety of the plants;
- Activity of injuries prevention;
- Checks of health and safety of employees;
- Technical and administrative management of the hydrocarbon exploration exploitation and storage licences.

The mining and chemical Laboratory is responsible for the experimental monitoring of environmental components (e.g. soil, noise, and atmosphere), of inspection campaigns and chemical-physical analysis on samples of mining substances and geological materials coming from the extractive industry, including its recovery materials and waste.

Within its functions, the DGS-UNMIG can also counts on collaborations with Research Centres, Universities and other State Institutions (e.g. Italian Navy and Port Authority), which all together constitute the "Network for offshore safety".

THE "NETWORK FOR OFFSHORE SAFETY"

In order to ensure the full performances of the supervision and control of the safety of offshore installations, pursuant to art. 35 of the Legislative Decree n.83/2012, DGS-UNMIG, has funded cooperation agreements with major Italian Research Centres, Universities and other State Institutions (e.g. Italian Navy and Port Authority) with a view to constantly improving the safety of offshore operations in the hydrocarbons sector (Panei et al., 2016) (Fig. 1).

The objectives of the Network are managed into 6 research projects (web link http://unmig.mise.gov.it/unmig/accordi/accordi.asp):

1. Definition of a National Safety Index;
2. Monitoring activities and technological innovation;
3. Development of regulation and best practices;
4. Improvement of dialogue and transparency on the territory;
5. Analysis on the potential triggered seismicity offshore and tsunami;
6. Development of a sustainable decommissioning plan and multipurpose use of the offshore platforms.

Figure 1 - Representation of DGS UNMIG partnerships in the framework of the “Network for the offshore safety”.

The definition of a National Safety Index has for the main task the creation of an easy and transparent tool for the management and improvement of safety in the hydrocarbon exploration and production activities. This type of tool is important not only in the mining field but for the entire energy sector.

In fact, the possibility to demonstrate the "safety state" for the upstream sector allows improving the control and measurement of the performance and the Government effort in the dialogue with the territory.

About monitoring and technology innovation the DGS-UNMIG, in cooperation with Research Centers, is deepening the scientific issues related to the implementation of monitoring according to the Ministerial Guidelines (Dialuce et al., 2014), in order to discriminate natural from induced/triggered seismicity (Grigoli et al., 2017), and generate greater awareness of the risks associated to the natural hazard – NATECH risks (e.g. Gasparini et al., 2017; Capuano et al., 2017). Through monitoring studies, the DGS-UNMIG is analyzing the problems associated with subsidence and the proper instruments for measurement of subsoil deformations. DGS-UNMIG is also carrying out studies on the dynamics of marine pollutants dispersion even in relation to major accidents, analyzing the gas emission in the atmosphere coming from the hydrocarbon exploitation activities (Bonetti & Antoncecchi, 2015) and is studying also the subsurface geology of unexplored Italian areas (e.g. western Sardinia offshore; Antoncecchi & Ceruti, 2015).

These researches should be the input for the definition of some *key performance indicators* to consider in the definition of the Safety Index and should be the base for the implementation of the best practices and regulation in the hydrocarbon sector, as suggested by the research project on the "Best practices and Regulation".

The DGS-UNMIG is moreover engaged in the communication project in order to promote the data sharing among the partners and to assure the dialogue and transparency with the territory. Since by the beginning of the agreement of the Network for offshore safety were organized numerous events with both scientific and dissemination purpose, particularly thanks to the collaboration with the Interuniversity Research Centre for Economy and Territory of the University of Milan "Bicocca" – CRIET.

On 2017 was born two new projects: the SPOT project started with the technical collaboration of the Italian Civil Protection, concerns the specific issue of the potential triggered seismicity in Italy. The phenomenon, little known at national and international level, is characteristic of an area with high natural seismicity, such as that of Italian territory, and could be favored by some anthropic activities. Considering the Recommendations resulted by the studies conducted during these last years and overall considering the Recommendations of the Major Risk Committee, the Directorate has therefore continued to work with the best entities in the field of risk prevention and seismic vulnerability study of buildings.

The main task of the project is to study the potentially triggered seismicity generated by offshore operations along the coast, in a view of prevention and safety. This theoretical study is necessary to realize a mapping of the phenomenon and an estimation of potential damages linked to it. CNR ISMAR, INGV, RELUIS and EUCENTRE are the Researches Centers involved in the project.

Finally, another DGS-UNMIG project in the framework of "Network for offshore safety" recently started concern the "Safety and Sustainable Decommissioning" of the offshore platforms. The project has the main task to define, on the base of objective criteria, some indicators for the decommissioning or multiuse of hydrocarbons platforms for example for environmental monitoring, touristic or recreational use.

CONCLUSIONS

DGS-UNMIG has launched a series of collaborations in the field of prevention for offshore safety of mining and energy activities offshore. From 2014 to 2016, scientific collaborations have made the first results in terms of guidelines, scientific publications, and contributing to knowledge enhancement and existing monitoring systems.

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ANALYSIS OF LIQUID AND GASEOUS EMISSIONS OF OFFSHORE PLANTS

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ABSTRACT

This work shows what is the current state of the procedures and controls carried out in accordance with environmental regulations (Legislative Decree of April 3th, 2006, n.° 152 "Environmental Regulations" and subsequent amendments) on offshore oil & gas activities as well as those specific for safety and health of workers in the extractive industries (Legislative Decree. n.° 624/96 and Presidential Decree n.° 128/1959), presenting examples of analysis of chemical contaminants in air and water carried out by the laboratories of the National Mineral Office for Hydrocarbons and Geothermal Resources (UNMIG) of the Ministry of Economic Development and supported by Bicocca University of Milan.

KEY-WORDS

Health and Safety; Environment management; Offshore structure; Oil and gas production; Water analysis

ACTIVITIES AND STATE OF ART OF ITALIAN OFFSHORE OIL & GAS SECTOR

At the national level are taking place actions to implement the measures of monitoring and contrast the marine pollution and the supervision and control of the security, also environmental, of the plant of exploration and production at sea. Specifically, control programs and supervision are made by the Sections and Laboratories of the National Mineral Office for Hydrocarbons and Geothermal Resources (UNMIG), on the basis of the technical guidelines and regulations in force in Italy on environmental issues and on safety and occupational hygiene. Also plant operators subject under the Integrated Environmental Authorization (AIA-IPPC) regulated by the Legislative Decree no. 152/2006 and, more generally, all business that operate facilities with emissions into the atmosphere are required to perform periodic monitoring to check and verify the emissions into the atmosphere. Regarding the water layer extracted with the produced hydrocarbons, in Italy the activities of direct discharge into the sea, are subjected to a monitoring aimed at verifying "the absence of hazards for water and aquatic ecosystems", as disposed in art. 104 of Legislative Decree April 3, 2006 n. 152 and subsequent amendments and related implementation decrees (Ministerial Decree July 28th, 1994). In marine areas A and B (Fig. 1a, 1c) are focused the highest number of plants: in zone A there are 77 marine platforms and for zone B 45 platforms on a total of 138 plants in the sea (data from Ministry of Economic Development - updated July 28th, 2017).

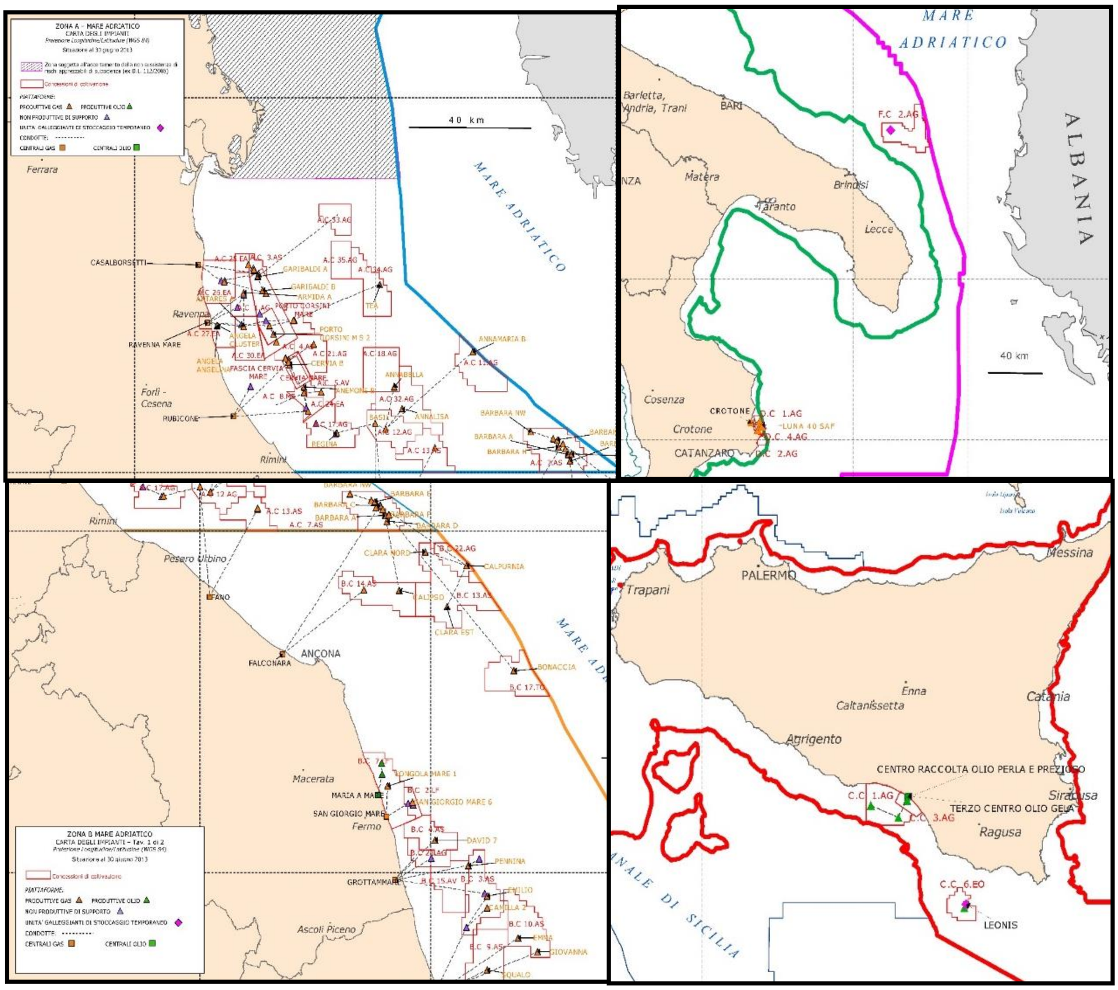

Figure 1 – State of offshore oil & gas plants in the Italian seas: a) blue line = zone A in northern Adriatic; b) green line = zone D and pink line = zone F to the south and the Adriatic and Ionian Sea; c) in yellow line= zone B in the central Adriatic Sea d) red line= zone C in the Sea of Sicily.

Currently, the following conditions have been identified:

- ✓ 6 offshore plants on which are required to perform periodic monitoring to check and verify the emissions into the atmosphere;
- ✓ 34 offshore plants that are subjected to a monitoring aimed at verifying "the absence of hazards for water and aquatic ecosystems".

STATUS OF CONTROLS IN THE E&P SECTOR ON AIR MATRIX

The activities can be carried out in two different cases:

- ✓ platforms with compression plants with a thermal combustion power > 50 MW are subject to an Integrated Environmental Authorization that prescribes monitoring for the measurement of the concentrations of CO and NO_x in the gaseous effluent emitted from the chimneys in the atmosphere.

- ✓ Platforms on which the single point of emission is the torch where the gas phase obtained from the degassing of the crude oil is combusted.

The purpose of compression located on platforms is to elevate the gas pressure and the compression unit can be used for many purposes (for example to move the gas in the pipeline, to elevate pressure of the field when too low for proper treatment, etc.). In this case surveys are conducted by performing consecutive measurements for one hour of full load operation of the machines with an automatic analyzer (flue gas analyzer "Testo 350"). In the second case the gas is analyzed by a portable gas chromatography instrument and then the amount of SO_2 emitted by torch smoke is derived from the mass flow of H_2S in torch power: the value is calculated considering the torch gas supply flow rate in the sampling phase and the stoichiometric combustion ratio of the H_2S. From the beginning of the first investigations (2003) till today (2016) were examined, more than once, 5 offshore plants.

