Politecnico di Torino

Ingegneria Energetica e Nucleare – Renewable Energy Systems
a.a 2023/2024
Sessione di Laurea Ottobre 2024

Novel approach for offshore wind siting using the Marine Strategy Directive Framework

Relatori:
Prof. Giorgi Giuseppe
Dott.ssa Chicco Carola
Ing. Moscoloni Claudio

Candidati:
Arianna Nicosia

Index

Figures Index

Table Index

Abstract

Italy is committed to achieving carbon neutrality by 2050; to do so a significant development of renewable energy capacity is needed. As it is known, wind energy production is one of the most efficient, hence, Italy, in the National Integrated Energy and Climate Action Plan (NIECAP), intends to reach 2050 goal of carbon neutrality by setting the intermediate target of installed wind capacity of 19.3 GW (including 0.9 GW offshore) to be reached by 2030. Therefore, a steep increase of wind energy production is expected, both onshore and offshore. As to offshore wind facilities, their environmental impact is yet to be fully understood. This study's aim is to provide a novel framework that individuates the principal pressures produced by an offshore wind turbine and the receptors that can be affected by them. However, the ultimate purpose of this analysis is to merge the technological and environmental aspect concerning an offshore wind turbine and identify the optimal site for its construction. To simplify the understanding of the process, it will be applied to a case study which is the Island of San Pietro (or Carloforte Island), located near the south-west coast of Sardinia. The analysis is articulated in multiple steps that bring to the identification of the most suitable area for the implementation of an offshore wind turbine. The first step is to identify the impacts and the factors that they might affect, to do so the Good Environmental Status descriptors, presented in the European Marine Strategy Framework Directive (2008/56/EC) and extended bibliographic research were used. Then the data regarding both the impacts and receptors were retrieved. At the same time, an analysis that explored the wind potential of the area under analysis was conducted on WasP 12 software. The analysis continued by processing environmental and technological data on QGIS software. The processed dataset was then used to carry out the CRITIC analysis, a multicriteria method which aims at finding the objective weights of the considered parameters. The first result was the creation of sustainability index, which identifies the most sustainable areas among the ones contained in the area of investigation developing an in-house environmental impact assessment. The sustainable areas are considered as ones where the implementation of an offshore wind turbine would have a less negative impact from an environmental point of view. The second result of this study is the suitability index, obtained with a second CRITIC analysis that included the sustainability index and the parameters concerning the technology aspect of the offshore wind turbine (the Annual Energy Production and the Bathymetry). Finally, the suitability index identifies the area having the optimal conditions for both the technology and environmental parameters. Hence, the most suitable area is the one where the offshore wind turbine should be placed.

Introduction

Climate change is heavily impacting the planet at different levels, one of the main causes for this modification is to be found in the rise of greenhouse gas emissions due to the energy production by the combustion of fossil fuels (Assandri et al., 2024). To achieve a sustainable development all renewable energy technologies' developments should run in parallel (Margheritini et al., 2012) and, among them, wind energy is indubitably necessary to reach that goal. In particular, the nations constituting the European Union aim to be climate neutral by 2050, meaning that their economies must have a net-zero greenhouse gas emissions, hence, the energy produced by means of fossil fuel combustion must be substituted by renewable technologies (European Commission , 2024).

Italy, being a member state of the EU, is also committed to achieving carbon neutrality for 2050 and must make considerable efforts to meet this target (International Energy Agency, 2023). Italy energy system has considerably changed since 2010, today the country's electricity mix includes mostly natural gas (accounting for 50% of the electricity production) and renewable energies: hydro is in fact the second-largest source of electricity (16%), followed by solar (9%), bioenergy and waste (8%) and wind (7%). Lastly, coal accounts for a 5% and oil for 3%, there is also a small share of geothermal energy (2%) (International Energy Agency, 2023).

Italy heavily relies on the importation of natural gas especially from Russia, in fact, Russian gas accounted for 41% of the total gas imported in 2021 (International Energy Agency, 2023). The conflict between Ukraine and Russia made the transition towards renewable energy technologies also a matter of energy security. In line with this, European Commission proposed the REPowerEU plan, which aims to decrease the dependency on Russian gas by increasing the share of renewables in the EU gross energy consumption to at least 45% by 2030. Therefore, a steep increase in the renewable energy sector is expected especially for photovoltaics (henceforward, PV) and wind technologies.

According to TERNA, 2021 the majority of the new PV capacity will be installed in the northern part of the country, while, due to the suboptimal wind conditions in these areas, wind capacity will be mostly developed in the southern regions and in the islands. Moreover, in the National Integrated Energy and Climate Action Plan (NIECAP) Italy outlines its goal to achieve an installed wind capacity of 19.3 GW (including 0.9 GW offshore) by 2030 (Ministero dell'Ambiente e della Sicurezza Energetica, 2024).

As said wind capacity in Italy would be mostly concentrated in southern regions and islands, in this optic, since just part of the country would be able to host this kind of facilities, it would be wise to understand where to locate them in order to reach the predicted targets both for onshore and offshore installations. In both cases, the siting search should consider multiple factors, like, for example, the energy yield of that area, as well as its natural significance or its proximity to a site where the produced energy would be used. Focusing on islands, in particular smaller Italian islands, due to a limited space for the implementation of renewable energy resources (henceforward, RES) on the mainland, wind farms can be mostly implemented offshore (Peñalvo-López et al., 2024) .

From these considerations comes the idea for the present work: this analysis aims to create a replicable framework that contributes to identifying a site for the implementation of an offshore wind turbine (henceforward, OWT). The framework combines both the environmental and technological aspects covered by wind turbines and the ultimate result would be the identification of a site in which these features reach an optimal combination. Doing so it would be possible to simplify the licensing process and speed up the administrative procedures which usually stall due to the lack of exhaustive environmental impact assessment.

Due to the growth that offshore wind technologies will have in future, developing a sustainable implementation of an OWT seems to be fundamental. By applying the methodology proposed in the present study, it is auspicial for offshore wind facilities to be less impactful for the marine environment, and more acceptable under a socio-economic point of view.

