DEPARTMENT OF INTERNATIONAL AND EUROPEAN ECONOMIC STUDIES

ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

Introduction to the MERMAID Project

Phoebe Koundouri

Laura Airoldi

Arjen Boon

Amerissa Giannouli

Eleftherios Levantis

Aris Moussoulides

Marian Stuiver

Stella Tsani

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Phoebe Koundouri, Laura Airoldi, Arjen Boon, Amerissa Giannouli, Eleftherios Levantis, Aris Moussoulides, Marian Stuiver, and Stella Tsani

Abstract This chapter provides an introduction to the MERMAID project. MERMAID focused on developing concepts for offshore platforms which can be used for multiple purposes, such as energy and aquaculture production. These concepts were developed with input from experts as well as societal stakeholders. MERMAID consortium comprised of 28 partner institutes, including Universities, Research institutes, Industries and Small and Medium Enterprises from several EU countries. Consortium members brought a range of expertise in hydraulics, wind engineering, aquaculture, renewable energy, marine environment, project management, as well as socioeconomics and governance. Within the scope of MERMAID it has been developed and applied an Integrated Socio-Economic Assessment of the

P. Koundouri (✉)
ICRE8: International Centre for Research on the Environment and the Economy,
Artemidos 6 & Epidavrou, Marousi, 15125 Athens, Greece

School of Economics, Athens University of Economics and Business,
76 Patission Street, Athens 104 34, Greece

London School of Economics and Political Science, Grantham Institute,
Houghton St WC2A 2AE, London, UK
e-mail: pkoundouri@aueb.gr

L. Airoldi
Dipartimento di Scienze Biologiche, Geologiche ed Ambientali (BIGEA),
University of Bologna, Ravenna, Italy

Centro Interdipartimentale di Ricerca per le Scienze Ambientali (CIRSA),
University of Bologna, UO CoNISMa, Via S. Alberto 163, Ravenna 48123, Italy

A. Boon
Deltares, Boussinesqweg 1, P.O. Box 177, 2600 MH Delft, The Netherlands

A. Giannouli • A. Moussoulides
School of Economics, Athens University of Economics and Business,
76 Patission Street, Athens 104 34, Greece

E. Levantis • S. Tsani
ICRE8: International Centre for Research on the Environment and the Economy,
Artemidos 6 & Epidavrou, Marousi, 15125 Athens, Greece

M. Stuiver
Wageningen Environmental Research at Wageningen UR,
PO Box 47, Wageningen 6700 AA, The Netherlands

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sustainability of Multi-Use Offshore Platforms, using the results from the natural and engineering sciences as inputs, boundaries and constraints to the analysis.

Keywords Mermaid • Marine spatial planning • Multi use offshore platforms • Socio-economic assessment • Marine infrastructure • EU • Energy • Aquaculture

During the next decades, there will be a substantial development of offshore marine structures in the European seas, such as offshore wind farms, constructions for marine aquaculture and the exploitation of wave and tidal energy. Offshore platforms that combine multiple functions, such as energy and aquaculture production, offer significant economic and environmental benefits. However their installation and maintenance, and the transport of materials and products to and from these structures, will unavoidably exert environmental pressures on the marine ecosystems. It is therefore crucial that the economic costs, the use of marine space and the environmental impacts of these activities to be appropriately captured and explored and to remain within acceptable limits.

A key initiative in this context has been the launch of *The Ocean of Tomorrow* cross-thematic calls in FP7 (FP7-OCEAN). The initiative aimed to foster multidisciplinary approaches and cross-fertilisation between various scientific disciplines and economic sectors on key cross-cutting marine and maritime challenges such as reduction of fossil-based energy and promotion of sustainable aquaculture. A key feature of the initiative has been the participation of business partners, in particular Small and Medium Enterprises (SMEs), in the funded research projects.