STATE OF INVESTIGATIONS ON OFFSHORE PLATFORMS FOR WATER MATRIX

During the production phase, together with the gas or oil, it is extracted water of natural origin, present in the field and commonly referred to "water layer". Appropriate processes of degassing, de-oiling and passage of activated carbon filters allow to separate the hydrocarbon residues in the water layer and enhance its recovery. The water layer is sampled upstream and downstream of the activated carbon filter plant and at the base of the “casing morto” pipeline used for the discharge, below the sea level, of the treated water layer. Controls for the characterization of the water layer discharged into the sea are carried out with a chemical and physical "integrated" study approach. The analysis carried out concern the following parameters:

1. *Measurement of pH, conductivity and temperature.*
2. *Determination of total suspended solids in the samples of water.*
3. *Determination of the concentration of anions and cations by Ion Chromatography.*
4. *Determination of the concentration of metals by Inductively coupled plasma atomic emission spectroscopy (ICP-OES).*
5. *Determination of hydrocarbon oil index using solvent extraction and gas chromatography (GC-FID).*

In art. 104 of Legislative Decree April 3, 2006 n. 152 is disposed that 40 mg/l is the limit value for the hydrocarbon content in the water layer sampled downstream of the activated carbon filter plant and discharged in sea water; the same Legislative Decree, also, dispose that the temperature of the discharged water must not exceed 35 °C.

From the beginning of the first investigations (2003) till today (2016) were examined, more than once, 13 offshore plants.

DEVELOPMENT AND STUDY OF NEW METHODOLOGIES OF ANALYSIS

The water samples analyzed require an analytical approach articulated as characterized by low analytical concentrations and a saline matrix that can cause strong interference to the instrumental measure; the salinity of these samples, in fact, may fluctuate from the typical values of poorly saline waters to levels comparable to seawater (35 g/l in sodium chloride). For the determination of the concentration of anions and cations by Ion Chromatography it is necessary to apply:

- ✓ high dilution factor for the determination of the most present species (sodium and chloride);
- ✓ lower dilutions, such as to bring the values obtained into the calibration curve set in the method and consequently determine the remaining species.

For the determination of the concentration of metals was found that ICP-OES spectrometry is a more effective alternative to Atomic Absorption Spectroscopy: it allows to minimize analysis times, interference hazards and detection limits. Finally, by means of instrumentation suitable for ensuring low detection limits (GC-FID), the analytical methodologies for analysis of the extractable fraction (C_{10}-C_{40}) were studied and thoroughly investigated.

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INTERNATIONAL LEGAL FRAMEWORK OF OFFSHORE ACTIVITIES IN THE ADRIATIC AND IONIAN SEAS

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ABSTRACT

A variety of international, European and national rules apply to the different national maritime zones and, in some cases, to the high seas including the Adriatic and Ionian Seas. As the existing rules do not cover all spaces and practice often reveals the inadequacy of the international and national compliance systems, this paper will propose some observations on the high degree of legal fragmentation, the international cooperation on the protection of the marine environment, and the existence of certain security gaps in the offshore platforms regulations.

KEY –WORDS

Legal fragmentation, international cooperation, offshore platforms regulations, maritime zones, oil and gas resources.

INTRODUCTION

The issue of the exploration and exploitation of oil and gas resources in the Adriatic and Ionian Seas is complex and multiform from a legal point of view since it deals with the high fragmentation of the existing legal framework as well as a number of legal loopholes. On the one hand, a variety of international, European and national rules applying to different national maritime zones and, in some cases, to the high seas, thus regulating the Adriatic and Ionian Seas. On the other hand, the existing rules do not cover all spaces and practice often reveals the inadequacy of the international and national compliance systems.

The main critical aspect, however, is the lack of specific provisions to prevent and prosecute major accidents that could potentially be catastrophic for the marine environment. As far as the environmental impact of this activity is concerned, two main aspects are involved: the nature and the extent of the coastal states' powers of exploitation and the related obligations of conservation of the marine environment, on one side, and the prevention of transboundary environmental damage, on the other. The analysis of those aspects has already been the subject of previous papers to which reference can be made (Andreone, 2016).

Against this complexity, and due to length restrictions, it seems useful to delimit the scope of the present work to some observations regarding the multiple layers of the legal fragmentation, the current state of international cooperation on the protection of the marine environment in the Adriatic and Ionian Seas, and the existence of certain security gaps in the offshore platforms regulations.

FRAGMENTATION OF THE LEGAL FRAMEWORK

As is foreseen in the 1982 United Nations Convention on the Law of the Sea (UNCLOS) and in customary law, productive activities carried out by the coastal state, either directly or with their consent within the Territorial Sea (TS) – i.e. within 12 nautical miles from the baseline – fall under the control of the state as regards both regulation and all the coercive activities that may derive from the application of domestic law. This is due to the almost absolute sovereignty the state enjoys, and the only limitation on the coastal state's sovereignty is the right of innocent passage by foreign ships. Nevertheless, within the TS, the coastal state has wide and highly discretionary powers to regulate navigation by imposing limitations on navigation or traffic schemes and sea lanes to protect the safety of oil platforms, since the state is only required to consider International Maritime Organization (IMO) recommendations and customary navigational uses within its territorial waters.

When oil exploration and exploitation activities are decided upon or authorized by the coastal state in areas beyond 12 nautical miles, within the Exclusive Economic Zone (EEZ) and/or the Continental Shelf (CS), such activities are to be considered legitimate in virtue of the sovereign rights of the coastal state over its economic resources according to Arts. 56 and 77 UNCLOS. However, the power of coastal states to protect the rigs and to regulate navigation in the areas in the proximity of the platforms appear to be more limited as evidenced by the recent *Arctic Sunrise* case (Oude Elferink, 2014).

Art. 56 provides for a coastal state's 'sovereign rights' over the living and non-living resources of its EEZ, as well as other activities connected with the exploration and economic exploitation of the zone. The same provision also provides for 'jurisdictional rights' over the establishment and use of artificial islands, installations and structures, scientific research activities, and the protection of the marine environment, thus introducing a distinction between 'sovereign rights' over resources and the more simple 'jurisdictional powers' attributed to the coastal states in the other domains (Andreone 2015).

The rights, whether sovereign or jurisdictional, and the related duties of coastal states cannot be intended as absolute, since due regard to the rights and duties of other states is expressly provided for by Arts. 55, 56(2) and 58 UNCLOS. Indeed, third states enjoy rights to free navigation in the superjacent waters, and to lay pipelines and submarine cables (Rothwell and Stephens 2010). As far as jurisdiction over the protection of the marine environment is concerned, the coastal states have an exclusive right to prescribe laws and regulations over third states' vessels, but do not have either exclusive powers to enforce them nor to adjudicate the foreign vessel having committed an environmental crime in its EEZ. Indeed, the flag state of the suspected vessel is authorized by Art. 228 UNCLOS to judicial pursuits against its vessel for an illicit spill (Andreone 2015).

When the coastal state has proclaimed its EEZ, the legal regime of this zone will absorb the CS legal regime, since, according to Art. 56 UNCLOS, coastal states' powers are extended to the waters superjacent to the seabed and to the seabed and its subsoil up to 200 nautical miles from the coast.

In the absence of the proclamation of an EEZ, the norms to be applied to exploitation of oil and gas resources are those foreseen by the UNCLOS for the CS (Part VI UNCLOS), this being a zone automatically determined, requiring neither effective occupation nor an *ad hoc* proclamation on the part of the coastal state. Nowadays, this is a very rare hypothesis, relating to the minority of states which have not yet proclaimed their EEZ, among them some Mediterranean States, such as Italy, Bosnia and Herzegovina, Montenegro, Albania, and Greece, in the Adriatic and Ionian Seas.

In this context, the legal fragmentation is undeniable as to the differing nature of coastal states' powers over the different maritime zones (TS, EEZ and CS) and as to the fact that only two Adriatic states (Slovenia and Croatia) have proclaimed *de facto* EEZs (as reduced zones, such as fishing protection zone and environmental protection zone).

The legal fragmentation is even more evident considering that not all the Adriatic-Ionian states are members of the European Union (EU). Consequently, the EU rules regulating fisheries, marine environment and offshore platforms are not applicable to all the Adriatic-Ionian CSs.

Moreover, in some coastal states, such as Bosnia and Herzegovina, Montenegro and Albania, there is a lack of extensive and adequate legal regulations regarding the protection of the marine environment and offshore platforms. In other states, such as Italy, the extended normative production in those fields is often too fragmented rendering the assessment of the applicable rules highly uncertain and univocal (for example, the normative approach to the soil and subsoil is different from that used for the column of water beyond 12 nautical miles).

Finally, since most of the Adriatic-Ionian states have not proclaimed their EEZ thus far, the laws prescribing the enforcement powers of coastal states are limited to environmental protection of the CS. The exploration and exploitation of mineral resources of the soil and subsoil can be regulated by coastal states in their respective CS, where they also must respect the obligations and responsibilities provided by the UNCLOS, such as ensuring the freedom of navigation of third states and preventing, and eventually compensating, transboundary damages.

INTERNATIONAL COOPERATION ON THE PROTECTION OF THE MARINE ENVIRONMENT

Implementing Art. 123 UNCLOS, which provides for cooperation among the coastal states of a semi-enclosed sea in the field of conservation of resources and protection of the marine environment, the Mediterranean States instigated the first conventional legal framework devoted to the environmental protection of this basin in 1976, named the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution, later modified and renamed in 1995 as the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. The framework convention, ratified by all the 21 Mediterranean States and the EU, has been enriched over time by seven Protocols regulating the different forms of pollution and environmental risks in the Mediterranean region. All the Protocols have been amended since the 1992 Rio Declaration to incorporate its outcomes and principles and, as of 2011, all of them have entered into force. Notwithstanding, some of these Protocols cannot be considered successful since they received only a minimum number of ratifications.

The Protocol most relevant to the prevention of accidents and pollution deriving from offshore activities has not been widely ratified. Indeed, as of 11 September 2017, the Protocol for the Protection of the Mediterranean Sea Against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (the so-called Offshore Protocol), adopted on 14 October 1994 and entered into force on 24 March 2011, has been ratified by only six coastal states (Albania, Cyprus, Libya, Morocco, Syria, Tunisia, as well as the EU) of the 22 contracting parties to the Barcelona convention system.

Also relevant, even if only incidentally, is the Protocol dealing with Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea (the so-called Prevention and Emergency Protocol), adopted on 25th January 2002 and entered into force on 17 March 2004. As of 11 September 2017, this Protocol has been ratified by 15 coastal states and the EU. The scope of application of this Protocol is limited to cooperation in preventing and combating pollution from ships, but it also includes the management of emergency situations in cases of pollution of the Mediterranean Sea caused by incidents provoking spills of dangerous and noxious substances. The Protocol is aimed at enhancing bilateral and multilateral cooperation to promote contingency plans and other means of preventing and combating pollution incidents. Under this Protocol, states should share information to prevent and coordinate their efforts to minimise potential damage.

The Offshore Protocol is more relevant than the Emergency Protocol, since it deals specifically with the cooperation to prevent, abate, combat and control pollution in the Protocol area resulting from activities concerning exploration and/or exploitation of all mineral resources, whether solid, liquid or gaseous. The Protocol covers almost all the phases relevant to offshore activities, including the authorization system, the treatment of wastes and harmful or noxious substances and materials by the operators, the safety measures with regard to planning and building operations, the contingency plan and obligation to share information and mutual assistance in cases of emergency, and the rules for the removal of installations.

Finally, the Protocol also provides for a duty of the contracting parties to take measures to ensure that activities under its jurisdiction do not cause any transboundary pollution that may cause harm to the marine environment of other states. Parties are also committed to cooperate in adopting rules and procedures for the determination of liability and compensation for damage resulting from the activities (Art. 27 Offshore Protocol).

The low participation in this regional sectoral agreement, even though it can already be considered outdated from a technical point of view, indicates that the theme of environmental security has not been and is not a priority of the Mediterranean States so far.

Against this background, it appears evident that one of the most critical issues, regarding the exploration and extraction of hydrocarbons in the Mediterranean and Adriatic Seas, is the extent of cooperation between coastal states on environmental damage prevention as well as liability prosecution.

SECURITY GAPS IN THE OFFSHORE PLATFORMS REGULATIONS

A number of critical aspects emerge from an analysis of the legal framework and state practice regarding the exercise of coastal states' powers over offshore platforms and the balancing of states' sovereign and jurisdictional rights with the freedom of navigation in the zones beyond the territorial seas.

Moreover, when difficulties in interpreting international rules occur, any possible negative impact they may have is much more evident and risky in the case of semi-enclosed and fragile seas. In addition, it must be emphasised that in a semi-enclosed sea, such as the Adriatic, a possible attack against operating offshore installations could have serious consequences and therefore should be prevented by all lawful means.