Considering the complexity of the analysis, it is deemed appropriate to articulate it in different steps: first, it is necessary to understand which are the environmental factors involved in the study and how to quantify the pressures they undergo. Abramic et al., 2022 affirms that it is not entirely clear what are the impacts of construction, operation, and decommissioning of offshore wind facilities and how they affect the marine ecosystems. On the other hand, any offshore project developed in Europe must be compliant with the EU Environmental Impact Assessment Directive (the initial version 85/337/ EEC and its amendments) which is the most widely used tool in the European countries (Josimović et al., 2021). However, this Directive covers the minimum requirements to be considered when developing an environmental impact assessment, and the aspects that it must identify, describe, and assess in an appropriate manner (Abramic et al., 2022).

Instead, the European Directive 2008/56/EC, the Marine Strategy Framework Directive, describes the so called "Good Environmental Status" (henceforward, GES) which must be achieved and maintained by applying the framework illustrated in the directive, which consists of eleven descriptors. Abramic et al., 2022 explores the applicability of the GES framework to an environmental impact assessment of an offshore wind farm. In the study, a GES checklist is created to help understand which factors to consider and the impacts they undergo.

Hence, in line with the work described by Abramic et al., 2022, the present study will be developed by observing the following steps: firstly, an overview of the state of the art of the known impacts produced by offshore wind turbines will be assessed, then, it will be followed by the illustration of all the GES descriptors, highlighting the ones that will be involved in the analysis. The GES descriptors are fundamental to understand both the pressures brought by offshore wind energy and the factors that must be considered when developing an analysis concerning the environmental impacts on a marine environment. Thus, it will be possible to understand which factors must be considered and, for each of them, a georeferenced dataset regarding their distribution over the area of interest will be retrieved. The dataset will be imported on QGIS software, an open-source software that deals with spatial information, hence with georeferenced data (QGIS, 2024). At the same time, also the impacts of the construction, operation, and decommissioning of an OWT will be assessed.

Once a dataset has been retrieved for each factor, it will be possible to group them creating a unique set that will be used to develop the subsequent steps of the analysis. In fact, despite the theoretical knowledge regarding how each factor is impacted by the turbine, to individuate an area favorable to the OWT construction, it is necessary to mathematically quantify the impacts. To obtain such results, it is firstly necessary to understand how much the factors weigh on the area under analysis, hence, how they are distributed over the region of interest. A process that gives as results the objective weights of multiple factors is the Criteria Importance Through Intercriteria Correlation (henceforward, CRITIC) method. Thus, by implementing the CRITIC method, the objective weights of the factors under analysis will be computed.

Moreover, a "Scale of Importance" will be created: its purpose is to quantify the relevance that the different impacts have on a specific element. With the Scale of Importance, it will be possible to quantify the relevance that a particular impact has on each of the elements. These quantifications will be fundamental to compute the factors' weighted averages.

Using Matlab, a programming language performing calculations with matrixes and arrays (MATLAB, 2024), by processing together the objective weights and the weighted averages of each element, it will be possible to obtain the first result of the analysis which is the sustainability index. This index combines the environmental factors and the impacts affecting them, so, it identifies portions of the area under study in which there are less environmental factors involved, thus, areas in which the construction of an OWT would be more sustainable.

As to the technical aspects concerning an OWT, the elements that will be considered are the bathymetry and the wind potential of the area under analysis. Thus, data regarding both the bathymetry and the wind potential will be retrieved, the latter will be successfully processed on WasP 12 software.

WasP 12 is a State-of-the-art software for wind resource assessment, siting and energy yield calculations for wind turbines and wind farms (Technical Univestity of Denmark , 2024). Using it will allow to compute the annual energy production of the turbine that will be chosen to be built in the area under analysis.

The last step needed for the identification of a suitable site for an OWT, will be the implementation of a second CRITIC analysis which will involve the sustainability index and the two technology's aspects. The result will be the suitability index which identifies the portion of the area under study that would be the most suitable for the construction of an OWT. Hence, the area in which the aspects regarding both the marine environment and the energy production reach their optimal combination.

However, the presence of multiple sustainable areas would imply another step, which would involve the establishment of a criterion able to choose one region instead of another. The criterion would involve the socio-economic impacts of an OWT, these kinds of pressures are usually linked to the distance between the facility and the coast. In particular, two factors will be considered: the intervisibility and the cost of the submarine cables, these two factors are, respectively, inversely proportional and directly proportional to the distance from the coast. In fact, the level of acceptability of an OWT increases when it is not visible from the coast, hence, when it is far from it (Moscoloni et al., 2024). Instead, the cost of the submarine cables increases with distance (Giglio et al., 2023). Thus, among all the suitable areas, the chosen one would be the region whose distance from the coast is optimal for both the intervisibility and the cost of submarine cables.

As said, this analysis is made to be replicable multiple times, however, to simplify the creation of the framework and prove the solidity of the method, it will be applied to a case study. It was decided to explore the feasibility of the implementation of an OWT in the waters surrounding San Pietro Island, also known as Carloforte Island. San Pietro is one of the two principal islands of the Sulcis archipelago, and it is located in the south-western part of Sardinia (LAT 39°08′26″ N, LONG 8°16′01″ E) (E. Giglio, 2023). It extends for 51.10 km² and covers a perimeter of 33,34 km, it has a trapezoidal shape with a maximum length of 10.5 km and a maximum width of 8 km (E. Giglio, 2023).

The choice of a small island is not accidental, in fact, the implementation of RES has a complex development due to the lack of space on the mainland. Hence, it is usually necessary to implement these technologies offshore. San Pietro, in particular, aims to reach the total decarbonization in a short time, imposing 2050 as the maximum temporal target (E. Giglio, 2023). To do so, the island's future energy system must be characterized by a high RES penetration and a technology mix that exploits different resources (E. Giglio, 2023). The principal sources that can be exploited are solar radiation and wind. The former is particularly favored by the geographical position of the island, this makes San Pietro one of the locations with the highest potential in Italy (E. Giglio, 2023). As to the wind resource, Carloforte is exposed to high wind forces, in fact, the mean wind speed measured at 50 m above the ground has a value of 8 m/s.