MERMAID (http://www.mermaidproject.eu/) is an EU-FP7 project selected for funding in response to OCEAN.2011 call on multi-use offshore platforms (FP7-OCEAN.2011–1 "Multi-use offshore platforms"). MERMAID had a cost of 7.4 million Euro and comprised of 28 partner institutes, including Universities (11), Research institutes (8), Industries (5) and Small and Medium Enterprises (4 SME's), from several regions of the European Union (EU). The group represented a broad range of expertise in hydraulics, wind engineering, aquaculture, renewable energy, marine environment, project management, as well as expertise in socio-economics and governance (MERMAID Project 2015). MERMAID focused on developing concepts for the next generation of offshore platforms which can be used for multiple purposes, including energy production, aquaculture and platform related transport. The project did not envisage building new platforms, but examined new concepts, such as combining functions and building new structures on representative sites under different conditions. These concepts were developed with the input from experts as well as societal stakeholders (MERMAID Project 2014).

MERMAID designed concepts of Multi-use Offshore Platforms (herafter MUOPs) that addressed different physical conditions in order to make the best use of the ocean space. Going from deep water (north of Spain) to shallow water with high morphodynamic activity (north of the Wadden Sea) and further to inner waters like the inner Danish/Baltic areas and the Adriatic sea changes the focus from a

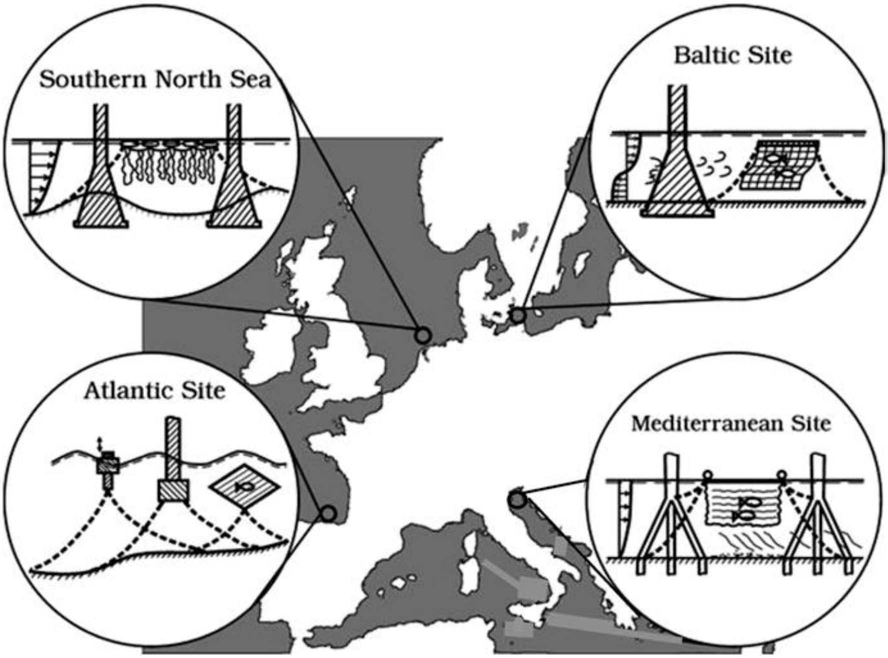

Fig. 1.1 Map of Europe with close-up at the four sites, with focus on local challenges (MERMAID Project)

strong to low physical control of the environment. That made it possible to develop, assess and integrate different technologies but also to address site specific challenges concerning social, ecological and economic issues (Fig. 1.1).

Shared use of marine space implies shared environmental effects due to reduction of human activity in many different places. This is in line with the EU Directive on Maritime Spatial Planning (Directive 2014/89/EU) which is dedicated to establish efficient and sustainable planning of human activities that take place at sea. To ensure the sustainable development of MUOPs, the following need to be addressed: economic efficiency, social equity and environmental and ecological sustainability:

Economic Efficiency Economic efficiency satisfies the condition that the marginal (social) cost of each production activity under consideration equals the respective marginal (social) benefit. In this framework costs and benefits are considered in order to provide a holistic economic assessment in terms of efficiency. Production activities are considered sustainable, when the economic efficiency condition is satisfied over time and over space.