As far as EU Member States are concerned, and as mentioned above, the EU ratified the Offshore Protocol in March 2013. Since then, the processes of harmonisation and technical coordination of offshore activities was consolidated in Directive no. 30 of 2013 of the EU Council on the safety of maritime operations in the sector of hydrocarbons, which modified Directive no. 35 of 2004. As it is known, this Directive only applies to maritime spaces under the EU Member States jurisdiction. Consequently, the coastal states of the Adriatic and Ionian Seas that are not EU members do not have any obligations arising from this Directive.

Even though the scope of application of the Directive is narrower than that of the Offshore Protocol – since it deals solely with the safety of offshore oil and gas operations – it represents the only obligatory regulations on offshore platforms implemented thus far, providing for a minimum and common level of safety protection in the Adriatic Sea.

As was noted, this Directive is the expression of the preeminent prevention approach of the EU and it does not contain provisions relating to the applicable liability regime in cases of accidents. The Directive does not give adequate application to the 'polluter pays' principle, although the latter has been incorporated into the EU legal order (Schiano di Pepe, 2017).

CONCLUDING REMARKS

A few concluding remarks can thus be outlined.

Legal fragmentation implies a high level of legal uncertainty among the activities of exploitation and exploitation of mineral resources and their impact on the marine environment of the Adriatic and Ionian Seas. A number of actions could be taken to reduce the fragmentation, such as the proclamation of the EEZs, the harmonisation of rules (approximation of laws) among EU and non-EU members, and the implementation of existing international cooperation tools.

The EU is already playing a crucial role in facilitating these actions, yet the risk of failure of cooperation efforts if limited to the EU context and tools cannot be underestimated. A wider international cooperation approach, inclusive of the Barcelona convention system, should be ensured while specifically regulating the protection and damage prevention of the Adriatic and Ionian Seas.

As it is widely known that there is no lack of conflicts, even among EU Member States, either explicit or implicit, and even regarding oil and gas resources. For example, the determination of maritime borders creates tension in the relations between states, as in the case of Slovenia and Croatia, and the relations between Malta and Italy have also been threatened by the existence of a latent conflict regarding the overlap of some maritime areas.

It is a matter of fact that maritime borders delimitation among adjacent and opposing states is not comparable to land boundary definition, as to the impact of tracing borders in the maritime environment. In the light of this evidence, it has been recently invoked the necessity of "softening maritime borders" in favour of common and cooperative actions adopted by the neighbouring states to protect and preserve marine habitats and resources (Mackelworth et al., 2013). Against this background, it can be argued that cooperation on environmental protection, fisheries and disasters prevention should be included by states when negotiating maritime borders.

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Session 2 – Environmental impacts, concerns and monitoring from the perspective of the scientific community

NATURAL HYDROCARBON SEEPAGE IN THE ADRIATIC AND IONIAN REGION

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ABSTRACT

Italy hosts the largest petroleum systems in southern Europe and of the 167 fields currently in production, about 60 are located in the Italian offshore and specifically in the Adriatic and Ionian region (Adriatic Sea, Ionian Sea, Sicilian Strait). In addition to these deep reservoirs, the Italian seas are characterized by the presence of significant hydrocarbons in the shallow sediments, which sometimes pierce the sea bottom and escape into the water column. These may or may be not related to the petroleum reservoirs. This contribution aims at presenting the preliminary map of the natural emissions of hydrocarbons at the seabed and in the water column in the Italian seas, by analysing high resolution seismic reflection data obtained using high frequency systems, bathymetric and reflectivity data of the sea-bottom and the water column acquired with the ultimate generation of multi-beam systems. The majority of the data were acquired for different purposes and this study can be considered an effective reuse of vintage data.

KEY WORDS

cold seep; gas plume; Adriatic and Ionian region; pockmark; water column reflectivity

INTRODUCTION

Hydrocarbons are organic compounds that contain only carbon and hydrogen atoms. In nature, hydrocarbons, both as gaseous and liquid phases, are mainly found in the porosity of the rocks that make up the upper continental crust and are the product of chemical-physical processes that may persist for thousands and / or millions of years. Marine environments are ideal for the formation of hydrocarbons, because organic matter (*e.g.* plankton and phytoplankton, terrestrial and marine vegetation) falls out in large quantity on the sea bottom and rapidly undergoes anaerobic degradation for the anoxic conditions. In addition, also high and fast sedimentation rates, typical of certain marine depositional environments, favour rapid burial and decomposition of organic matter, due to increasing temperature with depth. Methane is by far the most common gas in the sedimentary rocks of the Earth's crust and deep marine sediments are the largest reservoir of methane, mostly in their hydrate form (10^4 Gt of C, Kvenvolden, 1988). Some estimates indicate that various sources of methane annually inflow into the oceans 0.02 Gt of C, although most is thought to sink in the carbonate precipitation-related process (Boetius & Wenzhöfer, 2013), there is still an open debate about how much these gases contribute to the atmosphere CO_2 budget. As a matter of fact, since hydrocarbons are less dense than the surrounding rocks and sediments, they tend to migrate to shallower sedimentary horizons and eventually to "pierce" the seabed, giving rise to peculiar seafloor features. This phenomenon was first discovered by Alessandro Volta, who in 1776 noted that flammable gas bubbles were forming when shaking the muddy bottom of Lake Maggiore and called it "Gas di Palude". In 1600 French explorers observed some Native Americans developing fires on the surface of Lake Erie. Today, Lake Erie, which is exploited for its energy resources, is considered a geo-hazard for greenhouse gas escapes into the atmosphere, due to recurrent algal blooms (Heisman, 2016). In the deep ocean, hydrocarbon seeps were first discovered along the continental slope of Florida (Paull et al., 1984) and Lousiana (Kennicutt et al., 1985). Through visual submersible inspections, it became apparent that the chemo-synthetic benthic fauna, living around these seeps, had resemblances with those discovered around the hydrothermal vents, made up of H_2S dissolved in seawater super-heated up to 400 ° C, in 1977 along the Galápagos Rift, in the Pacific Rise (Corliss et al., 1979). The definition “cold seep” became immediately popular (Sibuet et al., 1988), hydrocarbons do not indeed give rise to thermal anomalies in the water column, but their density anomaly can be detected by marine geophysical instruments, such as echo sounders, the side scan sonars, and more recently can be measured and displayed in 3D thanks to modern multibeam systems (Fig. 1).

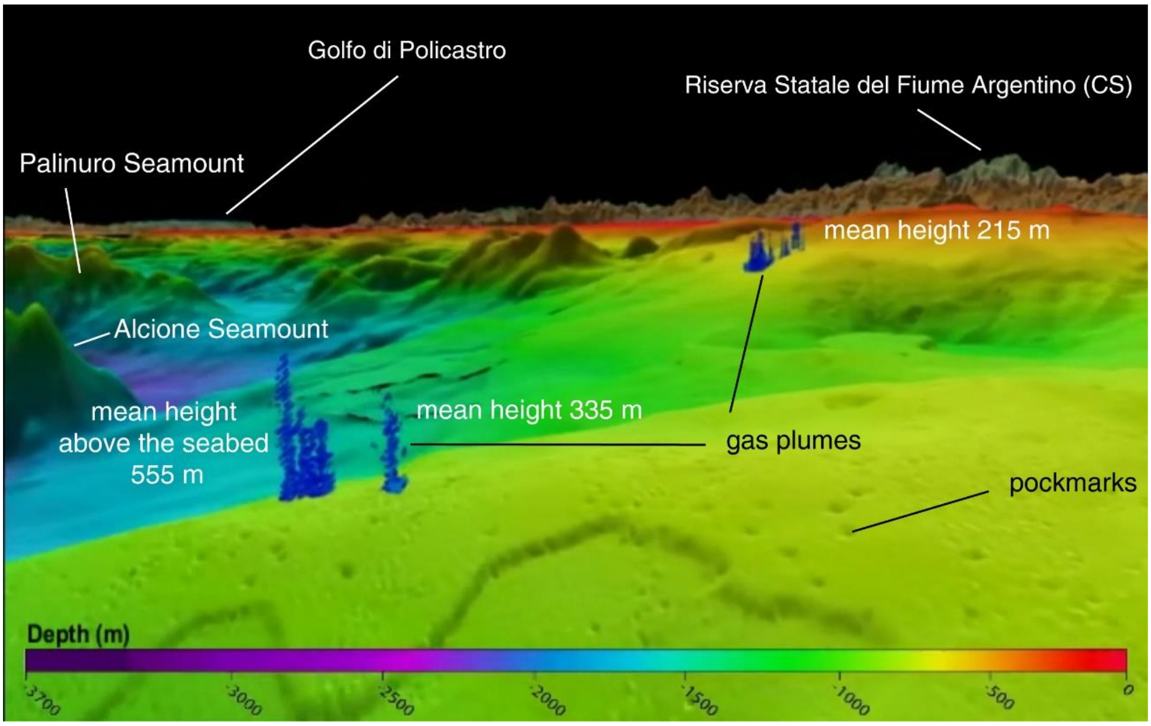

Figure 1 - Gas plumes in the water column, acquired by means of a Kongsberg EM 710 multibeam system, in the southern Tyrrhenian Sea, Paola Basin, 40 km offshore Cetraro, NW Calabria.

MATERIALS AND METHODS

A large database of geophysical and geological data, acquired by CNR-ISMAR during a long time span (1991-2016), has been used and consists of 130 x 10^3 km of single channel very high and high resolution seismic profiles of different technologies (Compressed High-Intensity Radiated Pulse CHIRP; sparker), 25 x 10^3 km^2 of multibeam swath bathymetry, hundreds of sediment coring samples. Where our data are sparse, we have used literature information by georeferencing data sources and maps, using ESRI ArcGIS. Bathymetric and seafloor reflectivity data have been post-processed using the suite CARIS HIPS & SIPS; water column reflectivity data have been post-processed using FMMidwater (QPS software).

MAPPING RESULTS AND CONCLUDING REMARKS

For quickly achieving a complete mapping of fluid escapes in the marine domain, the very first step is the geophysical investigation by means of high frequency/resolution multibeam systems, which are now capable of imaging in detail both the morphology of the seafloor and the water column, coupled with high vertical resolution sub-bottom seismic data to understand the connecting path of the plumbing system. When the plumbing system is located deeper, multichannel seismic data are needed to locate the source of the gas. To understand the actual composition of the gas, between thermogenic or biogenic origin, direct geochemical analysis over the hydrocarbon fluids is needed. This study is the first effort to compile a general map and catalogue of the natural hydrocarbon seepage in the

Adriatic and Ionian region (Fig. 2). In the northern and central Adriatic, there is widespread presence of past and active methane seeps that favoured the precipitation of methane-imprinted authigenic carbonates on the seafloor, these seeps may be or not be connected to deeper rooted fault systems. In the central Adriatic, there is a 3336 km^2 layer of gas, averagely 25-m-thick, trapped in the HST, that constitutes the upper systems tract of the stratigraphic sequence, and lies directly on the maximum flooding surface, formed when marine sediments reached their most landward position (i.e. the sea reached its present seal level position), around 5,500 years ago. The HST is capped by a sequence boundary and lies below meters-thick prograding clinoforms. 4081 km^2 of gas, which thickness is less assessable because of the depth, are trapped in the TST, which comprises the deposits that accumulated from the onset of the last coastal marine transgression until the time of maximum transgression of the coast (19,000-6,000 years ago). These layers are not substantially connected to the seafloor by seepage. Pockmarks, 50-70 m in diameter, are present in the Mid Adriatic Deep where fluids escape from deeper underlining units, probably because here the gas-permeated layers have been unroofed by mass wasting processes.

The only known oil seepage is located in the central Adriatic, about 1-2 km offshore the village of Fontespina in the Marche Region, at a water depth of 10 m. In the southern Adriatic Sea, a large deep reservoir of thermogenic gas it is known to be present around the Aquila field, but there is no evidence of upward connection along the continental slope, even because a large, 40-m-thick, landslide seals the deeper deposits. On the contrary, there are peculiar structures, less than 10-m-tall, emplaced in sandy sediments, on the continental shelf that have conical shapes and small crater-like structures on top. In the northern Ionian Sea there are large, up to 200 m in diameter, pockmarks, along main structural alignments, which are most probably connected, along normal faults, with fluids buried in the Miocene sedimentary succession (> 1.5 km in the sub-seabed). On top of the accretionary wedge present in the Ionian Sea, there is a large province of mud volcanoes, well documented in literature that probably hosts more edifices than those discovered up to date. In the Strait of Sicily, there is an area, close to the Vega field and between Sicily and Malta, where small height (5 m) 200-m-diameter circular features are interpreted as mud volcanoes, some of them present water column plumes in the sub-bottom seismic data. Furthermore, ridge-like remnant structures of the LGM host small conical muddy structures on top. At the toe of the continental slope, in the vicinity of the Gela and Panda fields, where several mass-transport deposited have been discharged during the Late Quaternary (< 1 Ma), few 250-m-large pockmarks are scattered in several places and also here are associated with authigenic carbonate precipitation.