Moreover, due to the high presence of wind resource, a growing interest has risen for Carloforte, in fact, an offshore wind farm has already been planned approximately 36 kilometers away from San Pietro's western coast, it is called "Ichnusa Wind Power". The project has not received a full approval yet.

Furthermore, Carloforte is an island with a relevant environmental value, in fact, almost the whole territory is classified by Natura 2000 network as "Site of Community Importance", thus, a site which contributes to the maintenance or restoration of a favorable conservation status of natural habitats (European Environment Agency, 1992). The sites of community importance can be distinguished in: "Special Conservation Interest" (henceforward, SCI) and "Special Protection Areas" (henceforward, SPA). SCI are areas given special protection thanks to EU Habitat Directive, while SPA are designated under EU Bird Directive, which aims to provide conservation measures to particularly important species.

As to Carloforte's protected sites, SCI cover most of the territorial extension of the island and part of the marine space surrounding San Pietro (E. Giglio, 2023). SPA are concentrated, instead, in the north-western part of the island (E. Giglio, 2023). Thus, the choice of San Pietro as case study for the present analysis is further strengthened by the naturalistic significance that the island has. In fact, the island would need a detailed environmental impact assessment to allow the construction of an OWT near Carloforte's perimeter.

What was briefly introduced in this chapter will be thoroughly described in the following paragraphs.

1.1 Offshore wind impacts: State of art

Offshore wind sector has been rapidly expanding since 1991, being a relatively young technology, its long-term effects are yet to be discovered (WWF- France, 2019). Offshore wind facilities have impacts both on the marine ecosystems and on offshore human activities, the effect they provoke can be both positive and negative. Therefore, it is necessary to understand which are the receptors impacted by the stressors brought by an offshore wind facility.

Figure 1-1 shows a simplified representation of the pressures that offshore wind farms have on the environment. The lifecycle of an offshore wind facility is divided in three phases: construction, operation and decommissioning. Each phase has different impacts acting on different time scales. Construction and decommissioning can last from few days to some weeks (Chitteth Ramachandran, 2022) while operation lasts for about 25-30 years (Liu et al., 2019). Construction and decommissioning have similar impacts, although decommissioning operations usually take less time to be completed. Each of the operation composing the three phases brings pressures to the environment each causing different impacts (see Table 1).

Pressure	Impact	Taxonomic group/ habitat
Cable laying	Habitat loss Physical damage disturbance	Habitats Benthic communities
Submerged Structures	Reef effect	Habitats Benthic communities Fish
Underwater operation cables	Electromagnetic fields Temperature increase	Habitats Benthic communities Sea turtles Fish
Ship traffic/presence Ship noise	Physical damage, disturbance Collision/ displacement	Marine mammals Birds
Operating wind turbines	Collision Barrier effect	Birds
Waste and pollution	Habitat degradation, disturbance, physical damage	All taxonomic groups and habitats

Table 1- Pressure and Impacts (WWF- France, 2019)

Each stressor brought by offshore wind has different effect depending on the receptor perceiving them, it can have a negative, positive or neutral response. Since there are multiple taxonomic groups undergoing the impacts, their behaviors will be analyzed in the following paragraphs.

Figure 1-1- Understanding the impacts on different species (Galparsoro et al., 2022)

1.1.1 Impact on benthic habitats and communities

The stress on benthic habitats[1] and communities derives from different factors, these are the turbines' foundations, the associated infrastructures, scour protection[2] and cable laying (WWF- France, 2019). The magnitude and permanence of these impacts change based also on the characteristics of the seabed: depending on the location, sensitive habitats might be destroyed, thus, choosing a less endangered site would cause minor damage (WWF- France, 2019). Particular attention should be paid to seagrass meadows and coral reefs: both highly sensitive to direct physical destruction and sedimentation changes in hydrographic regimes (WWF- France, 2019).

1.1.2 Impact on fish

Fishes communities are impacted by offshore turbines on different levels: during construction and decommissioning phases the noise originated both from the vessels and the pile driving might cause hearing loss, injuries and changes in behavior (WWF- France, 2019).

As to the operation phase the principal stressors are electromagnetic fields (henceforward, EMF), turbine noise and mooring noise, while there is also a positive impact, the reef effect. For what concerns EMF it seems that some species can detect it: it is known that many elasmobranchs[3]' species possess an electro sensory system known as the Ampullae of Lorenzini (Normandeau Exponent T. Tricas and A. Gill., 2011). Elasmobranchs have shown high sensitivity to high frequency alternating electric fields (from 1 to 10 Hz), this implies that they have low or null sensitivity to the low frequency EMF (50 Hz), which is created by the alternating current flowing in submarine cables (Normandeau Exponent T. Tricas and A. Gill., 2011). Conversely, both sharks and rays are sensitive to standing EMF field created by direct currents. EMF impact elasmobranchs' migration path over short distances by affecting their feeding behavior: sharks, especially, use their electro sense to detect preys which have a natural EMF (usually at 10 Hz).

---

[1] Benthic habitats are the ecological regions located at the lowest level of a body of water.
[2] Scour protection refers to the measures taken to prevent the erosion around structures fixed on the seabed.
[3] Elasmobranch fish are cartilaginous fishes including sharks, rays, skates and sawfish. These fishes are characterized by a skeleton made of cartilage rather than bone (earthlife, 2023) .

As to bony fishes, such as, for example, Atlantic Blue Fin Tuna (*Thunnus Thynnus,* Linnaeus 1758), there is no evidence of their electro sensitivity or magneto sensitivity. Normandeau Exponent T. Tricas and A. Gill., 2011 show that Yellow Fin Tuna (*Thunnus albacares* Bonnaterre, 1788) is magneto sensitive with a sensory range that goes from 10 up to 50 µT, where 50 µT is the Earth's electromagnetic field. Being Atlantic Blue Fin Tuna and Yellow Fin Tuna similar, it can be supposed that also Atlantic Blue Fin tuna is able to detect the same magnetic field.

