JPI OCEANS

Underwater noise in the marine environment

Research projects – 2022 - 2026

Co-branded by:

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

BANOS Baltic and North Sea Coordination and Support Action

blueMed

JPI OCEANS

FUNDING PARTNERS

RESEARCH PROJECTS 2022 - 2026

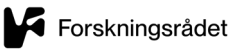

TABLE OF CONTENTS

1.0 INTRODUCTION

The innovative projects presented in this booklet are the result of a JPI Oceans call on underwater noise in the marine environment, establishing a unique collaboration between Belgium, Germany, Ireland, Italy, Norway, Poland, Romania and Spain together with BANOS, BlueMed, NOAA and the UN Ocean Decade.

The joint call was the first UN Ocean Decade contribution and implementing activity by JPI Oceans, in its role as Decade Implementing Partner for Europe. The call offered a concrete opportunity to systematically approach ocean challenges, support policy and governance, and carry out experimental research activities on the emerging issue of the acoustic pollution of ocean and seas. In the first phase, thirteen project proposals involving partners from all eight participating countries were received. The proposals were evaluated by independent, international peer reviewers and ranked by an evaluation panel. On this basis, the Call Steering Committee selected five projects for funding.

WHY IS THIS IMPORTANT?

Mankind is noisy by nature, and the impact of noise on human societies seems well known. With growing environmental awareness, our society – scientific researchers, NGOs, policy makers, and citizens – recognizes anthropogenic noise as an emerging pollutant and growing concern for subaquatic environments. Underwater acoustic pollution impacts on the health of marine animal populations and biological productivity, but the extent is not well known.

Therefore, in December 2021, Belgium, Germany, Ireland, Italy, Norway, Poland, Romania and Spain under the framework of JPI Oceans and together with endorsements by BANOS, BlueMed, NOAA and the UN Ocean Decade, launched a call on 'Underwater Noise in the Marine Environment'. The overall aim is to decrease existing knowledge gaps and to promote specific lines of research that will contribute to the implementation of the Marine Strategy Framework Directive at regional sub-basin scale, and, therewith, contributing to reach the Good Environmental Status of the European seas and oceans.

2.0 ORCHESTRA

Ecosystem responses to constant offshore sound spectra

Coordinator: Maarten Boersma, Alfred Wegener Institute for Polar and Marine Research (Germany)

The two most common sources of continuous anthropogenic noise are shipping, and more recently, offshore wind turbines or wind farms. In order to understand the impacts of offshore wind farms on the marine environment, all aspects need to be understood - both the potential positive effects in terms of reduced take zones and increased habitat availability, as well as the negative effects in terms of changes in sediment-water dynamics and those of exposure to the continuous operational noise. As the knowledge on the effects of noise on invertebrates is still very limited, especially in comparison to the other effects, there is an urgent need to create the fundamental knowledge base by combining laboratory-based experimental work under controlled conditions, using different key organisms, and field observations and experiments.

Orchestra will investigate the effects of continuous underwater noise on the physiology, growth, reproduction, feeding, intraspecific communication, predator avoidance and mortality of key invertebrate species in multi-stressor laboratory setups. Further, the project will evaluate the potential ensuing cascading effects on the function of those species in the ecosystem. In addition, it will assess the validity of the results obtained in the laboratory and complement them by using a combination of sampling and experimental studies in the field at different distances to continuous boat and offshore wind noise sources. The results from these experiments will be checked against existing invertebrate species distribution and abundance data sets. Further, understanding the combined effects of underwater noise with climate warming is particularly relevant as underwater noise propagation changes with temperature, salinity and pressure and animal sensory organs can be affected by temperature. The project will uncover the conservational relevance of underwater noise on invertebrate-based food webs in a warming environment. In laboratory settings, Orchestra will cross underwater noise treatments with temperature treatments, in order to assess how these stressors interact. This is particularly relevant given that most poikilothermic organisms react

strongly to changes in temperature, and higher temperatures may incur stress to those organisms, which could then be exacerbated by underwater noise in turn.