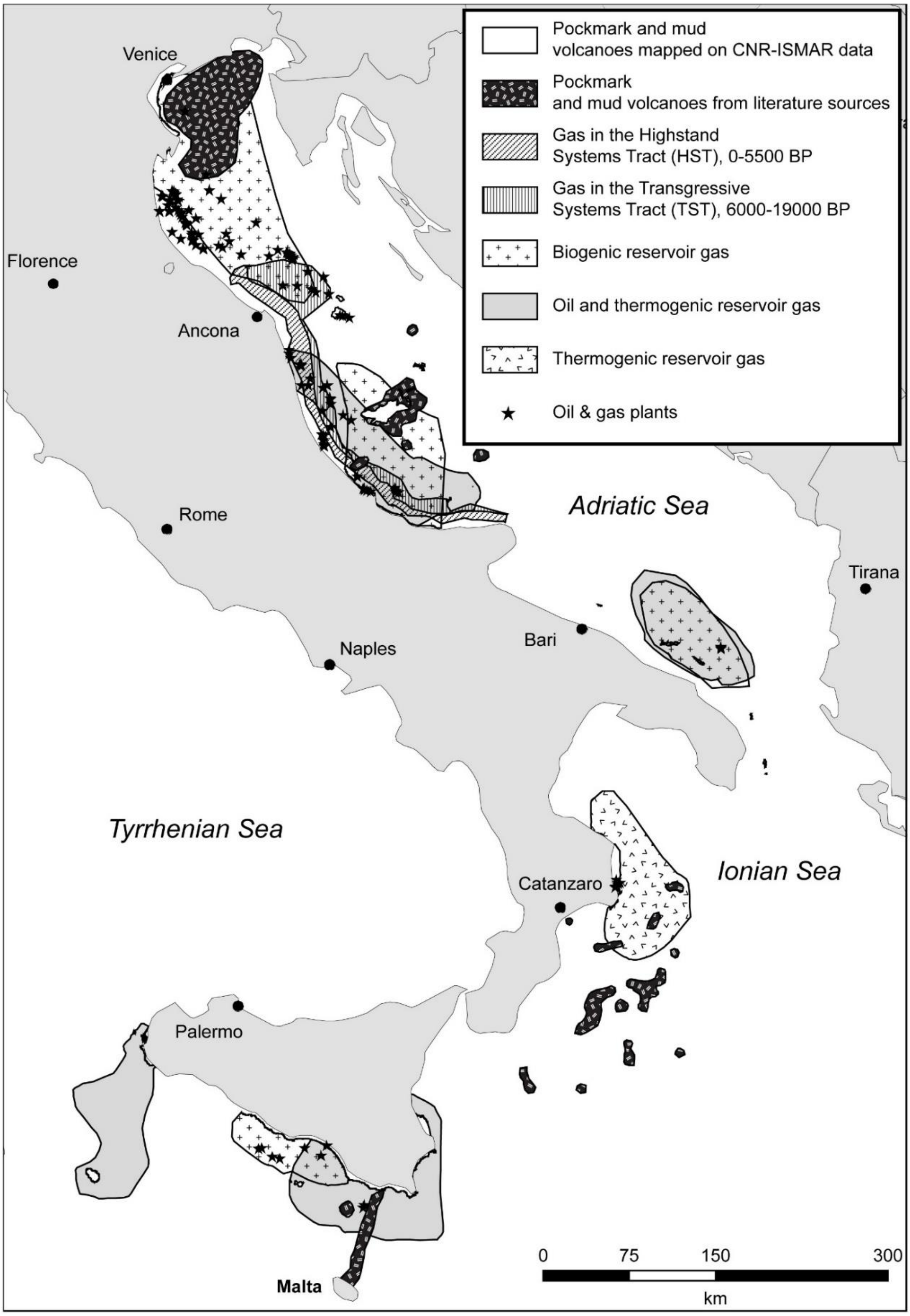

Figure 2 - Preliminary map of natural hydrocarbon seepage in the Adriatic and Ionian Region.

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SATELLITE-BASED OIL SPILL MONITORING: A CASE STUDY IN THE STRAIT OF SICILY

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ABSTRACT

Oil spill pollution, an increasing threat for the marine environment, requires dedicated operational services for its monitoring and mitigation. In this context, satellite remote sensing has provided an effective support in oil spill detection. The new generation of optical satellite sensors, such as the Medium Resolution Imaging Spectroradiometer (MODIS), showed great potential for operational oil spill detection. We present a methodology to detect oil spills using MODIS images. By combining its high-resolution spectral bands, we show that it is possible to enhance the oil-water contrast and then make more effective the detection of an eventual oil spill floating on the sea surface. We developed the methodology by using a set of MODIS images collected from 2015 to 2016 and covering the Strait of Sicily, identifying 14 oil spills. The analysis showed that they originate from ships rather than from the oil platforms in the area. Furthermore, results confirm not only the capability of the MODIS sensor to detect oil spills but also a promising approach towards automatic oil spill detection by using optical satellite sensors.

KEY WORDS

oil spill detection; MODIS; optical remote sensing; Strait of Sicily.

INTRODUCTION

Oil spill pollution is a frequent occurrence that, apart from rare accidents such as ships in distress and/or malfunctioning of oil extraction plants, is mainly due to the illegal hydrocarbon discharge in the marine environment from vessels under way cleaning their bilges to cut harbour costs. Regarding the Mediterranean Sea, which is one of the major routes for oil transportation, it has been estimated (REMPEC, 2002) that about 600.000 tons of oil every year are spilled into the Mediterranean as a consequence of this illegal tank-washing practice. In the last decades, several governmental and research institutions pursued the challenging objective to set up near-real time operational services for the monitoring and detection of oil spills and felon vessels. In this context, satellite sensors have provided an effective tool, being able to identify oil at the sea surface by means of appropriate techniques (e.g., Fingas & Brown, 2014; Brekke & Solberg, 2005; Pisano et al., 2016).

Among all satellite sensors, optical sensors, such as MODIS on board the TERRA and AQUA satellites, thanks to their daily global coverage, near-real time data delivery and high spatial resolution (250 m), showed great potential in the exploitation of oil spill detection (Hu et al., 2009; Pisano et al., 2015). Indeed, they can provide a synoptic view of large marine areas and repeat them with a short revisit time, thus complementing naval and/or aerial surveillance. The visibility of an oil spill in an optical image, thus the possibility of detection, is due to the optical contrast between the spill and surrounding water. In addition, because of its higher refractive index and absorption coefficient with respect to water, an oil film generally appears as a patch darker than water.

In the framework of the Italian RITMARE project, we analysed more than a thousand MODIS images covering the Strait of Sicily, which is one of the principal tanker routes of the Mediterranean Sea, thus an area characterized by a high density of illegal spills (Ferraro et al., 2007). A band-ratio approach to detect oil spills was thus developed.

MATERIALS AND METHODS

We acquired all the available MODIS (AQUA and TERRA) passages from the NASA website (https://ladsweb.modaps.eosdis.nasa.gov/) from 01/07/2015 to 31/08/2016 and covering the Strait of Sicily (see Fig. 1), building a dataset of about 1200 images, an average of 3 images per day. Each image provides two high spatial resolutions (250 m) reflectance bands at wavelengths λ = 645 nm and 859 nm, which we named R_{859} and R_{645} respectively, and a Bidirectional Reflectance Distribution Function (BRDF) product at λ = 645 nm, named $BRDF_{645}$. The former two products, i.e. R_{859} and R_{645}, are the MODIS-retrieved reflectance images, while the latter is the same quantity but estimated from a model, thus simulating clear seawater reflectance. The methodology is as follows: first, we compute the band ratio $R = R_{859}/R_{645}$ in order to perform a custom atmospheric correction (i.e., removing the atmospheric signal as much as possible); then, we compute the ratio with respect to the "ideal" case, i.e. clear seawater, as *R'* = $R/BRDF_{645}$. The basic idea behind this band-ratio approach is that an eventual oil spill can be detected as an anomaly in the ratio image *R'*. Finally, we computed the ratios *R'* for the whole dataset.

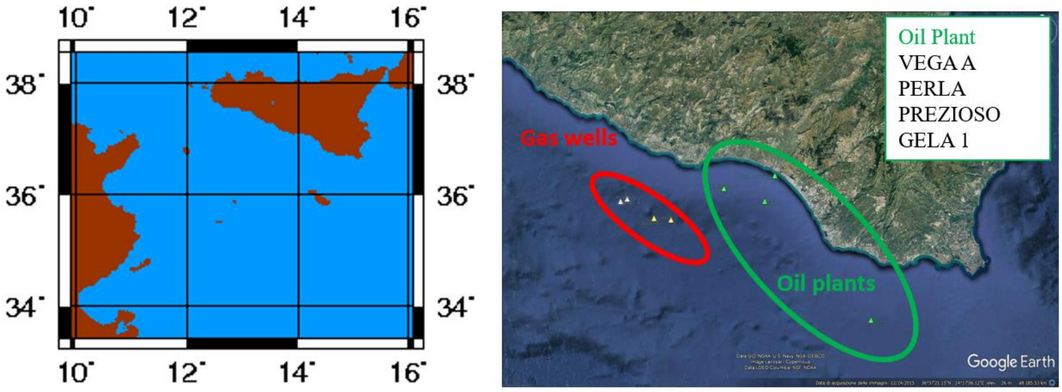

Figure 1 - (Left) The Strait of Sicily. (Right) Gas wells (red), inactive, and active oil plants (green) along the Sicily coast.

RESULTS

First, we visually inspected all the *R'* images, discarding cloudy and/or corrupted images or without any spill-like feature, while retaining only those images in which features suspected to be oil spills were found. This screening left 41 out of 1200 images in which such potential oil spills were identified (see Table 1). We then empirically defined three levels of probability, in order to assign a "score" to each potential spill, as follows: unlikely polluted (score 1: 0-33%); uncertain (score 2: 34-66%); and likely polluted (score 3: 67-99%).

# oil spills	**Score 1**	**Score 2**	**Score 3**
41	18 (44%)	9 (22%)	14 (34%)
Spill length	---	---	5 – 90 km
Spill width	---	---	0.5 – 2.0 km
Spill area	---	---	3 – 80 km2

Table 1 - Number of detected oil spills during the period 2016 – 2017 in the Strait of Sicily and the relative classification scores. Geometric characteristics are also given (minimum and maximum value), only for the likely polluted (score 3) oil spills.

According to this classification, 14 spills were identified as likely polluted, 9 as uncertain and 18 as unlikely polluted. For the likely polluted spills, we computed three geometric parameters, i.e. length, width and surface area (Table 1), as useful descriptors in order to provide a first characterization of their geometry and shape. The 14 likely polluted spill-like features display an average length of 50 km, an average width of 0.85 km and an average area of 43 km^2. Fig. 2 shows three *R'* images in which three spills are present (highlighted in red ellipses): two of them classified as likely polluted (score 3) and one as uncertain (score 2). The elongated shape of the spills is evident in Fig. 2, this being a unique feature of the slicks released by ships. For this reason and considering the distance of the detected 14 spills from the oil platforms along the coast (shown as green triangles in Fig. 2), we can discard the hypothesis that they come from the oil plants. Finally, it is evident from Fig. 2 how the spills stand out with respect to a flattened, homogeneous and uniform surrounding background, a result obtained thanks to the band-ratio approach that removes the atmospheric signal, even though not completely.