The installation of an offshore wind facility would be rapidly followed by a colonization of all submerged parts by a variety of fouling organisms (Rezaei et al., 2023), this phenomenon is called "reef effect". The former is a beneficial impact that the artificial hard substrate provides, creating artificial habitats for marine organisms (see Figure 1-2). The union of this phenomena with the decrease of fishing areas, now occupied by the offshore facility, can bring benefits to the fish population. Therefore, offshore turbine reefs positively draw fish species with both rocky habitats preferences and sandy environments preferences (Rezaei et al., 2023).

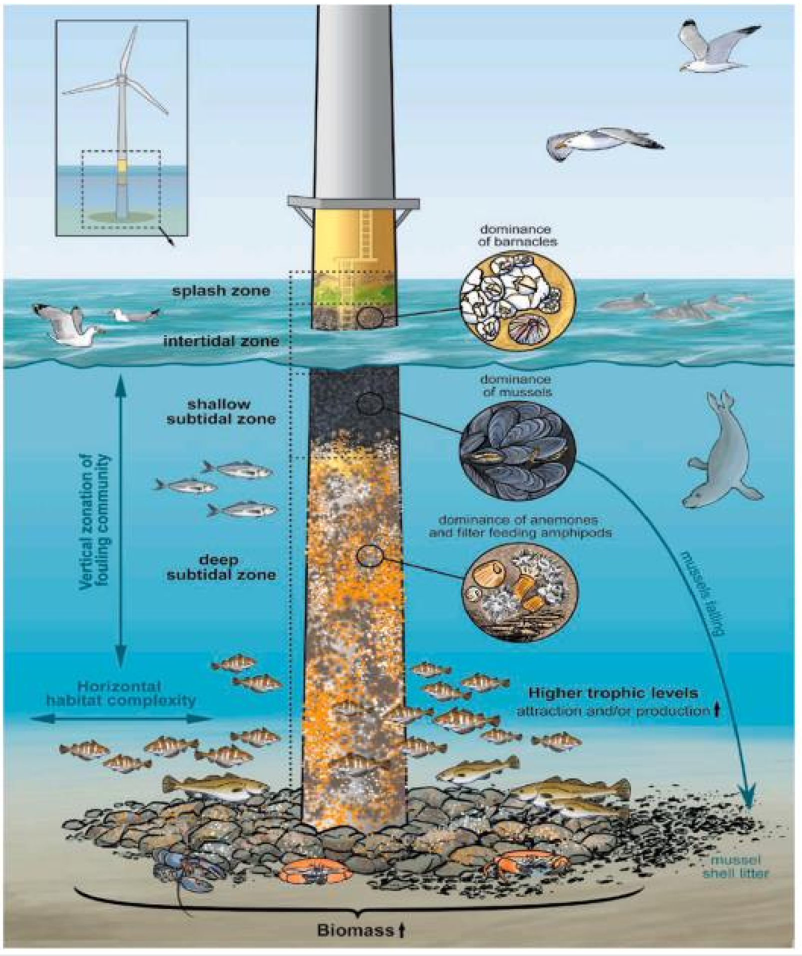

Figure 1-2- Reef effect provided by fixed bottom wind turbine[4] (Rezaei et al., 2023)

1.1.3 Impact on marine mammals and sea turtles

The most significant impact on marine mammals is given by anthropogenic underwater noise, it can cause communication alterations and hearing damage (WWF- France, 2019). Construction noise can be reduced by choosing foundation types requiring limited pile driving activity (like floating foundation)[4]. On the other hand, floating foundations might generate underwater noise from their floating platforms moving on swells and from the chain that might constitute their anchoring system.

[4] The difference between fixed and floating bottoms will be explained in paragraph 2.2

As to electromagnetic field impact, M.Klinowska, 1985 suggests that cetaceans can sense the geomagnetic field and use it during their migrations. Evidence suggests that also marine mammals are sensitive to changes in magnetic fields (Walker et al., 2003), in fact, during their migration, a change in swim direction or longer detour can happen depending on the magnitude and persistence of the field (Gill & Kimber, 2005).

As to sea turtles there are not enough information of their sensitivity to anthropogenic noise, on the other hand, evidence suggests that also sea turtles are able to detect magnetic fields (Normandeau Exponent T. Tricas and A. Gill., 2011).

A significant risk for both marine mammals and sea turtles is created by the presence of the submerged part of the turbine and the moorings that might be needed to fix the structure. The former can cause the collision of species with the structure or their entanglement in the moorings. The first can cause injuries, disorientation of the individuals or, at worst, their death, the second can also create injuries and the incapability of the individuals to disengage which can lead to starvation, hence, death (Andrea Copping, 2023).

1.1.4 Impact on birds

The interactions between birds and wind turbines were divided in five typologies (Dierschke et al., 2016):

- Strong avoidance: total absence or strong diminish in the abundance in the turbine facility area
- Weak avoidance: less abundance of species presents in the turbine facility area compared to the prior state
- Indifferent behavior: no wind farm effect, species behavior does not seem to be impacted by the turbines' presence
- Weak attraction: the turbine facility area is used by a higher number of species
- Strong attraction: high increase in the number of species using the turbine facility area compared to a prior state of little use of the latter