With that the objectives of ORCHESTRA are:

Objective 1

Evaluating the responses of selected invertebrates to continuous low-frequency noise. The response of individual organisms will be linked to physiological and behavioural response measurements. The molecular expression of genes associated with stress responses will provide information about the ecological performance or lifespan resulting from noise exposure.

Objective 2

Understanding how individual reaction norms of key species affect species interactions (predator-prey interactions), both in benthic communities, as well as in the pelagic zone, and shape invertebrate-based food webs and, in turn, biogeochemical cycles.

Objective 3

Predicting ecosystem consequences on larger scales, thus allowing the assessment of the impact of underwater noise on marine ecosystems and ultimately the prediction of potential implications in the age of 'Blue Growth'. Objective 3 will use the outcome of ORCHESTRA laboratory and field work and integrate this with existing literature and data sets about species distribution, plus abundance in the North Sea and Adriatic Sea soundscape/ noise maps that can be obtained from assessments of locations of offshore windfarms (OWF) and important shipping routes.

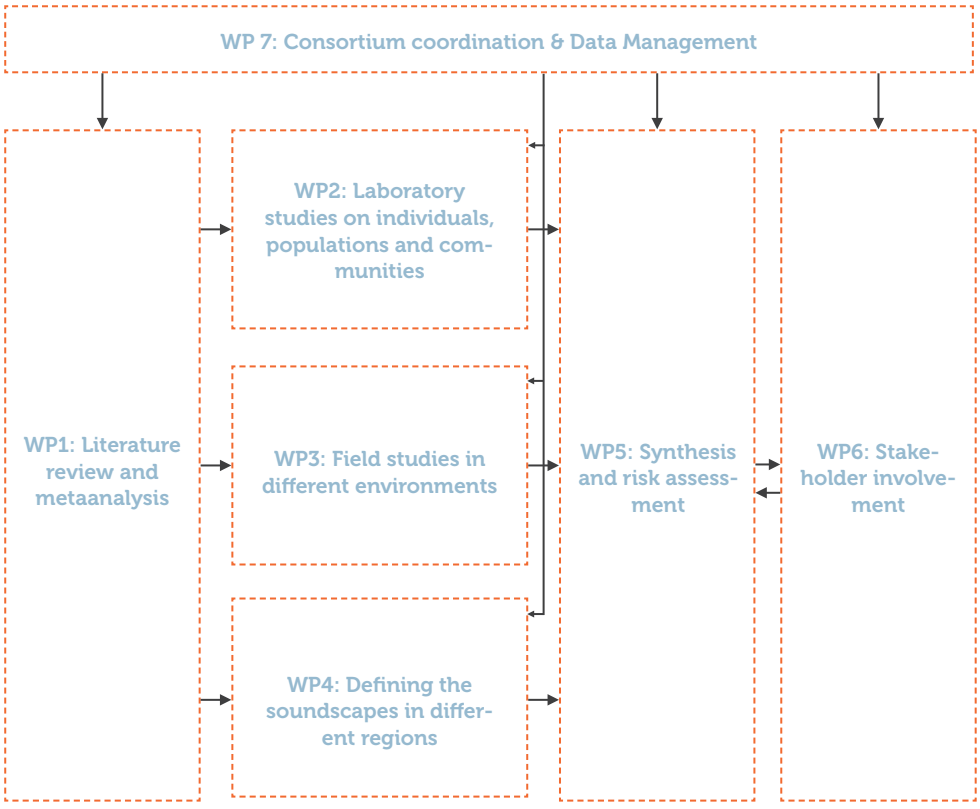

Figure 1. Overview Work Packages (WPs) of the ORCHESTRA consortium, and the information pathways between them.