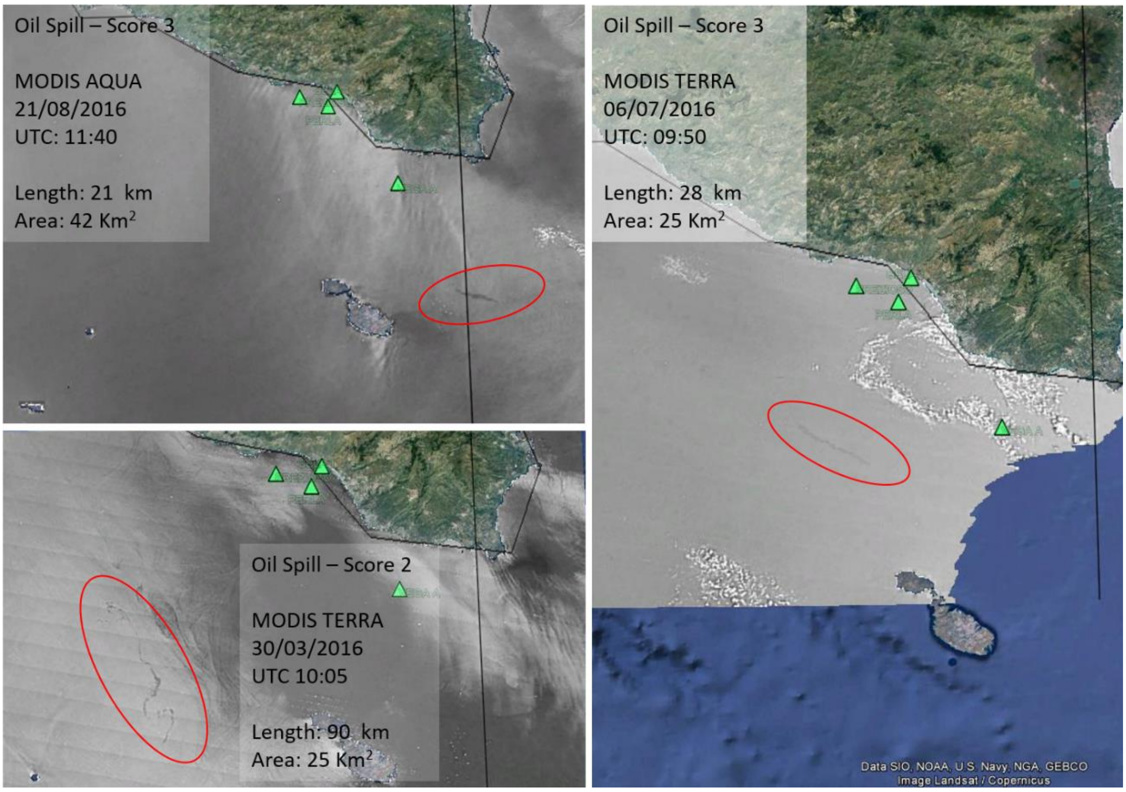

Figure 2 - Examples of Score 3 (upper left and right) and Score 2 (lower left) spills, together with their detection times and geometric characteristics. Green triangles show the location of oil platforms (see also Fig. 1).

CONCLUSIONS

We presented a methodology to detect oil spills at the sea surface by using MODIS high-resolution spectral bands. The method was developed by analysing one year (2015 - 2016) of MODIS scenes covering the Strait of Sicily, an area characterized by a high occurrence of oil spills, mostly voluntary illegal discharges from tankers. 41 potential oil spills were identified in the MODIS dataset and 14 of these classified as likely polluted. The analysis of these 14 spills, based on visual inspection and geometric parameter computation, showed that they originate from illegal discharge by vessels rather than from the nearby oil plants. In addition, results not only confirm the ability of MODIS sensors to detect oil spills at the sea surface, but also the high potential in its usage towards automatic oil spill detection. Indeed, with an appropriate oil spill spectral characterization, we feel that the method could be improved and used in automatic mode, i.e. without visual inspection by expert operators.

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PERSISTENCE AND SORPTION OF THE POLYCYCLIC AROMATIC HYDROCARBONs (PAHs) IN THE ADRIATIC SEA SEDIMENTS

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) are an important class of organic compounds widely distributed in the environmental matrices with toxic, mutagenic and carcinogenic properties. In the aquatic environment, PAHs tend to sorb onto the particle phase and to sediment due to low water solubility and marked lipophilicity. The key point for describing their environmental fate is the study of PAHs behaviour through the determination of PAH persistence and PAH sorption. This work investigated how sediment type, grain size and various environmental factors affect the PAHs behaviour in marine sediment of the Adriatic Sea. PAHs persistence and PAHs sorption critically influence PAHs behaviour, providing useful information for environmental risk assessment.

KEY-WORDS

persistence; sorption; hydrocarbons; marine sediment; Adriatic Sea

INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are classified as environmentally hazardous organic compounds due to their known hydrophobic and mutagenic characteristics in addition to its toxicity and carcinogenicity. PAHs are formed primarily from the combustion of fossil fuels, with major sources being of anthropogenic origin. Bacteria and plants can also contribute to input some PAHs in the environment, as well as the petrogenic source, such as oil spill. In the aquatic environment, due to their hydrophobic character, PAHs tend to adsorb onto the particulate matter so that they are transported to and accumulate in sediments. Indeed, sediments represent the most important reservoir of PAHs in the marine environment (Bergamasco et al., 2014). These compounds are frequently detected in seawater and sediments at increasing levels and can have adverse health effects on marine organisms and humans (Nikolaou et al., 2009). Therefore, it's important to investigated the PAH behavior, once they are discharged into the sea by rivers. The PAHs investigated in this work are included in the United States Environmental Protection Agency (USEPA) priority pollutant list (Omayma et al., 2017). Degradation and sorption experiments were carry out by evaluating of the half-time ($t_{½}$) and the sediment/water distribution coefficient (K_d) of PAH compounds, respectively. These parameters were used to determine the persistence and the partitioning of most organic compounds in order to understand the PAHs behavior (Marini & Frapiccini, 2013). The aim of this study is to understand how certain characteristics of the sediments (grain size and total organic carbon, TOC) and some environmental factors, in particular, the temperature, the sunlight and the salinity, affected PAH bio/degradation and PAH distribution, including the presence/absence of the biotic influences.

MATERIALS AND METHODS

Different types of shallow sediment (coastal and offshore) were collected in the Adriatic Sea and were used for bio/degradation and sorption tests. These tests have been carried out at different environmental condition of temperature, salinity, sunlight/darkness and in presence/absence of microorganism in the sediments. PAHs were extracted from sediment samples and analyzed by HPLC-PDA and FD following the procedure described by Marini & Frapiccini (2013). The degradation and sorption parameters were calculated according to Frapiccini & Marini (2015).

RESULTS AND DISCUSSIONS

Degradation parameters ($t_{½}$)

The results obtained from degradation experiments in marine sediments have shown that the PAHs extracted from sediments exposed to the conditions of low temperature (4/6 °C) and absence of light, have higher $t_{½}$ than those treated in sediments exposed to temperature of 18/20 °C and sunlight conditions (Fig. 1a). Furthermore, the high salinity values (superior or equal to 37) slow down the degradation of PAH molecules, with consequence raising of $t_{½}$ (Fig. 1b). The biodegradation of PAHs is facilitated by the presence of environmental conditions favorable to microorganisms (Marini & Frapiccini, 2013). As expected, the lack of indigenous microbial sediment community has induced a slowdown of the degradation kinetics (PAHs residual, %) for three investigated PAH compounds. This was more noticeable for the phenanthrene (3 rings) than naphthalene (2 rings) and benz(a)pyrene (5 rings) (Fig. 2).

a

b

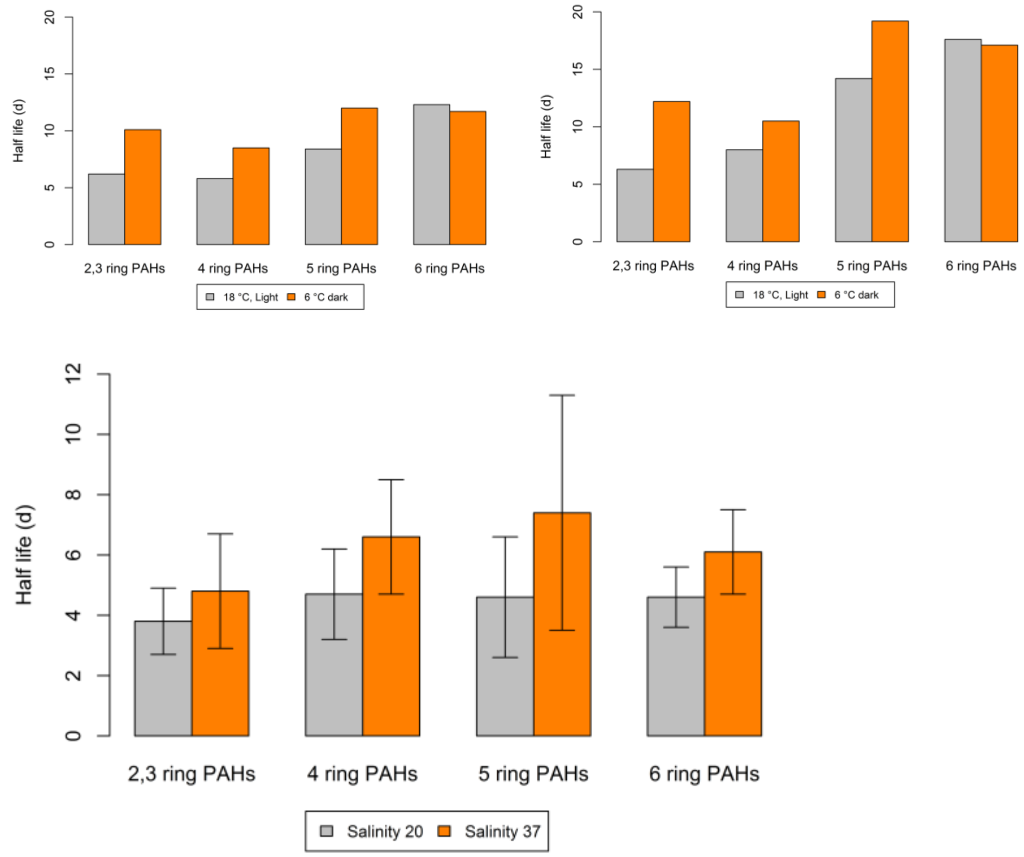

Figure 1 - The half-life ($t_{½}$) of the four PAH groups calculated at the sediment sites in different temperature, sunlight/darkness (a) and salinity (b) conditions (Marini and Frapiccini, 2013).

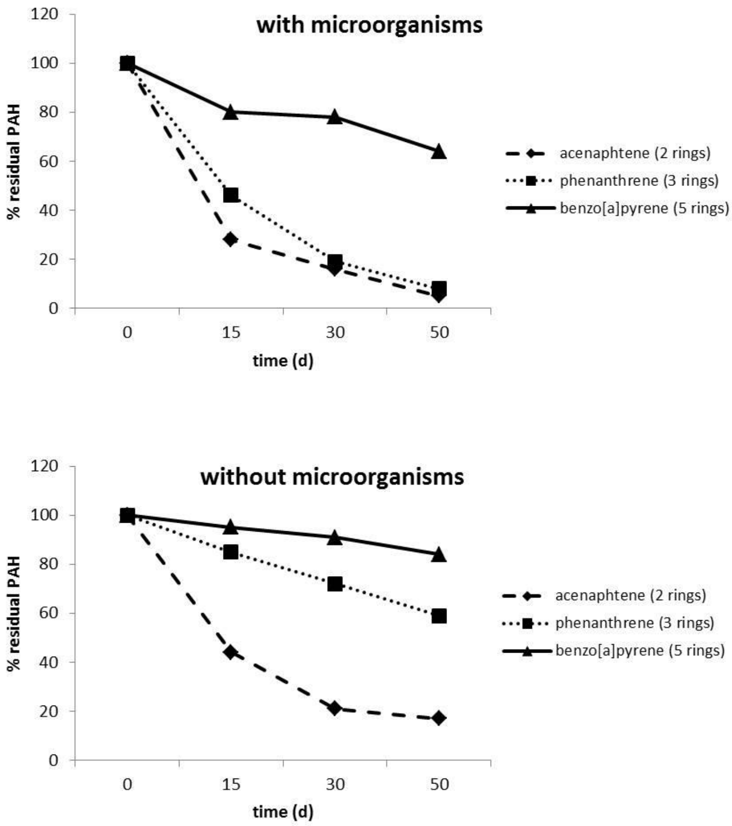

Figure 2 - PAHs residual (%) in marine sediments with and without microbial activity.

Sorption parameters (K_d)

K_d values of LMW (low molecular weight) and HMW (high molecular weight) PAHs were determined by construction of linear adsorption isotherms. Sorption experiments have been carried out in two marine sediments (site A, coastal and site B, offshore) with different grain size and TOC. Clay values were 12 and 27, while TOC values were 0.8 and 3.4, for site A and site B, respectively. The results have shown how TOC and grain size heavily control the PAH sorption capacity of sediment. Moreover, the results have shown how the K_d difference between site A and site B was particularly marked for HMW PAHs, whereas they were similar for LMW PAHs (Fig. 3). This happens because HMW PAHs, being more tightly bound to sediment particle due to their high lipophilicity, were more influenced by sediment characteristics. Therefore, HMW PAHs were associated with the clayey sediment with high TOC value (site B).