Criterion	**Strong avoidance**	**Weak Avoidance**	**Indifferent behavior**	**Weak attraction**	**Strong attraction**
Significant change in numbers	Decrease>50%	Decrease<50%	Parallel trends inside and outside wind farm	Increase <50 %	Increase > 50%
Non-significant change in numbers	Decrease>80%	Decrease>50%	Change < 50%	Increase >50%	Increase> 80%
Distance of effect	Significant avoidance > 2 km	Non-significant avoidance > 2 km		Non-significantly increased utilization> 2km	Significantly increased utilization> 2km
Distribution pattern at wind farm	Obvious lack of presence in the designated area	Less obvious lack of presence in the designated area	No distribution gap in the designated area	Less obvious concentration in the designated area	Obvious concentration in the designated area
General occurrence	Complete disappearance following formerly high density	Nearly complete disappearance following formerly moderate or low density	No change in occurrences		Numerous occurrences following formerly low density or absence
Behavior when flying at wind farm	Macro avoidance 50-100%	Significant or obvious avoidance if entering the turbine facility area	No reluctance to enter wind farm		
Comparison to reference area		Significantly higher density in reference area		Significantly lower density reference area	
Reason for change in			Change in abundance demonstrably or vary		

abundance at wind farm			likely not to related to wind farm		
General results			No criteria for avoidance or attraction fulfilled despite relevant study conducted		
Contradictory results			Contradictory results in diverse studies at a given farm		

Table 2- Birds spatial behavior towards offshore turbines (Dierschke et al., 2016)

One of the most dangerous impact that a turbine can have on birds is the collision of the individuals on the turbine's structure. The causes of collisions are multiple and strictly connected, there is not one particular factor determining the phenomenon (Marques et al., 2014). Marques et al., 2014 divides them into three macro groups: species-specific factors, site-specific factors and wind farm-specific factors.

The species-specific factors comprehend:

- Morphological features: their size was found to be collision risk determinant (Janss, 2000). The explanation is linked to the use of thermal and orographic updrafts that large birds need to gain altitude.
- Sensorial perception: birds' visual is superior to other vertebrate; some species have relatively small binocular field, moreover, some birds tend to look downward when in flight searching for food.
- Phenology: it was shown that resident birds of prey are more prone to collision than migrating birds of the same species. The answer is found in how they are more likely to cross the turbines area rather than migratory birds (Karen L. Krijgsveld, 2009).
- Bird behavior: for example, flight type, sex and age seem to play an important role in collision risk. As to flight type, hunting and foraging strategies as well as high flight altitude, determine a higher hazard (Marques et al., 2014).

The site-specific factors are:

- Landscape features: steep slopes, valleys and shorelines might be frequently used by some birds during hunting or migration (Marques et al., 2014)
- Flight paths: building turbine in areas crossed by many birds increases the risk of collision
- Food availability: reef effect enhances the presence of food (Marques et al., 2014)
- Weather: strong winds might affect the capability of birds to control their flight or might reduce the visibility (Marques et al., 2014)

The wind farm-specific factors comprehend:

- Turbine features: higher tower have a larger rotor therefore a larger collision risk area
- Blades' visibility: it can be decreased due to their rotation, in fact, the latter causes motion smear effect, meaning that the brain is not able to process the moving object that appears blurred or transparent (Marques et al., 2014).
- Wind farm configuration: Hötker et al., 2005 demonstrated that the risk of collision increases if the turbines are disposed perpendicularly to the main flight path

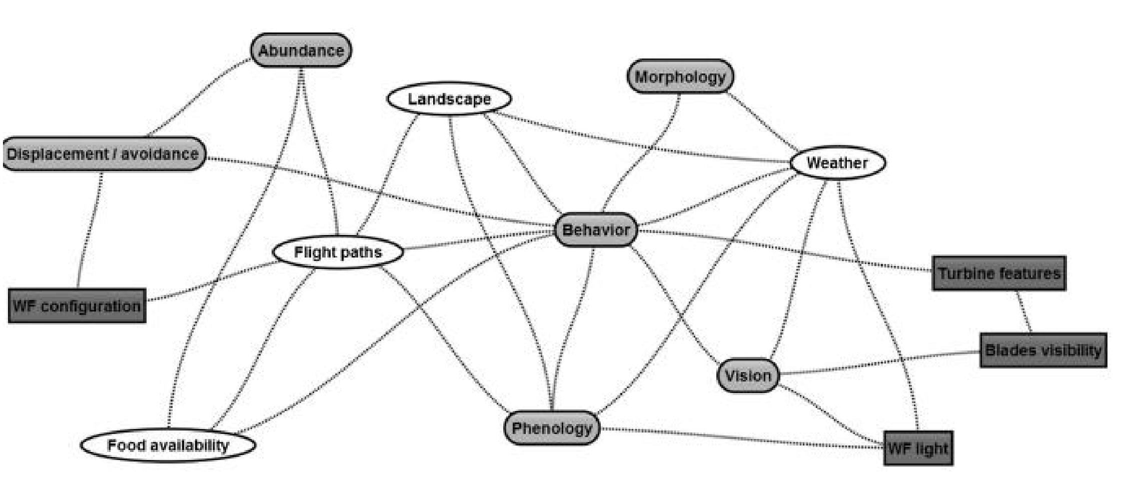

Figure 1-3 Interconnection of the factor affecting collision risk (Marques et al., 2014)

Figure 1-3 helps to understand how the abovementioned factors are strictly interconnected, therefore, to avoid the risk of collision these parameters must be considered in their entirety. The construction of a wind energy facility is incompatible with the abovementioned scenarios, if the area chosen to host a wind farm presents one of those characteristics, then mitigation measures must be adopted. Marques et al., 2014 divides the mitigation measures in three macro groups: avoidance, minimization and compensation.

- Avoidance: the presence of at-risk species, or of habitat necessary for their survival, must be protected, hence, the construction of wind turbines is incompatible with the previous scenarios. An alternative is considering the repowering of an already existing wind farm, as its presence is already known to the species.
- Minimization: the avoidance measures might not be sufficient as the risk might persist, hence, it is important to minimize it. A minimization measures can be the turbine shut down on demand which consists of the implementation of a real-time monitoring system that can shut down the turbine whenever a dangerous situation occurs. A stricter version of the previous method consists in scheduling some inoperable periods (hours, days or months) during which the turbine must not operate. Less drastic methods are, for example, the habitat management (reduction of food availability in the turbine area and creation of another habitat in another territory), the increment of the turbine visibility or the use of ground devices or deterrents that diverts or distract birds from their flight path.
- Compensation: if the first two steps fail, this is the last resource. It can be achieved through enhancing the number of birds (actions on biological parameters that influence population levels) or reducing other impacts by acting on other human activities that limit the bird populations.