PARTNERS

Organisation	Country
Alfred Wegener Institute for Polar and Marine Research	GERMANY
Christian-Albrecht University of Kiel	GERMANY
University of Padua	ITALY
Ghent University	BELGIUM
Norwegian Institute of Marine Research	NORWAY
National Research Council	ITALY

3.0 DEUTERONOISE

Characterization of maritime noise in different European basins and its impact on ecological relevant deuterostome invertebrates

Coordinator: Lucia Manni, University of Padua (Italy)

The DeuteroNoise project is focused on characterizing noise pollution caused by maritime traffic, both through measurements and simulations, and to test its impact on various species of marine invertebrates. There is a growing concern about the impact that noise from human activities can have on marine life and the health of the oceans. Noise coming from maritime traffic or drilling can affect marine ecosystems, and it is still poorly understood.

In noise research, there has been an almost exclusive focus on vertebrates, and information on invertebrates is very scarce. We do know that in vertebrates, noise affects the mechanoreceptor cells of the ear and can cause hearing problems, even deafness. Homologous cells have been discovered in tunicate marine invertebrates , raising the question of their ability to sense and, therefore, be affected by noise. The DeuteroNoise consortium, made up of seven partners from four European countries (Italy, Norway, Spain and Romania), will work to characterize noise pollution caused by maritime traffic and will measure its impact on various species of invertebrates. The latter are closely related to vertebrates (i.e., deuterostomes) and will be represented by hemichordates, echinoderms, cephalochordates and tunicates.

First, the DeuteroNoise project will measure maritime noise in situ at selected sites in the North Adriatic Sea, the Venetian Lagoon, the North Sea, the Black Sea and the coast of Barcelona in the Mediterranean Sea. Noise pollution will afterwards be modelled and simulated in laboratories, to test their effects on invertebrates' behavior, with special focus on their nervous system and sensory organs, their immune system, embryonic development and resilience. These animals are common in European seas and cover different levels of the food web, from holoplankton-meroplankton to sessile or sedentary primary consumers.

Behavioral, morphological, and genetic studies will be conducted on invertebrate animals living in areas affected by reproduced noise pollution versus unpolluted areas. In the final stage, the animals will be exposed to

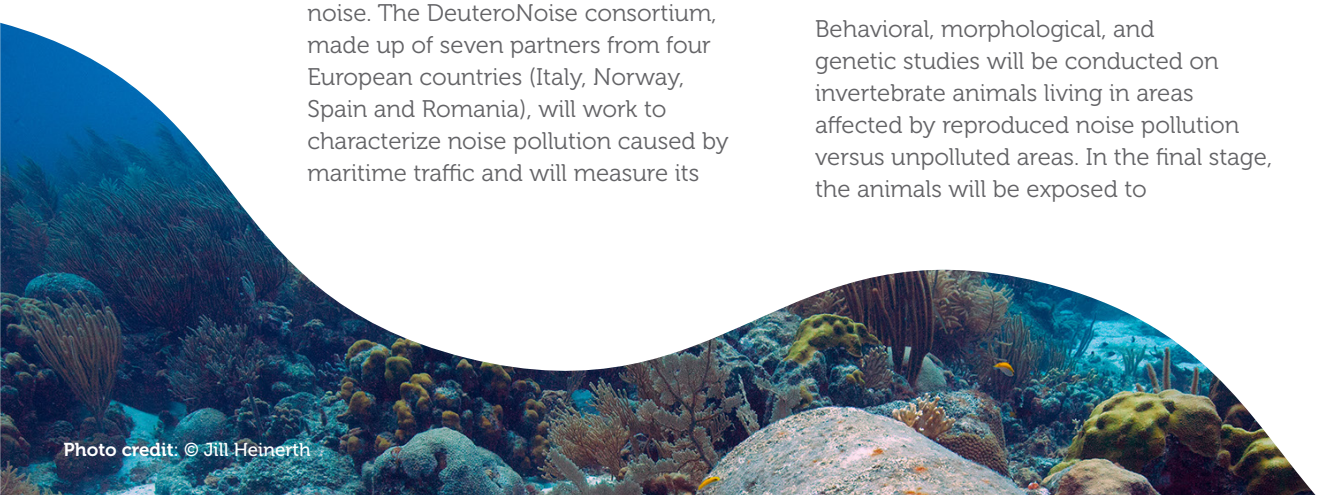

Photo credit: © Jill Heinerth

the gathered noise under controlled conditions in the laboratory, to check the effect on the larval, juvenile and adult stages at an individual and generational level. Comparative studies will:

- allow to highlight the origin of noise pollution – the potential noise sources - in the different basins;
- determine how species react to noise;
- identify morphological features and common genetic pathways that respond as adaptations to noise (the noisesome);
- predict sensitivities in closely related animals that cannot be easily studied in the laboratory or in situ;
- predict noise pollution, supporting future efforts in predicting ecosystem responses to anthropogenic noise and in developing policies to regulate it and infer best practices to achieve Good Environment Status (GES) of European sea basins.