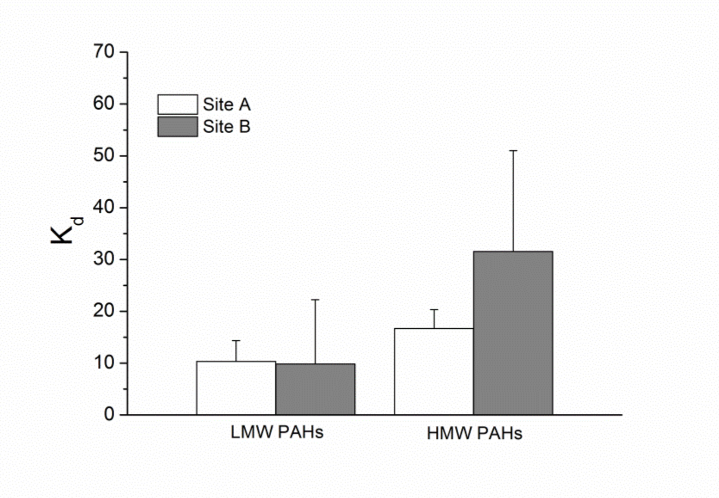

Figure 3 - Average Kd values on the basis of the PAHs molecular weight at site A (coastal) and site B (offshore), (Frapiccini & Marini, 2015)

CONCLUDING REMARKS

The persistence and sorption of PAHs were analyzed in the laboratory in conditions mimicking offshore and coastal sediments, which differ in grain size and TOC and characterized by different oceanographic and environmental conditions including biotic influence. It has been observed as PAHs that come into contact with offshore sediments were exposed to particular environmental conditions of the temperature, the salinity and the absence of light which together with clayey nature of sediment, increased accumulation and persistence processes.

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ENVIRONMENTAL IMPACTS OF EXPLORATION AND PRODUCTION ACTIVITIES IN THE CONTEXT OF PRESENT AND FUTURE SEA USE

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ABSTRACT

Since the beginning of the 20th Century, hydrocarbons became more and more important, firstly for industrialized countries and then for all economies worldwide. 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. For these reasons, in the context of ocean planning, scenario sharing and building management, the necessity of getting fast access to all information and finding fast answers to complex questions become essential. In particular, in the last decades, Geographic Information Systems (GIS) coupled with online services and OGC standard demonstrate their crucial importance as tools to use in such studies.

In this work, developed under the umbrella of the RITMARE Flagship Project, we built a geodatabase of offshore energy infrastructures data for the Italian Adriatic-Ionian Region in order to have a preliminary assessment of: (1) data type and availability, (2) potential multipurpose use of offshore infrastructures and their spatial role in environment interaction.

KEY WORDS

GIS; geodatabase; Web Map Service; Adriatic and Ionian Region

INTRODUCTION

Geographic Information Systems (GIS) applied in marine context have gained popularity in recent years because they demonstrated the ability to integrate physical, ecological, socioeconomic and hazardous information, providing an ideal assessment tool in support of management efforts of offshore and coastal resources.

Using GIS, researchers, technicians and analysts are able to manage nature conservation issues, considering biophysical and socio-economic interests of the sea, in order of providing decision makers with the necessary tools to protect communities and effectively manage sea resources. Nowadays it is well known the importance of the marine environment as player with a key role in hosting or supporting the new energy strategies, which is why the European Parliament and the Council have adopted legislation to create a common framework for Maritime Spatial Planning (MSP) in Europe. The MSP has highlighted the need to manage European waters more coherently to ensure human activities at sea can take place in an efficient, safe and sustainable way (EU Maritime Affairs, 2017).

Many countries, Italy included, have an abundance of geographic data for analysis, and governments often make GIS datasets publicly available.

Our work underline the importance of getting immediately access to maritime geospatial data for a variety of needs. For example, by identifying ocean areas used for various purposes, users can understand and de-conflict various uses lead to better planning: renewable energy building development, sand extraction for beach replenishment, benthic habitat protection or restoration and cables laying. In a second example, maritime geospatial data could be used to help Italian Ministry of Economic Development (MISE) analysis related to the leasing of areas for such resources. Thirdly, geospatial data is used to define the National Baseline along the coastline of Italy in order to generate official offshore boundaries.

MATERIALS AND METHODS

The core activity of this work was focused on finding the best online available data-source that can be used to build a geodatabase with the main geospatial object for a hypothetical case study, with a particular attention on the data type. Main target in this work are discrete object (i.e.: pipelines, cables, oil and gas buildings, benthic habitat areas…), for this reason we started our data search with priority for vector data (shapefile extension) in order to assess all their attributes.

First checkpoint tested whether the users can easily find and use data they need or not. This was done by assessing the data availability and quality from the perspective of a pre-defined set of userfunctions such as planning a pipeline pre-lay survey or siting an oil and gas production area. Second checkpoint evaluated how the collected data and existing information systems addressed potential needs of users, especially in relation to what kind of information are stored in the attributes table.

Main results from our work underlined three principal web sources (Tab.1) for the Adriatic-Ionian marine data: (1) International Project data, (2) Italian Government data and (3) Stakeholders data.

International Project data	Italian Government data	Stakeholders data
EMODNET http://www.emodnet.eu ***ADRIPLAN*** http://www.adriplan.eu ***SHAPE*** http://atlas.shape-ipaproject.eu ***OBIS*** http://www.iobis.org ***Marine Regions*** http://marineregions.org	***Portale Cartografico Nazionale*** http://www.pcn.minambiente.it ***Ministero Sviluppo Economico*** http://www.sviluppoeconomico.gov.it ***Ministero Ambiente*** http://www.minambiente.it ***Repertorio Nazionale Dati Territoriali*** http://www.rndt.gov.it	***Snam*** http://www.snamretegas.it ***Eni*** http://www.eni.com ***Galsi*** http://www.galsi.it

Table 1 - The main data sources used for the creation of the database.

The second activity of the work was focused on assessing the potential multipurpose use of offshore infrastructures and their spatial role in environment interaction. Italy has begun to take an interest in offshore hydrocarbon exploration since the 1950. The reasonable assurance that the Adriatic Sea was a rich gas province pushed indeed Agip to make the first marine seismic survey in Italy in the mid-fifties. The exploration of new reservoir in the sea has had its greatest period of expansion in the early 90's with an average of approximately 80 new wells drilled per year of which a large part of was exploratory. From the second half of the 90’s the number of new drilling at sea has been gradually declined, and in the last decade there has been a progressive decrease in the research of new deposits (MISE, 2015).

Several studies recently documented the occurrence of marine habitats of ecological value in areas occupied by hydrocarbon platforms, providing evidences that the in most of the case, the high abundance and diversity of fishes in these areas was related to the high structural complexity of the hard substrate used to build the infrastructures. The platform structure supports indeed a diverse community that provide the base of the food web for platform fishes (Eklund, 1997; Love et al., 2003; Page et al., 2007; Macreaide et al., 2011; Claisse et al., 2014).

For this reasons, the high density of oil and gas platform in the Adriatic Sea, could potentially be transformed into a huge net of monitoring observatories based on the Poseidon Project created by ENI in collaboration with Italian National Council (CNR), Institute of Marine Sciences (ISMAR) and Fondazione Cetacea. This observatory net, equipped with the modern real-time measuring instruments, could be able to produce a huge amount of time-continuous scientific data for environmental monitoring with a direct web access for the scientific community.

DISCUSSION AND CONCLUSIONS

Making high quality geospatial data available to multiple users, creating standards, formatting and continuous updating present a number of challenges. Many data products come in formats that the public or other stakeholders cannot easily input into available GIS software, and such data can be voluminous. Therefore, work to implement home-made geospatial standards to the Open Geospatial Consortium standard can be very challenging.

Nevertheless, align all the data to a unique standard should be a mandatory goal for both the socio-economic and scientific community.

Results of this work found the evidence of this concept, in particular for the data coming from Italian Government source, especially because there is a huge amount of available data, often through Web Map Service (WMS) or Web Feature Service (WFS), although there's an. important lack of a common standard for attributes tables and metadata. In addition, some data are still not vectorialized and there is also a lack of a central national portal for the data.

The huge EMODnet Portal and the SHAPE Project data services, with the powerful tool of the WMS specification and WFS, seem to represent the most important data sources that could create a usable, well-organized geodatabase.

In this work we evaluated the efficacy and the availability of marine spatial data for the Adriatic-Ionian region in the context of the energetic resources, using a modern GIS tool for the assessment of potential synergies between oil and gas infrastructures and marine environment. We underlying the importance of a high-quality net of marine data, publicly available and interoperable, across disciplines and sectors that makes the open access policy the most efficient option.

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MONITORING OF THE MARINE STRATEGY FRAMEWORK DIRECTIVE

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ABSTRACT

The Marine Strategy Framework Directive (MSFD) constitutes the vital environmental component of the Union's Maritime Policy, designed to achieve the full economic potential of oceans and seas in harmony with the protection of the marine environment. Monitoring activities represent a crucial aspect of all MSFD initiatives and they are representing the only practical actions that will provide pivotal information to reach the Good Environmental Status by 2020. Monitoring activities are carried out following specific criteria for each of the eleven descriptors of GES set out in Annex I of the MSFD, and are accompanied by a number of related indicators, setting the scene for the final GES assessment. The aim of this paper is to describe the implementation of monitoring programmes in Italian water with a specific reference to planktonic and benthic communities of the Adriatic and Ionian regions, as indicators of the environmental status.

KEY-WORDS

Marine Strategy Framework Directive; European directives; monitoring; benthos; plankton; biodiversity; Adriatic and Ionian region

INTRODUCTION

The Marine Strategy Framework Directive (MSFD: 2008/56/EC) requires that Member States take measures to achieve or maintain *Good Environmental Status* (GES) by 2020. The aim of the MSFD (adopted in June 2008) is to promote the sustainable use of the seas and to protect, across Europe, more effectively the marine environment (ecosystems) and the associated resource base upon which marine-related economic and social activities depend. Member States (MS) are therefore working on the 'building blocks' leading to the preparation and planning of measures to achieve the GES on the basis of 11 qualitative *Descriptors* (Fig. 1).

The 'building blocks' of the MSFD are: i) the assessment of essential features and characteristics, and of predominant pressures and impacts; ii) the determination of GES for 11 qualitative *Descriptors* by using a set of criteria and indicators; iii) the establishment of *Environmental Targets* and associated *indicators* so as to guide progress towards achieving GES in the marine environment; iv) the establishment and implementation of coordinated monitoring programmes for the on-going assessment of the environmental status of their marine waters (Fig. 1).

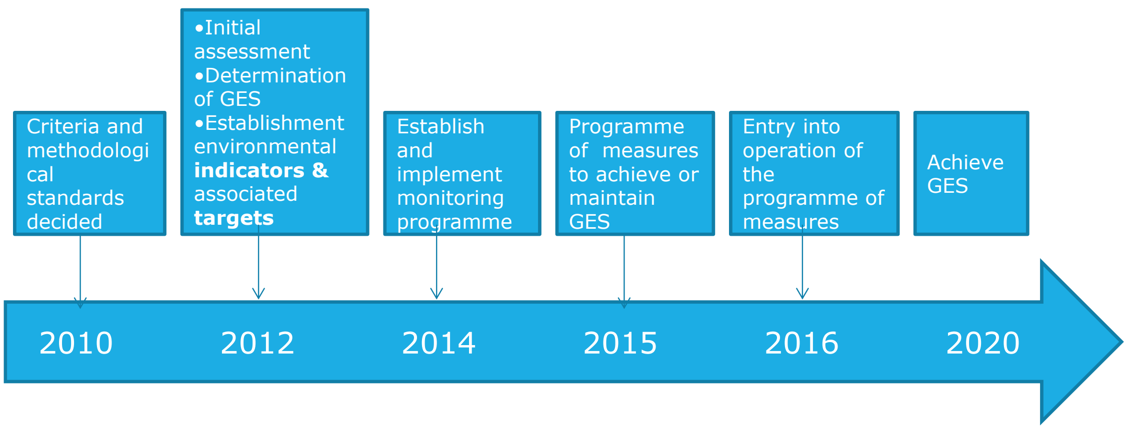

Figure 1 - *Building blocks* of the Marine Strategy Framework Directive (MSFD).