Social Equity Social equity requires that the social effects of the production activities are acceptable and affordable by the different social groups in the region. These affordability and acceptability conditions should be assessed spatially (intra-generational effects) but also dynamically (inter-generational effects).

Environmental and Ecological Sustainability Environmental and Ecological Sustainability ensures that the environmental and ecological effects of the activities under consideration are compatible with the persistence of vital ecosystems and their associated services over space (in the region under consideration) and time.

For the MERMAID project assessing the sustainability of MUOPs required the identification of the key impacts depending on the nature of the designs (floating, offshore, large size, combined activities). Their identification is important since they are expected to be financially and socially related to both the business/industry under consideration and to the wider local or regional community. Tables 1.1 and 1.2 present the potential socio-economic and environmental impacts, as well as activities affected due to MUOPs, respectively, without being exclusive (MERMAID Project 2012).

While aiming to develop MUOPs, specific policy, economic, social, technical, environmental, and legal (PESTEL) factors will become influential in some way. Recognizing these external factors to a business environment can assist in understanding the "big picture" in which businesses need to operate (Issa et al. 2010). For example: It is relevant to assure protection of the marine ecosystem by licensing procedures based on site-specific environmental studies and to guarantee the implementation of an environmental monitoring system in the designated marine areas for MUOPs development.

Table 1.1 Activities affected

Commercial fishing
Recreational fishing
Commercial shipping
Yachting and recreational boating
Other water-based activities
Land-based activities
Regional tourism

Table 1.2 Socio-economic and environmental factors potentially impacted

Regional employment (direct and indirect) and training opportunities
Cultural and natural heritage
Access to local seafood and energy
Sustainable food and energy production
Risk potentially affecting the seabed and associated ecosystems
Risk associated with the characteristics of the water column and associated species
Risk to fish, mammals, turtles and birds
Risks related to the spread of invasive species and/or diseases
Environmental aesthetics

The construction of MUOPs might cause a variety of different changes to the environment and human health. Since the first installation of offshore wind farms, these effects have been studied in increasing detail, and numerous publications have appeared on the subject (Degraer and Brabant 2009; Lindeboom et al. 2011; Bergström et al. 2013). The modification of the natural environment, i.e. the replacement of natural substrata with harder surfaces of stone, concrete, asphalt, metal or other artificial material can enhance the distribution of a number of species typical of hard substrata, some of which can thrive on these anthropogenic surfaces. Because of this, marine infrastructures are sometimes perceived as an opportunity for habitat enhancement, providing local benefits associated to hard substrata where none previously existed, or potential refuge for rare or threatened native rocky species. Also, there is evidence that marine infrastructures can offer particularly favourable substrata to many non-indigenous species (NIS). NIS may colonize from nearby natural rocky habitats or could spread out of ports, harbours, marinas, or other sources of introduction, especially when multiple artificial structures are built relatively close to one another. Furthermore, offshore structures provide some degree of refuge from trawling activities since for safety reasons it is forbidden to navigate closer than a distance of between 200 m and 1000 m from offshore platforms.

On the other hand, marine structures can seriously affect the genetic and species diversity (Fauvelot et al. 2009, 2012), the biological resources and the water quality because of the high levels of disturbance in the marine environment. The epifauna on the hard structures may compete for food with zooplankton or planktivorous fish, and create limiting amounts of food for these faunal groups, especially in accumulation when aggregations of offshore wind farms are placed within a larger area (which will be the case in the southern North Sea) (Maar et al. 2009).