Offshore wind farms (henceforward, OWF) bring multiple pressures to both to the marine environment and to the socio-economic context in which they are developed, hence, it is necessary to establish a framework that helps to identify them and quantify their impact. As Josimović et al., 2021 affirms, the most widely used tool in Europe to develop an Environmental Impact Assessment (henceforward, EIA) for the projects developed offshore is the EU EIA Directive (the initial version 85/337/ EEC and its amendments). This regulation aims to establish the minimum requirements that need to be considered when developing and EIA, however it is vague: by applying it there is a risk of overlooking important environmental components (Abramic et al., 2022). On the other hand, the European Directive 2008/56/EC (the Marine Directive) introduces the Good Environmental Status (GES) descriptors, which aim is to preserve the marine environment, they will be described in the following paragraph.

1.2 Good Environmental Status

The European Commission introduced the concept of "Good Environmental Status" (henceforward, GES) in the Marine Strategy Framework Directive (European Commission, 2024), which purpose is to protect the marine environment from unsustainable practices and multiple pressures from human activities. GES concept is expressed through eleven descriptors concerning both the biodiversity and the anthropogenic pressures. Determining GES implies setting a quality scale, which must be based on the latest scientific data available (European Commission , 2024).

Table 3 summarizes the eleven descriptors (from D1 to D11) and for each describes potential environmental issues, possible mitigation measures and recommendations on the data collection. All the abovementioned suggestions are correlated to the implementation of an offshore wind turbine (henceforward, OWT), thus to the impacts that it would have on the marine environment.

GES descriptor	*Potential environmental issues*	*Impact mitigation measures*	*Spatial data requirements and survey recommendations*
D1: Marine Biodiversity	The species long-term viability and habitat conservation should be ensured	Avoidance of the mating areas and of protected habitats	Research for each animal species and habitat
D2: Non-Indigenous species (henceforward, NIS)	OWT can provide new corridors for NIS especially during operational and decommissioning phases	Assessment of the NIS already present and avoidance of the areas where the already present quantity of NIS is high	Staff training to differentiate between local and potential NIS species.
D3: Commercial Fish and shellfish	Fisheries stock can be impacted by OWF especially during operational and decommissioning phases	Avoidance of the fisheries areas	Study of the implementation of aquaculture within the OWT
D4: Food webs	Specific food webs might be impacted by species mortality or by demographic modifications especially during operational and decommissioning phases	Further research is needed	In situ surveys
D5: Eutrophication	OWT can favor anoxia due to changes in currents regime and accumulation of biomass	Avoiding the areas already rich in nutrients and semi-enclosed water bodies	In situ surveys
D6: Seabed integrity	Impact on the physical, chemical, and biological features of the seabed	Choosing the right seabed (mud, sand) and preferring floating OWT rather than bottom fixed	Survey of physical and chemical features of the seabed
D7: Hydrographical conditions	OWT can increase turbidity and underwater cables might change water temperature	Further research is needed	Experimental modeling
D8: Contaminants	Contamination due to metal release of OWT submerged structures	Use of coating over the metallic submerged structure	Contaminants survey in the water column, seabed, and filtering organisms that colonize the artificial structures
D9: Contaminants in seafood	Further research is needed	Further research is needed	Further research is needed
D10: Marine litter	Marine litter concerns the presence of the substructure	Consideration whether the foundations should be left or removed	Marine litter survey and assessment prior to construction and decommissioning
D11: Energy, including underwater noise	Disturbance of marine species behavior due to energy use: heating and electricity systems, artificial lighting, noise, and EMF	Strategic avoidance of the areas where sensible species might be impacted	Analysis distribution ranges of sensible marine species and noise monitoring

Table 3- GES list (Abramic et al., 2022)

Abramic et al., 2022 explores the applicability of GES descriptors to guide the EIA of an OWF, his aim consists of the understanding of the main pressures and impacts OWF may extern on the marine environment. To do so he analyses each GES descriptor and creates an EIA-GES checklist to comprehensively systematize the information acquired on the impacts brought by OWF during its life cycle (construction, operation and decommissioning).

To follow the trail set by Abramic et al., 2022, the descriptors will be now analyzed by listing their properties and their involvement in the present analysis will be explained (see below)[5].

1.2.1 D1: Marine biodiversity

The normative says that "Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions" (European Commision, 2024). Marine biodiversity covers all types of marine flora and fauna species, including birds, mammals, elasmobranchs etc. The term also includes all types of habitats both pelagic and benthic[6]. However, the benthic habitats are also included in descriptor 6. This is by far the most important descriptor to consider when performing an EIA for an OWT. Biological biodiversity includes, in fact, all kinds of species and, as seen in paragraph 1.1, the pressures that an OWT brings are of different typologies and have different effects depending on the species perceiving them.

As to the application of D1 descriptor to the present study, bibliographic research was carried out to understand which of the abovementioned species and/or habitats were present in the area under analysis. It was important to understand which species inhabit the perimeter area, and which the migrating ones that can either be passage migrant or seasonal residents on the island. The species whose presence was investigated will be shown in Chapter 0.

1.2.2 D2: Non-indigenous species

Non-indigenous species (henceforward, NIS) are species introduced in areas different from their distribution ones. They can become 'invasive' when they threaten marine biodiversity (ISPRA, 2024).

D2 descriptor says that "NIS species introduced by human activities are at levels that do not adversely alter the ecosystem", therefore, it must be assured that no new NIS are introduce in the marine ecosystem, through human activity (European Commission , 2024), moreover, those already present must be controlled. In case of OWT construction, NIS can be brought through the vessel needed in the phases of construction and decommissioning as well as through the material composing the turbines' installation.