Monitoring under MSFD has been defined as the "systematic measurement of biotic and abiotic parameters of the marine environment", with predefined spatial and temporal schedule, in order to produce datasets that can be used for application of assessment methods and derive credible conclusions (with defined confidence) on whether GES is achieved or not for the marine area concerned (Zampoukas et al., 2012).

Methodological standards for monitoring activities, however, are not defined in the MSFD, nor are methodological standards clearly specified for any of the descriptors, although methodological standards would be needed, especially for comparability of approaches in determining GES and environmental goals within and among EU marine regions. The only indication from the MSFD is that, according to Article 11 of the directive, monitoring programmes shall integrate and complement the monitoring requirements imposed by other EU legislation, such as the Habitats Directive (92/43/EEC) and Birds Directive (2009/147/EC) and international agreements, such as the Regional Seas Conventions (RSCs).

The aim of this paper is to describe the implementation of monitoring programmes and the potential use of planktonic and benthic communities as indicators of the environmental status, with a reference to planktonic and benthic communities of the Adriatic and Ionian region.

PLANKTONIC COMMUNITES

The most common indicator of the trophic conditions of a marine ecosystem has been phytoplankton, which was used, in terms of chlorophyll concentrations, already in the 1960s. Later on, the need of assessing trophic status of aquatic ecosystems became a priority worldwide due to the serious impacts caused by eutrophication phenomena. Chlorophyll *a* concentration became the most commonly and routinely used indicator of trophic conditions, being easily measurable and well-correlated with nutrient enrichment (i.e. Ferreira et al., 2011 and references therein). More recently, the Water Framework Directive (WFD - Directive 2000/60/EC) and the marine conventions (OSPAR, HELCOM and Barcelona Convention) require the use of phytoplankton to assess water quality, and promoted and addressed several approaches on the use of various metrics beyond chlorophyll concentration, such as cell abundance, biomass as carbon content, cell size, diversity, etc. (Garmendia et al., 2013).

The MSFD, by recognizing that also other planktonic components are relevant indicators for the definition of GES, takes into consideration beside phytoplankton, also zooplankton and large metazoa (i.e. benthic macrofauna and fish) in the monitoring programs. But, in contrast with the widely recognized relevance of microbial processes in marine ecosystem functioning, the microbial components are not included in the MSFD monitoring (Caroppo et al., 2013).

A recent review (Caruso et al., 2015), demonstrated the potential suitability of prokaryotes and related variables/ parameters for the assessment of the health status of marine environments. The reasons why bacterioplankton should be considered in the in the implementation of the MSFD monitoring were highlighted. Particularly, monitoring of abundance, biomass and activities (enzymatic hydrolysis, production and respiration) of marine prokaryotes could give useful information to understand and predict the impact of both natural and anthropogenic changes on the marine environment (Caruso et al., 2016). On the basis of these researches, the MSFD monitoring in Italian waters of the planktonic communities includes also the evaluation of the abundance, biomass and function of the microbial component of the plankton.

BENTHIC HABITATS

Within the framework of the MSFD, the monitoring of benthic habitats represents a relevant measure to be collected in order to address MSFD requirements for Descriptor 1 (biodiversity). Development of monitoring in the wider benthic environment is very challenging because the area in which we work is extremely large and the benthic habitats within it are so diverse (even on a range of different spatial scales – Savini et al., 2014) and standard methodologies are far from being established across all European Seas (Grehan et al., in press). In Italy, relying on the initial assessment and considering the structure and present-day knowledge of Mediterranean Sea biodiversity, 4 criteria have been considered pivotal for monitoring benthic habitats:

1.2 *Population size*

1.3 *Population condition*

1.5 *Habitat extent*

1.6 *Habitat condition*

Posidonia oceanica meadows, *Coralligenous*, *Maerl* and *rodoliths beds* and *Cold-Water Corals* (CWC) represent crucial hotspots of biodiversity for the Mediterranean Sea and have been identified as of special scientific (or biodiversity) interest by the MSFD (MSFD, Annex III, Tab.1). The implementation of appropriate monitoring measures is indeed instrumental to guarantee their sustainable management (Lo Iacono et al., 2018); continuous maps of species distribution are especially highly required in the framework of any action/measure aimed at their protection and conservation. Nevertheless there are still several gaps in assessing the distribution of these complex habitats and in understanding their functioning and evolution, especially for the deep sea, although with the dissemination of seafloor mapping technologies and the use of *in situ* still and video imagery as a method of sampling the benthos, descriptions of deep-sea benthic assemblages have advanced more rapidly (e.g. Howell et al., 2010; Vertino et al., 2010, Davies et al., 2014, 2015; Savini et al., 2014). Recent goals reached in benthic mapping studies, revealed in particular that Coralligenous and CWC habitats represent characteristic benthic habitats of the Adriatic and the Ionian regions of the Mediterranean Sea (Savini et al., 2014; Angeletti et al., 2015; Bracchi et al., 2017). They are often (and almost exclusively for CWC) distributed offshore territorial waters and therefore require ad-hoc monitoring programmes, not addressed by the national Regional Agencies for Environment Protection (i.e.: ARPA – Agenzia Regionale per la Protezione Ambientale), nor by other programmes related to other European directives.

Quantitative data on C extension are available only for the Apulian continental shelf, where a total surface of 436 km^2 of seafloor is covered by coralligenous habitats (Campiani et al., 2014). A tentative large-scale assessment of the predicted distribution of C on a basin scale has been modelled on the basis of existing records of a total 2,763.4 km^2 of Mediterranean C (Martin et al., 2014). Unfortunately, the resulting model has a weak support by direct observations and published data (Lo Iacono et al., 2018). Results from future monitoring activities carried out within the framework of MSFD can undoubtedly improve future efforts of modelling C distribution at the scale of the Mediterranean basin.

Also CWC habitats are well represented within the Adriatic-Ionian regions, where quantitative information on CWC distribution (Savini et al., 2014) were delivered in 2012 and highly contributed in performing the MSFD initial assessment (Fig. 1) for Italian water.

CONCLUDING REMARKS

Implementing monitoring activities for the MSFD along the Italian margin presents challenges due to the need of methodological standards, especially for comparability of approaches in determining GES and environmental goals within and among EU marine regions. Concerning the Mediterranean Sea, studies carried within the Adriatic and Ionian regions, also within the framework of the RITMARE project, provided significant outputs in support of the need of developing standard methodologies for the MSFD. Large multidisciplinary projects, such as RITMARE have an important role indeed in improving the scientific knowledge base to support and ensure a sustainable exploitation of deep-sea resources, with an emphasis on the conservation of vulnerable marine ecosystems and biodiversity. Results obtained in the Adriatic and Ionian regions, contributed in particular to: I) evaluate the diversity and functioning of the pelagic communities; II). Detect and locate ecological or biological significant benthic habitats, assisting the definition of monitoring activities for benthic habitats.

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Session 3 – Conservation and health of the Mediterranean Cetaceans

MONITORING SYSTEM APPLIED TO CETACEANS IN THE NORTHERN IONIAN SEA: THE STATUS OF *STENELLA COERULEOALBA* (MEYEN, 1833) AND *TURSIOPS TRUNCATUS* (MONTAGU, 1821) AND THE ENVIRONMENTAL AND ANTHROPOGENIC VARIABLES IN THE GULF OF TARANTO

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ABSTRACT

Substantial progress has been achieved in the field of marine environmental policy especially with the adoption of the EU Marine Strategy Framework Directive (MSFD). However, the establishing of quantitative criteria and indicators to evaluate the Good Environmental Status (GES) remains an open issue. To that regards, since Cetaceans are key species in the marine food web, research studies on their distribution and conservation status along with their habitats can give an idea of the current impact of human pressure on biodiversity and marine ecosystem services. Therefore, the challenge to investigate their ecological significance is leading and highly informative when facing human induced environmental changes. For this reason, intense research activities have been performed in the last years for collecting scientific relevant information on the striped dolphin *S. coeruleoalba* and common bottlenose dolphin *T. truncatus*, modeling their critical habitats in the Gulf of Taranto (Northern Ionian Sea, Central-eastern Mediterranean Sea).

KEY-WORDS

Habitat modeling; Random Forest; Dolphin; Northern Ionian Sea; Mediterranean Sea

INTRODUCTION

Although several criteria and indicators have been proposed to assess the environmental status of marine ecosystems in the EU (i.e. Marine Strategy Framework Directive - MSFD), the significant gaps in the existing knowledge about the relationship between ecosystem components and anthropogenic pressures, still defeat the setting of effective management objectives (Azzellino et al., 2014; Berg et al., 2015). This is highly relevant in the Mediterranean Sea where, on the contrary, recent EU policy explicitly indicates the protection and conservation of key species and habitats as a practical goal to enhance the natural capital and maintain ecosystem resilience by 2020 (EEA - European Environment Agency, 2015). In this contest, the MSFD, as well as the Maritime Spatial Planning Directive (MSPD), operated as fundamental pillars of the Integrated Maritime Policy (Meiner, 2010). The former establishes environmental targets and associated indicators to reach Good Environmental Status (GES), while the latter incorporate the ecosystem-based approach (EBA) to the management of human activities to reduce the loss of biodiversity at an ecologically relevant scale. As a matter of fact, the Mediterranean Sea diversity has been severely altered over time by different anthropic pressures and by the increasing use of coastal and offshore marine areas, thus making it particularly vulnerable (Coll et al., 2012). Thus, the range of cetacean species and the identification of their critical habitats in the Mediterranean Sea represent fundamental indicator classes providing a common currency for evaluating the impacts of different human pressures on ecosystem functioning. Unfortunately, the knowledge about the presence and distribution of cetaceans is still lacking in the Mediterranean Sea and mostly in large areas of the central-eastern regions (Notarbartolo di Sciara & Birkun, 2010). Concerning the Ionian Sea (Central-eastern Mediterranean Sea), the available information from recent studies reported that the striped dolphin *Stenella coeruleoalba* (Meyen, 1833) and the common bottlenose dolphin *Tursiops truncatus* (Montagu, 1821) regularly inhabit the Northern Ionian Sea (Dimatteo et al., 2011; Fanizza et al., 2014; Carlucci et al., 2015). However, despite the presence of adults, juveniles and calves, no conservation measures to ensure a more favorable status and the long-term survival of these species are currently enforced in this area. On the contrary, dolphins inhabiting this basin could be exposed to elevated levels of anthropogenic threats such as strikes from merchant traffic, disturbance from high intensity military sonar and exposure to chemical pollution from the nearby the harbor of Taranto, reducing their habitat suitability as behavior response to human-induced environmental changes (Carlucci et al., 2016).

RESULTS AND CONCLUDING REMARKS

The Gulf of Taranto in the Northern Ionian Sea (Central-eastern Mediterranean Sea) is characterized by a very complex topography. A narrow continental shelf with a steep slope and several channels characterize the western sector, while the eastern sector shows descending terraces toward the "Taranto Valley", a NW-SE submarine canyon with no clear bathymetric connection to a major river system (Capezzuto et al., 2010; Russo et al., 2017). This singular morphology involves a complex distribution of water masses with a mixing of surface and dense bottom waters with the occurrence of high seasonal variability in upwelling currents (Matarrese et al., 2011; Carlucci et al., 2014). The coastal area of the Gulf of Taranto is subjected to anthropogenic pressures due to the presence of intense commercial shipping (Figure 1), heavy industries and navy exercise areas (Carlucci et al., 2016 and reference therein).

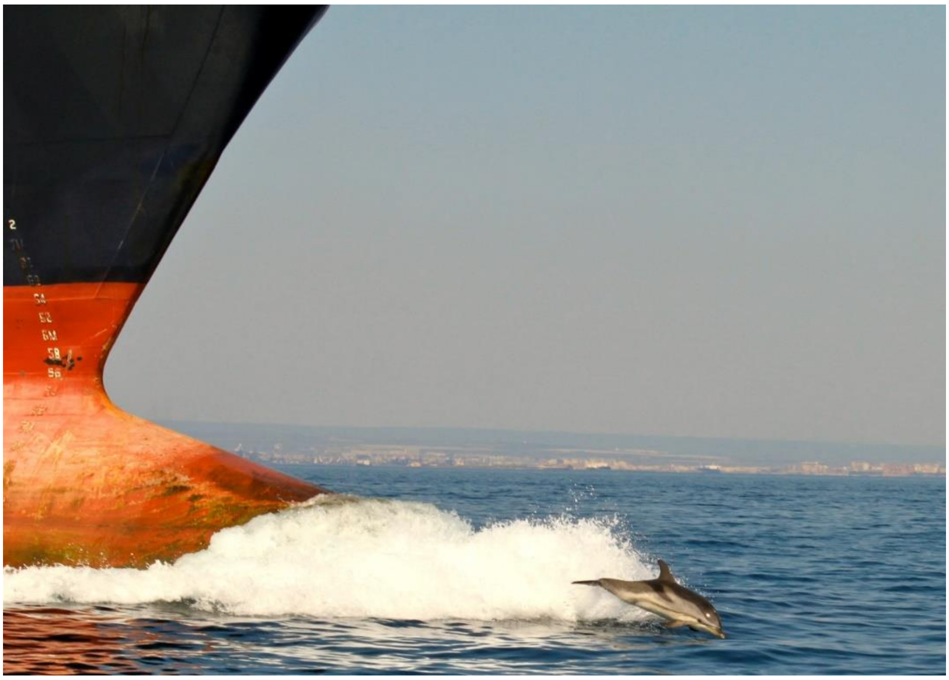

Figure 1 - Interaction between commercial shipping and the striped dolphin *S. coeruleoalba* in the Gulf of Taranto.