Other disturbances may include possible increased noise, light and electromagnetic fields. The installation of offshore wind farms is commonly carried out by piling. This creates a large acoustic underwater disturbance that affects the distribution and possibly migration and feeding of marine mammals in a radius of some tens of kilometers around the pile for the period of windfarm construction, ca. a half year. Relevant for MERMAID is the possible interaction between marine mammals and the offshore constructions through the observed aggregation of fish, that may attract mammals instead of repelling them. Due to the foreseen installation of tens of GW of offshore windfarm capacity in various coastal areas, it is assumed that the accumulative effect of the installation and operation of offshore constructions such as wind farms could create longer-lasting impacts on marine mammals, both negative (piling) and positive (aggregation and added production of fish). The same holds for birds and bats that use the marine space for feeding, migration and resting. The offshore constructions create a behavioural change in birds using the marine surface as a resting and feeding area (Lindeboom et al. 2011), next to the possibility of mortal collisions with rotors. The increased availability of fish and shellfish within offshore constructions may influence (both in negative and in positive terms) the distribution and fitness of birds. Last, electromagnetic fields (EMF) from cables running over the seafloor may impede foraging and migration of rays and sharks, due to interaction of the EMF with the electrosensory organis of these animals used for foraging (Gill 2005).

MUOPs can interfere or interact with several of these wind farm effects. Seaweed aquaculture may use nutrients that cannot be used by phytoplankton and cause nutrient depletion that may have effects on higher trophic levels (zooplankton, fish). Shellfish aquaculture such as for blue mussels may have a comparable effect, but then filtering algal biomass that will not be available to zooplankton and/or fish. Structures supporting such aquaculture may add to the amount of hard substrate and strengthen their effects. There is a lack of knowledge on the possible environmental and ecological interactions of MUOPs when based on offshore wind farms platforms.

In order to understand if and how the environment is being affected by the projects, and to avoid, minimize and eventually offset the adverse significant negative impacts, an environmental monitoring program is necessary that the business can use to guide their operations. Depending on the specific uses within the MUOPs, the environmental monitoring system could focus on issues such as e.g. spreading of invasive species, biodiversity, underwater noise and electromagnetic radiation, water pollution, along the lifetime of the project, preceded by environmental baseline studies. In some countries such as the Netherlands, it is currently forbidden to navigate within offshore wind farms at all. This creates the possibility for the benthic assemblage to recover from repeated and long-term trawling, although the anticipated positive effects seem to be time and substrate dependent (Bergman et al. 2014; Duineveld et al. 2007).

There is a call for clear policy frameworks at all levels to offshore multi-use platform development to make developers more willing to invest in MUOPs. This policy framework should adhere to the principles of Marine Spatial Planning (MSP) to foster sustainable use of marine space and it should also include permits and licensing procedures. At the moment it appears that the start-up of MUOPs comes with substantially higher investment costs and risks as compared to business-as-usual projects. Therefore mechanisms of financial support are needed to enhance the first stages of the development of MUOPs and make the investment more attractive.

Research in MERMAID has been conducted with the aim to involve various stakeholders of relevance. Involving different stakeholders has shared and increased knowledge on the difficulties with regards to the development and implementation of MUOPs. It is recommended to get familiar with this knowledge. This helps taking into account a variety of institutional, technical, environmental, financial and socio-economic aspects in MSP and for developing policy instruments that can support the development, implementation and running of MUOPs.

The recommendation is to engage different stakeholders in spatial planning and when developing policy instruments for offshore MUOPs. Important stakeholders are business partners and the potential future developers, environmental authorities, local and/or regional administration, relevant professional associations, local Non-Governmental Organisations (NGOs), and research institutes. The most valuable lesson derived from Van den Burg is that stakeholder involvement is indeed very valuable for the development and acceptance of the designs. However, the involvement can differ for each site and that consequently the selected approach should be tailored to the situation. During the MERMAID project, at the Baltic site, a clear selected group of stakeholders examined the feasibility of realizing a MUOP at a specific location, whereas at the Atlantic and Mediterranean sites, the idea of MUOPs was unclear and the process brought together stakeholders to explore the wider issue and potential of MUOPs at these locations.

This book derives from the interdisciplinary research within MERMAID in developing and applying an Integrated Socio-Economic Assessment of the sustainability of Multi-Use Offshore Platforms, using the results from the natural and engineering sciences as inputs, boundaries and constraints to the socioeconomic analysis. In this framework the economic, social and environment impacts of the proposed MUOPs, are identified, quantified and expressed in monetary terms, as detailed in the following chapters. The analysis concludes with a discussion on the challenges and obstacles to the MUOPs development and recommendations to consider.

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