The present analysis is concentrated only on studying which NIS is already present in the area considered to assess the potential risks of their further spread. In "Annuario dei dati ambientali della Sardegna" NIS presence is studied in the coastal waters surrounding the island, it is done by monitoring three different regions: port of Olbia, gulf of Oristano and gulf of Cagliari (ARPA Sardegna, 2022). Other data come from the sampling analyses done in areas close to Cagliari, Villasimius, Oristano, Alghero, Porto Torres, Olbia e Arbatax (ARPA Sardegna, 2022). The monitoring area closer to San Pietro Island is port of Olbia where NIS presence was almost 11% of the total samplings done to perform the analysis. Hence, considering the relatively small quantity of NIS reported and the low precision of the monitoring data for the present analysis, it was decided not to include NIS monitoring in the current study. In fact, the distance between the port of Olbia and Carlorte is not negligible: data retrieved from the former are not directly applicable to the latter, thus, in situ analyses would have been necessary to include illustrative data in the analysis.

[5] It was not always possible to set a distinct separation between the different descriptor, some are highly interconnected, and some are embedded in other descriptors.
[6] Pelagic habitats are all the habitats in the water column.

1.2.3 D3: Commercial fish and shellfish

As to commercial fish and shellfish the directive imposes the safety in terms of biological limits “exhibiting a population age and size distribution that is indicative of a healthy stock” (European Commision, 2024).

In the present analysis, D3 was applied to the commercial fish present in the area that is the Atlantic Blue Fin Tuna *(Thunnus Thynnus*, Linnaeus 1758) and, in particular, to the fisheries in which this species is exploited, the traditional “Tonnare”. These are traditional tuna traps, and their preservation must be guaranteed: Atlantic Blue Fin Tuna stock must not be affected by an OWT, and the space occupied by the traditional facilities must not be occupied.

Hence, the preservation of Atlantic Blue Fin Tuna is already included in D1, while the conservation of the traditional tuna traps and their functioning is linked to this descriptor. As specified in paragraph 2.1.2, data regarding the position of the tuna traps will be retrieved, and their preservation will be guaranteed by excluding their location from the possible sites for the OWT construction.

1.2.4 D4: Food webs

D4 reports that all the elements constituting marine food webs[7] must occur at normal abundance and diversity, assuring the abundance of the species depending on them. As to the present analysis, D4 is implicitly embedded in D1 and D6, as it implies the conservation of marine species and the preservation of benthic habitats and beings.

1.2.5 D5: Eutrophication

The descriptor regards human-induced eutrophication, it highlights the need to keep it at its minimum. Eutrophication is a process “driven by the enrichment of water by nutrients” (European Commission , 2024), which can lead to an oxygen deficiency in deeper water (anoxia). The cautions that must be taken in order not to increase the level of eutrophication are for example to avoid areas where eutrophication levels are already high due, for example, to the present of marine flora. OWT would certainly enhance eutrophication levels, in fact, as any structure introduced in sea water, it would foster the growth of fouling organisms and marine flora which would contribute to create an oxygen deficiency (Rezaei et al., 2023).

Due to the lack of data on the eutrophication levels of the area under analysis, it would have been impossible to include this descriptor in the present study. In situ analyses are needed, in this way it would be possible to monitor the changes in oxygen levels of the area and mitigate their effects.

1.2.6 D6: Seabed integrity

This descriptor deals with the integrity of the seabed and the preservation of benthic habitats, both must not be adversely affected. D6 identifies some of the most impacting human activities, among these there are: mining of sand and gravel, chemical and plastic waste, renewable energy operations and laying of submarine cables pipelines (European Commision, 2024).

As to the present study, detailed information regarding the benthic communities of the study area were lacking. However, it is known that hard seabed habitats are constituted for benthic communities with a higher complexity than the ones inhabiting sandy habitats (Siwabessy et al., 2018). To include the D6 in the current study, seabed conditions of the area around the perimeter of San Pietro were considered, and sandy environments were preferred to rocky ones. This aspect will be deepened in paragraph 2.1.3.

1.2.7 D7: Hydrographical condition

D7 concerns the physical parameters of seawater, such as temperature, salinity, depth, currents, waves and turbidity (European Commission , 2024). Some human activities can permanently alter these conditions affecting the marine ecosystem, the present descriptor was created to prevent this.

[7] Food webs comprehend all the food chains in an ecosystem (National Geographic , 2024)

An OWT can cause vertical mixing effect, generating upwelling effects reaching up to 1 km (Rezaei et al., 2023). Christensen et al., 2014 showed that the hydrographic changes can be generated by two distinct effects: the first is the slowing of the mean wind speed, the second the wave energy loss due to the contact between the structure and the water. The consequences of these effects are diverse, among which there is the increase of turbidity. Water turbidity might disturb seabirds while fishing; on the other hand, it positively impacts fish communities whose predation is reduced (Rezaei et al., 2023). Moreover, turbidity does not appear to impact sandy benthic organisms although further research is needed (Rezaei et al., 2023).

Among the hydrographical condition, seawater temperature can vary due to OWT, more specifically, due to the submarine cables transporting electricity. Temperature increases might be experienced close to the surface of the cables, the transportation of electric energy causes heat loss by the Joule effect (Taormina et al., 2018). Heat emissions are higher for cables transporting alternate current (AC) and lower for cables transporting direct current (DC). Taormina et al., 2018 reports that temperature increases can change the substratum chemistry (such as the oxygen concentration) impacting the development of microorganism communities. Taormina et al., 2018 adds also that the impact of temperature increase on benthic communities had rarely been examined and in situ analyses would be needed to draw accurate conclusions.

As to the present study, the lack of data regarding the current hydrography condition in the area, and the impossibility of monitoring any change caused by the OWT, caused the exclusion of D7 in the further steps of the analysis.

1.2.8 D8: Contaminants

A contaminant is any toxic and persistent chemical substance able to permanently alter the marine environment. D8 concerns the concentration of contaminants that must be at a level that does not rise the pollution effects (European Commission , 2024).