An intense research activity was carried out by the Department of Biology University of Bari (UNIBA Local Research Unit CoNISMa), the Jonian Dolphin Conservation (JDC) and the Institute of Intelligent Systems for Automation (CNR-ISSIA), reducing the shortcomings in the basic scientific information in the area. The spatial distributions of the striped dolphin *S. coeruleoalba* and the common bottlenose dolphin *T. truncatus* were investigated by means of a generalized additive model (GAM) and a Random Forest (RF) based on sighting data collected during standardized vessel-based surveys carried out from 2009 up to date. The sampling effort was set to about 5 h/day along 35 nautical miles (nm). Speed was maintained between 7 and 8 knots and trips only occurred in favorable weather conditions (Douglas scale ≤ 3 and Beaufort scale ≤ 4). A line transect sampling was adopted according to Buckland et al. (2001) investigating a survey area of about 640 km^2. Using the Distance 6.0 software the random equally spaced zigzag transects were generated daily with an angle of 45 degrees to the x-axis (Thomas et al., 2010), this proved to be more efficient in terms of reducing effective costs and minimizing off-effort navigation time than the conventional parallel line transects (Strindberg & Buckland, 2004). The observer team on board consisted of at least three people, of which one observer searching for species targets around 180° and counting the specimens during each sighting, while the others searched in a sector from the track-line to 90° ensuring the assumption of Distance sampling (Buckland et al. 2001) and supporting the activities of the former observer. Eight predictive variables were considered in Random Forest (RF) modeling, considering both the local physiographic features and human activities existing in the investigated area, suggesting an innovative approach to habitat modeling. The explanatory variables depth, distance from industrial areas and distance from the coast proved to significantly influence the distribution of both dolphin species. In addition, the distribution of *S. coeruleoalba* and *T. truncatus* were also significantly shaped by the distance from the navy exercise areas and the fishing areas, respectively. On the contrary, the slope and the distance from the main commercial routes never provided any major influence. RF model predicted that the striped dolphin is widely present in the central and deeper part of the Gulf of Taranto (Fig. 2). In contrast, the common bottlenose dolphin seems to be mainly distributed along the coasts in both the eastern and western sector of the basin. A clear overlapping of the preference habitats estimated for *S. coeruleoalba* and *T. truncatus* is shown north of Punta Alice and in front of Policoro as well as offshore from Ugento in the eastern and western parts of the investigated area, respectively. Finally, the critical habitats of *S. coeruleoalba* and *T. truncatus* are the outcome of both the influence of environmental conditions and anthropogenic pressures presently occurring in the Gulf of Taranto, basically indicating the need for conservation measures, especially considering that the area is expected to be considered for hydrocarbon prospecting. These results contribute to setting up a baseline reference for future assessment of environmental marine disturbances using cetaceans, which are considered a key group in the MSFD, as an ecological indicator.

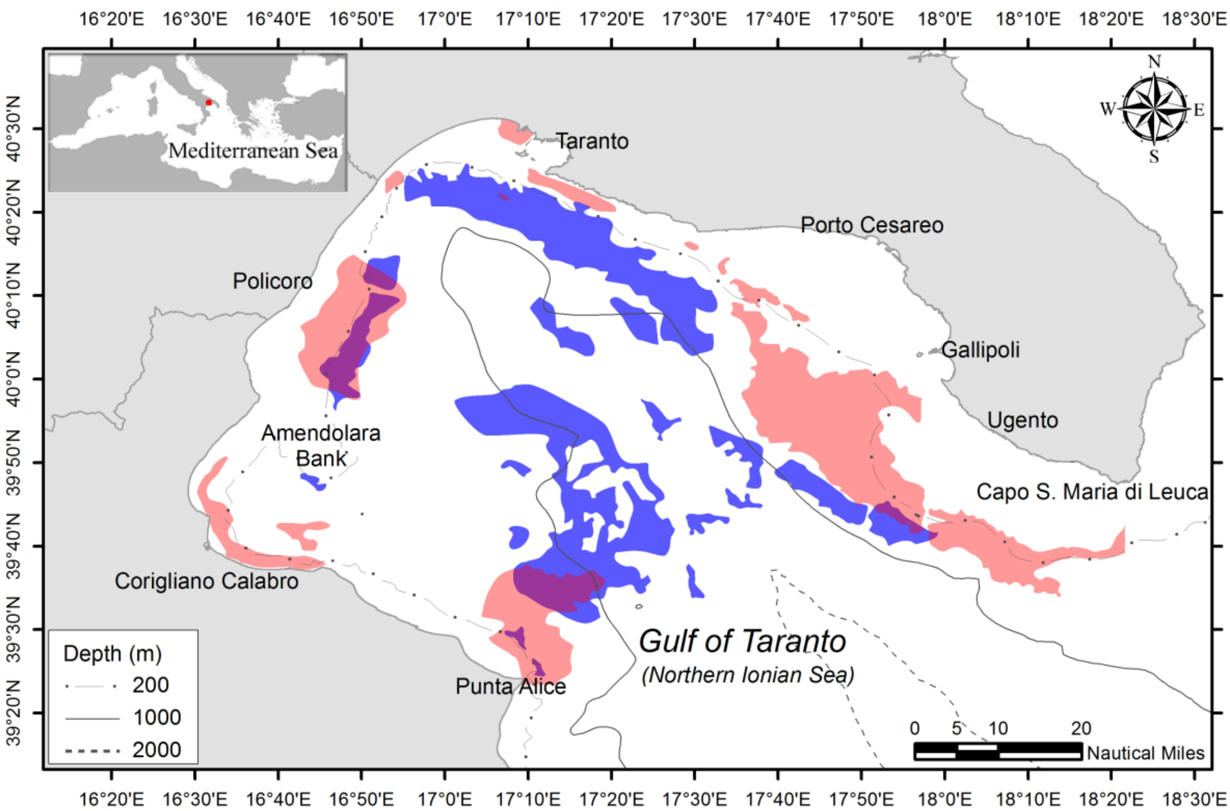

Figure 2 - Identification of habitat areas for the striped dolphin (blue) and common bottlenose dolphin (red) in the Gulf of Taranto (Northern Ionian Sea, Central-eastern Mediterranean Sea). Map edited in Carlucci et al., 2016 with DOI: 10.1016/j.ecolind.2016.05.0351470-160X/.

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MORBILLIVIRUS AND OTHER BIOLOGIC *NOXAE*, ALONG WITH THEIR IMPACT ON THE HEALTH AND CONSERVATION OF CETACEANS IN THE WESTERN MEDITERRANEAN

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ABSTRACT

In recent years, several studies have been focused on the effects of spontaneous disease on cetacean health and conservation, taking into special account host-pathogen interactions. Among the Emerging Infectious Diseases (EIDs) of cetaceans, those caused by *Morbillivirus*, *Herpesvirus*, *Brucella ceti* and *Toxoplasma gondii* are of special concern. EIDs have been reported in several cetacean species worldwide, being responsible for dramatic die-offs as with the *Dolphin Morbillivirus* (DMV) epidemics of 1990-'92 and 2006-'08 among Western Mediterranean striped dolphins (*Stenella coeruleoalba*) and pilot-whales (*Globicephala melas*) EIDs may also impact cetacean reproductive function and biology, with associated population declines. A brief overview on the aforementioned agents and infections in cetaceans from the Western Mediterranean is provided herein.

KEY-WORDS

Morbillivirus; Herpesvirus; Toxoplasma gondii; Brucella ceti; *Cetaceans*.

INTRODUCTION

Newly recognized and evolving infectious diseases showing either a recent increase in incidence or changes in pathogenicity or a geographical expansion are gathered under the common denomination of “emerging infectious diseases” (EIDs). Mass mortality events, population declines, biodiversity loss and increased risk of extinction may be the result of EID occurrence within wild animal populations (Cunningham, 2005). EIDs have been reported in several cetacean species and populations worldwide, being responsible for dramatic die-offs and/or impacting their reproductive function and biology, with associated population declines (Di Guardo et al., 2010; Van Bressem et al., 2009; 2014). In this respect, the synergistic effects, if any, of chemical pollutants (Aguilar and Borrell, 1994) are of special concern. The most significant cetacean EIDs, namely *Dolphin Morbillivirus*, *Herpesvirus*, *Brucella ceti* and *Toxoplasma gondii* infections, will be briefly reviewed herein, with special reference to the Western Mediterranean cetofauna.

Dolphin Morbillivirus

Dolphin Morbillivirus (DMV), one of the three more common strains of Cetacean Morbillivirus (CeMV), has been recognized, since the last 30 years, as a pathogen of great concern for free-ranging cetaceans (Van Bressem et al., 2009; 2014). Two dramatic DMV epidemics were recorded among Western Mediterranean striped dolphins (*Stenella coeruleoalba*) in 1990-’92 as well as in 2007-’08 (Van Bressem et al., 2009; 2014). Before this latter event, a DMV outbreak was additionally reported in long-finned pilot whales (*Globicephala melas*) around the Strait of Gibraltar (Van Bressem et al., 2009; 2014), while other smaller episodes were reported in subsequent years mainly in Italian waters (Casalone et al., 2014), affecting not only small odontocetes but also larger ones (Casalone et al., 2014; Mazzariol et al., 2017) and mysticetes (Mazzariol et al., 2016). In most of these events, the DMV strains involved were genomically and antigenically similar, thereby providing strong support to the capability of this virus to infect different cetacean species, as previously suggested (Van Bressem et al., 2014).

Herpesvirus

As reported elsewhere, *Herpesvirus* has been detected in association with other agents (especially DMV) also in Mediterranean cetaceans, often without any overt pathological changes (Casalone et al., 2014). Molecular evidence of *Alphaherpesvirus* infection has been also reported in a fin whale (*Balaenoptera physalus*) and in a minke whale (*Balaenoptera acutorostrata*) stranded along the Valencian coast of Spain (Melero et al., 2015).

Brucella ceti

Reports of brucellosis in Mediterranean cetaceans are occasional. *Brucella ceti* was reported for the first time in this basin by Alba et al. (Alba et al., 2013), who documented this infection in a striped dolphin affected by a non-purulent meningo-encephalitis and by a *T. gondii* coinfection. Two additional striped dolphins with severe meningo-encephalitic and pneumonic lesions were reported along the Ionian shores of Apulia (Garofolo et al., 2014). Brucellosis was also described in three dolphins with different lesions stranded along the Catalonian coast of Spain (Isidoro-Ayza et al., 2014). A more recent work on a case of meningo-encephalitis in a striped dolphin reported an interesting association of *B. ceti* with *T. gondii* and *Listeria monocytogenes* (Grattarola et al., 2016). Despite the low number of cases reported and the absence of outbreaks related to this bacterial agent, *B. ceti* infection is of great concern due to its zoonotic potential, especially for people working on stranded cetaceans (Van Bressem et al., 2009).

Toxoplasma gondii

This protozoan agent has been frequently encountered during *post mortem* investigations in cetaceans stranded along the Mediterranean shores and, in particular, along the Italian coastline. *T. gondii* is an opportunistic pathogen, often secondary to DMV infection (Van Bressem et al., 2009). However, during the multiple strandings of striped dolphins occurred in Ligurian waters in 2008, this pathogen was deemed as the likely cause of death for these animals, due to a chronic, severe meningo-encephalitis (Van Bressem et al., 2009; Di Guardo et al., 2011). Furthermore, interesting cases of *T. gondii* infection were reported in pelagic species like sperm whales (*Physeter microcephalus*) and fin whales (Mazzariol et al., 2011; 2012). Most of *T. gondii* isolates belong to type II or X, supporting a terrestrial source of infection from domestic cats and/or wild carnivores (Di Guardo et al., 2011; Van Bressem et al., 2009).

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