Finally, DeuteroNoise has the aim to disseminate the knowledge in maritime noise pollution and its impact in invertebrates, raise the awareness from authorities, companies, children and teenagers and the society in general, in order to improve the protection of these areas in the future by means of the required policies.

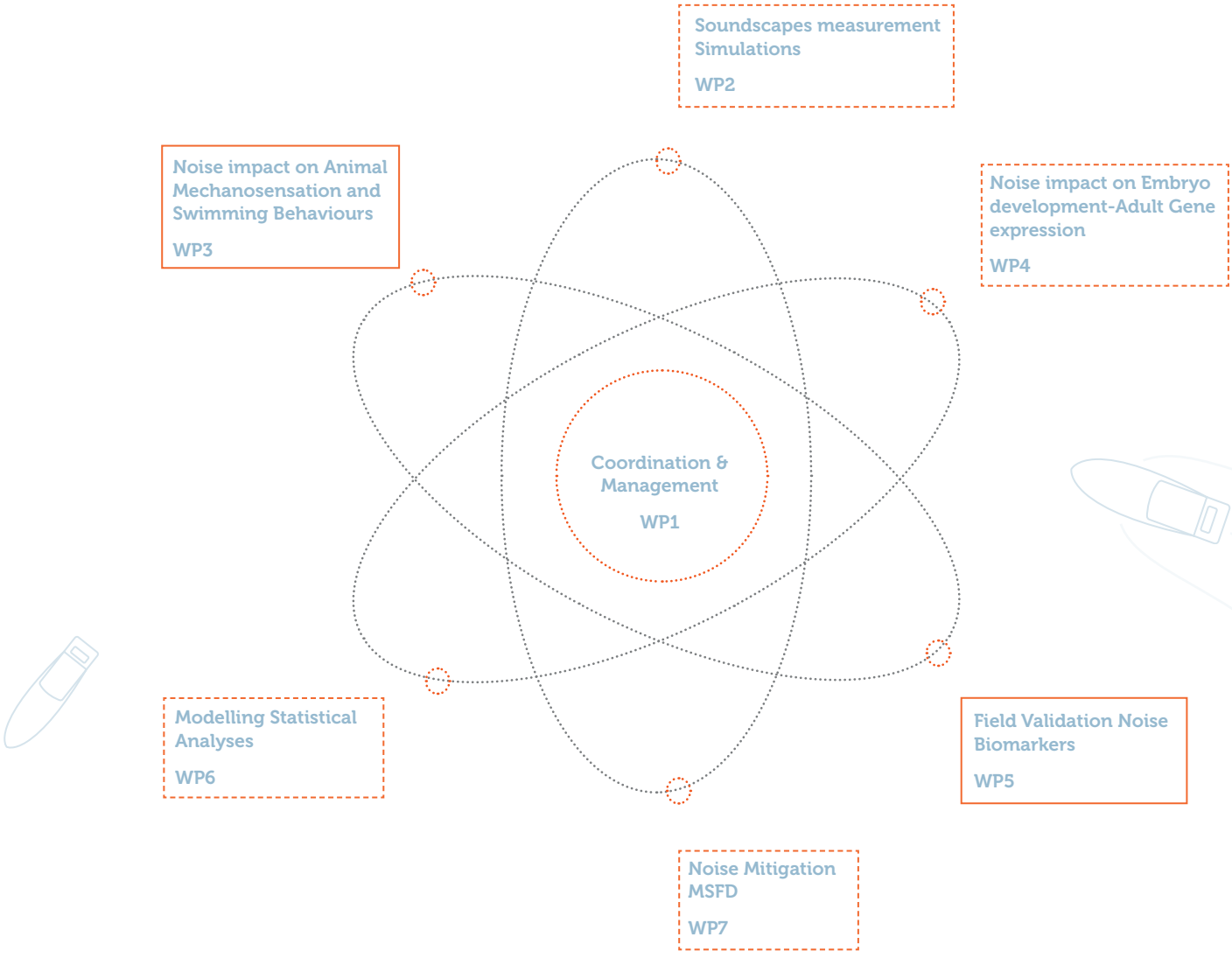

Figure 2. DeuteroNoise overview of Work Packages (WPs), consortium, responsibilities and tasks.

PARTNERS

Organisation	Country
University of Padua	ITALY
National Institute for Research and Development of Marine Geology and Geoecology – GeoEcoMar	ROMANIA
Anton Dohrn Zoological Station	ITALY
La Salle - Ramon Llull University	SPAIN
University of Milano-Bicocca	ITALY
University of Barcelona	SPAIN
University of Bergen	NORWAY

4.0 DIAPHONIA

Diagnostic framework to assess and predict the impact of underwater noise on marine species

Coordinator: Sandro Mazzariol, University of Padua (Italy)

In the European Union, the Marine Strategy Framework Directive emphasizes the severity of noise pollution in the marine environment and the need to understand and mitigate its impact on the ecosystem. The legislation covering the technical guidelines for underwater noise is rapidly evolving and is characterized by great variability at the national levels. There is an urgent need to identify tools which are validated scientifically and recognized by the authorities that allow the planning and execution of offshore prospecting and research activities respecting the environment in a sustainable and economic way.

Besides the increasing literature on the behavioral, physiological and pathological response to acoustic over-exposure, there are still relevant gaps and a lack of a multidisciplinary approach in investigations aimed to assess acute and long-term exposures considering both the single animals and populations. The difficulty of conducting analyzes on living organisms in the marine environment and the great diversification of sources of noise pollution lead to uncertainty about the extent and type of effects noise pollution has on marine fauna.

The main goal of DIAPHONIA is to fill existing gaps in the current knowledge regarding the impact of underwater noise on marine organisms of the food web, including invertebrates and commercial species, in different European basins. DIAPHONIA will develop a possible diagnostic fingerprinting approach composed of several tissue markers incorporating molecular, metabolomic and microscopic techniques in order to identify functional and morphological changes in the acoustic pathways of invertebrates, fishes and marine mammals. Additionally, the foreseen activities will explore the relationship between behavioural and cellular/molecular/organ effects of both long-term noise exposure of two commercial fish species in different European ocean basins, and short-term noise exposure in invertebrates and fishes, from micro- to macroscale. The project will gain insight into the morpho-functionality of the peripheral hearing apparatus in marine mammals and its role in defining the animal's acoustic sensitivity, by developing a standardised workflow for wave propagations in the

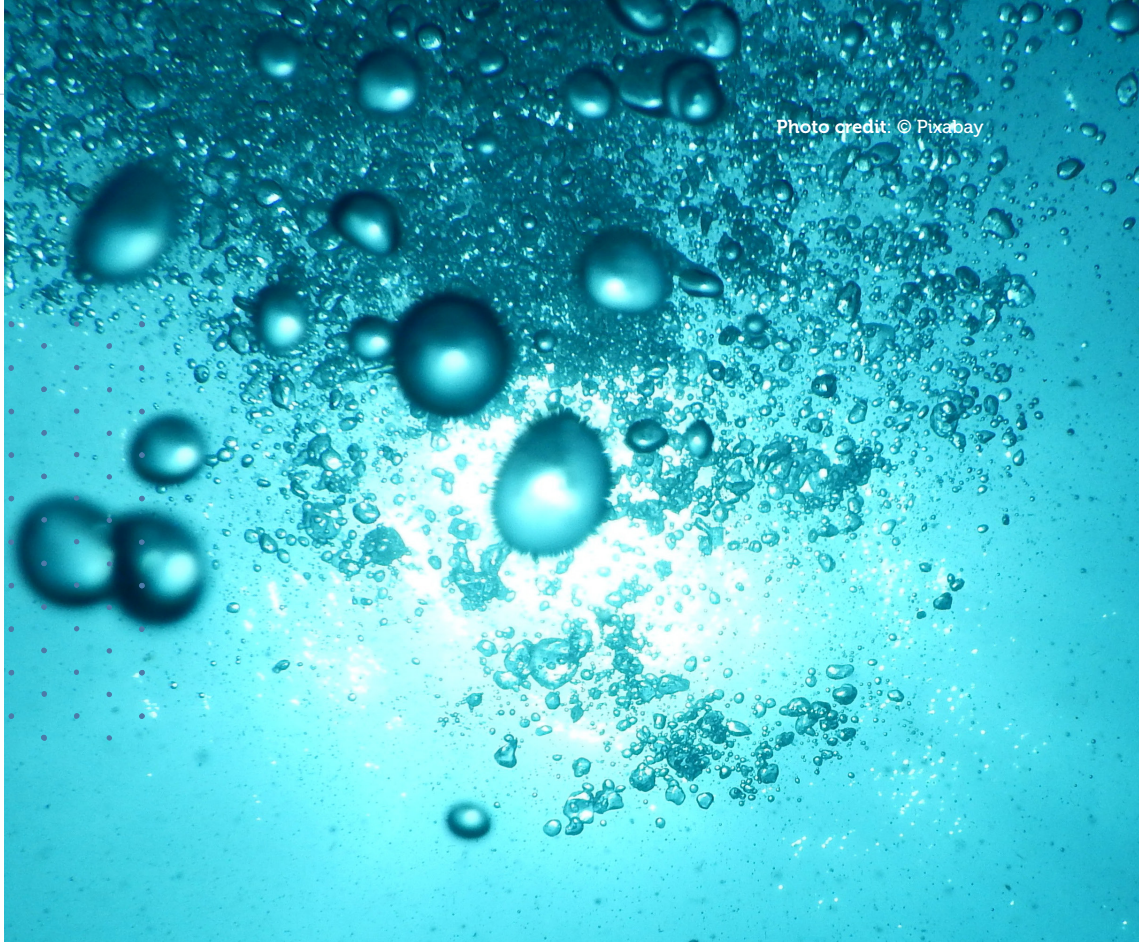
Photo credit: © Pixabay

associated tissues, to be extrapolated to other marine organisms. Finally, DIAPHONIA will develop an in-vitro system to support future studies on acoustic over-exposure by developing Induced Pluripotent Stem cells-derived organoids from stranded cetaceans and fish fibroblasts to recreate the auditory sensory organ leading to elucidate mechanisms of sound damages.

In summary, DIAPHONIA has the ambition to make substantial progress in various fields of expertise. The development of organoids, the implementation of new biomarkers and the development of a diagnostic approach to underwater noise impact will be brought from basic principles observed in the lab to validation in the field via different experiments. Linking behavioural with physiological responses will contribute a huge step forward for further understanding the underlying effects of noise on fish. Also, the development of 3D models helping to predict the impact of sounds in odontocetes species will lead to future application in the field, opening the way to predictive models.

PARTNERS

Organisation	Country
University of Padua	ITALY
Polytechnic University of Catalonia, BarcelonaTech	SPAIN
Norwegian University of Science and Technology	NORWAY
University of Veterinary Medicine Hannover, Foundation	GERMANY

5.0 SONORA

Filling the gap: Thresholds assessment and impact beyond acoustic pressure level linked to emerging blue-growth activities

Coordinator: Jaime Ramis Soriano, University of Alicante (Spain)

Emerging blue economy industries, such as marine aquaculture or seabed exploitation, have expanded in the last years. Related activities, such as shipping, construction of marine infrastructures or seismic campaigns are causing a progressive and more rapid increase of noise levels in the marine environment. Despite numerous studies conducted in recent decades on the impact of underwater noise on marine life, there is still a lack of both knowledge and methodological procedures, with often qualitative results. Likewise, even though most marine organisms, and in particular fish, detect sound primarily using particle motion, most of the studies performed up till now only address pressure field effects.

The SONORA project aims to deepen the knowledge about the relationship between particle motion and acoustic pressure fields to evaluate the impact of both variables on fish. In the project, noise generated by ocean-based industries, including opportunistic sources and seismic sources, will be characterised numerically and experimentally. A predictive monitoring system, based on modelling of noise sources and their propagation at sea, will be developed. The relationship between particle motion and pressure will be evaluated in situations beyond free field, considering shallow waters and reverberant environments. In addition, the project will investigate noise impact on fish in marine aquaculture facilities, both in indoor tanks and offshore aquaculture cages. Noise effects on commercial aquaculture fish species will be considered, focusing on behavioural and physiological impacts (biochemical parameters in blood or whole-body samples) on larvae, juveniles and adults. Not only commercial species, but also surrounding wild ecosystems around the cages will be considered. Based on the results and the knowledge acquired, quantitative thresholds of behavioural and physiological impacts on fish will be established and an acoustic risk matrix will be developed.

PARTNERS

Organisation	Country
University of Alicante	SPAIN
National Institute of Oceanography and Applied Geophysics	ITALY
Polytechnic University of Valencia	SPAIN
University of Palermo	ITALY
University of Trieste	ITALY

6.0 PURE WIND

Impact of sound on marine eosystems from offshore wind energy generation

Coordinator: Ana Širović, Norwegian University of Science and Technology (Norway)

PURE WIND is a consortium of eleven multidisciplinary partners from seven countries, Belgium, Germany, Ireland, Italy, Norway, Poland, and Spain, whose aim is to address the impact of sound from offshore wind energy generation on marine ecosystems. The project brings together acousticians, biologists, ecologists, oceanographers, and social scientists to expand knowledge of the radiating noise from these operations and their biological consequences and placing them in the appropriate regulatory contexts. From the acoustic side, key features of radiated noise from fixed and floating offshore wind farms will be quantified, to increase understanding and simulate cumulative effect of windturbine clusters on radiated noise. This effort will also help identify sensitive habitats across different soundscapes. Furthering the biological perspective, the project will identify how top predators use areas around operating offshore windfarms. The impacts of offshore windfarm noise on fish and zooplankton will also be studied. These efforts will advance knowledge of the effects of operational offshore windfarm noise across the food web.

Harmonising and combining acoustic and biological sides, PURE WIND will develop knowledge and tools for integration of all aspects of noise production and propagation from operational offshore windfarms to facilitate assessment of planned offshore windfarm expansion for spatial planning and environmental impact. Finally, relevant learnings and best practices from EU and international experiences with fixed offshore wind development will be synthesized and translated for application in the development of policy, mitigation, and regulation of floating and future offshore wind development within (inter)national and EU frameworks.

As part of the green shift, a substantial expansion in offshore windfarm infrastructure globally is expected. The data and approaches of the consortium will help facilitate this transition by providing knowledge necessary to minimize impacts of further industrialization of the offshore ecosystems on marine life.

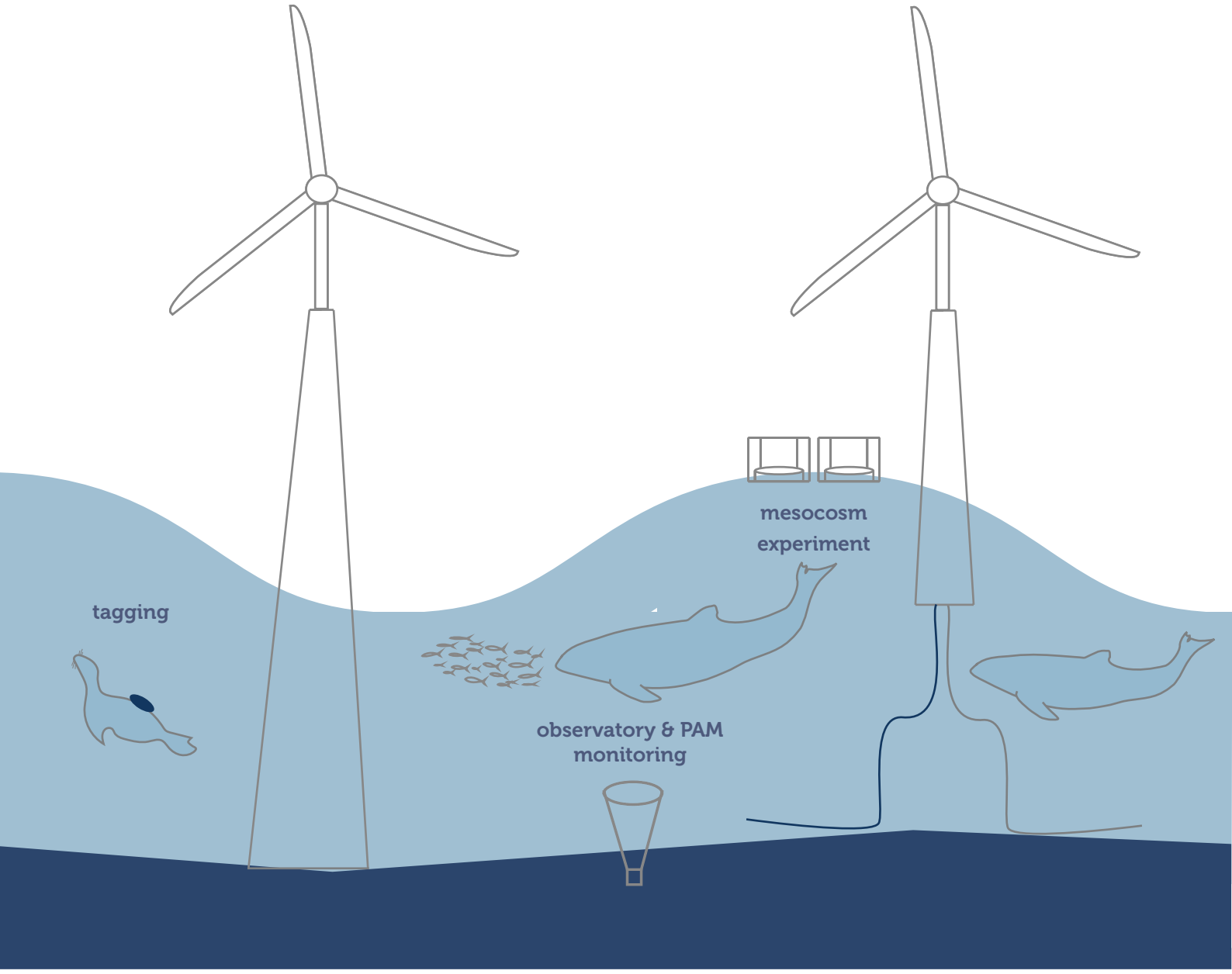

Figure 3. PURE WIND consortium will use varied approaches to study the impacts of offshore wind farm operations across the marine food web, and will synthesise learnings for application in policy, regulation and mitigation.

PARTNERS

Organisation	Country
Norwegian University of Science and Technology	NORWAY
National Research Council	ITALY
Oceanic Platform of the Canary Islands	SPAIN
Federal Maritime and Hydrographic Agency	GERMANY
Gavin and Doherty Geosolutions	IRELAND
Royal Belgian Institute of Natural Sciences	BELGIUM
University of Las Palmas de Gran Canaria	SPAIN
University of Genoa	ITALY
University College Cork	IRELAND
University of Veterinary Medicine Hannover, Foundation	GERMANY
Gdynia Maritime University	POLAND

JPI OCEANS

JPI OCEANS

Rue du Trône 4 I 1000 Brussels | Belgium
Tel. +32 (0)2 62616 60 I info@jpi-oceans.eu
www.jpi-oceans.eu