The possible contaminants related to an OWT are due to the corrosion effect which releases metals from galvanic anodes (Rezaei et al., 2023). A farm made of 80 OWT and offshore survival system is estimated to emit $45 * 10^3$ kg/year of Aluminum and $2 * 10^3$ kg/year of Zinc (Kirchgeorg et al., 2018). Aluminum concentration thresholds are not set by any international standard. The effect that it has on the environment varies species by species, moreover, since clay minerals present on the marine sediments are the main sources of Aluminum release, it is not easy to distinguish between natural and OWT release (Rezaei et al., 2023).

As to Zinc contamination further research are needed to understand its impact on the marine environment. Another effect that needs to be researched is the one related to Indium release that is strictly linked to materials OWT are made of (Rezaei et al., 2023).

On the other hand, the proposition made by some European countries (like Belgium) to allow passive fishing and aquaculture in the areas close to offshore wind farms (Climate, 2018), leads to the conclusion that the concentration of the cited contaminants might not adversely impact the safety of some marine species.

As to the present analysis, the lack of research implies the impossibility of retrieving any data concerning the matter, in fact, the study on this topic is still at its infancy. Hence, D8 will not be considered in the following step of the analysis. However, in the estimation of the impact explained in paragraph 3.2, the effect of substructure and mooring pollution will be considered as detrimental.

1.2.9 D9: Contaminants in seafood

D9 affirms that "Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards" (European Commission , 2024). This descriptor is strictly related to D8 as the pollutants released by an OWT are the ones cited above (paragraph 1.2.8). Therefore, no data were retrieved concerning this descriptor.

1.2.10 D10: Marine litter

D10 says that the nature and the quantity of marine litter should not cause harm to the marine environment (European Commission , 2024).

One type of litter caused by an OWT can be the permanence of the substructure [8]in the seawater even after the decommissioning of the farm. The harm that the substructure can cause, during both operation and decommissioning phase, is related to the entanglement risk of marine species, in particular of marine mammals, sea turtles, sharks and diving or plunging marine birds (Lebreton et al., 2018). Appropriate considerations must be made to evaluate the pros and cons of leaving the substructure in the marine environment.

As to the present analysis, no data were retrieved on the marine litter, and it will not be considered further in the analysis. However, as to the entanglement risk it will be included in the estimation of the impacts described in paragraph 3.2.

1.2.11 D11: Energy, including underwater noise

D11 affirms that any new source of energy (heating, electricity systems, electromagnetic field, noise, etc.) caused by the creation of an offshore facility, must be kept at levels that do not adversely affect the marine environment (European Commission , 2024).

As to OWT the principal sources of disturbance are electromagnetic filed (henceforward, EMF) and noise (caused by vessels, turbine blades and moorings). The present analysis will include the abovementioned disturbances in the calculations of the impact explained in paragraph 3.2. Moreover, as to vessel noise, data regarding the vessel traffic will be retrieved in order not to add further pressures to the environment, it will be explained in paragraph 2.1.4.

[8] The substructure is the platform on which the turbine is installed. Further descriptions are given in paragraph 2.2.1

2 Data analysis

At the moment, an Italian legislation for the use of the marine space is lacking, therefore the only guideline that can be followed is the European one. In paragraph 1.2 each GES descriptor is illustrated and the ones included in the analysis are specified. For the sake of clarity, they will be reported below:

- Descriptor 1: Biodiversity data
- Descriptor 3: Commercial fish and shellfish
- Descriptor 6: Seabed integrity
- Descriptor 11: Energy, including underwater noise

These four descriptors represent the starting point for the collection of the data that will be included in the analysis. As to descriptors 7 and 10 (respectively Hydrographical condition and Marine litter), they will be taken into account by including them in the study of the impacts.

2.1 Environmental data collection

The collection of the environmental data follows the guidelines of descriptor 1: the biodiversity of the area under analysis was studied. The latter was carried out by means of bibliographic research, the species and habitats, that were found to be present both on the island and in the coastal water surrounding it, were included in the study. Unfortunately, due to the lack of data, it was not possible to include some of the species that are part of the biodiversity of the island. The following paragraphs will describe which dataset were available and the ones that were not possible to find.

2.1.1 Biodiversity data

The wildlife data were found on the Global Biodiversity Information Facility (henceforward, GBIF) (Gbif, 1999), an open-access portal. The data available on GBIF are mostly occurrences data, indicating the presence of a particular taxon in a georeferenced point.

Since San Pietro Island is both a Special Conservation Interest area (henceforward, SCI) and a Special Protection Area (henceforward, SPA), it was deemed appropriate to download occurrences of all birds registered between 2017 and 2024 belonging to the area of interest (GBIF, 2024). Seen the abundance of data, a dataset of seven years is allowing to have statistically consistent analysis. The rationale behind the choice of the birds included in the analysis will be explained in paragraph 2.3.2, for the moment a list of the chosen species will be provided:

- Curlew Sandpiper - *Calidris ferruginea*
- Audouin's Gull - *Ichthyaetus audouinii* (Payraudeau,1826)
- Little Tern -*Sternula albifrons* (Pallas, 1764)
- Great White Egret - *Ardea alba* (Linnaeus, 1758)
- Western Marsh Harrier -*Circus aeruginosus* (Linnaeus, 1758)
- Barn Swallow - *Hirundo rustica* (Linnaeus, 1758)
- Northern House Martin - *Delichon urbicum* (Linnaeus, 1758)
- Sand Martin - *Riparia riparia* (Linnaeus, 1758)
- Dartford Warbler- *Curruca undata* (Boddaert,1783)
- Stonechat - *Saxicola rubicola* (Linnaeus, 1758)
- Northern Whetear -*Oenanthe Oenanthe* (Linnaeus, 1758)
- Spanish Sparrow - *Passer hispaniolensis* (Temminck,1820)
- Yellow Wagtail - *Motacilla flava* (Linnaeus, 1758)
- European Greenfinch - *Chloris chloris* (Linnaeus, 1758)
- Eurasian Linnet - *Linaria cannabina* (Linnaeus, 1758)
- European Goldfinch - *Carduelis carduelis* (Linnaeus, 1758)
- The Eurasian stone curlew - *Burhinus oedicnemus* (Linnaeus, 1758)
- The Black crowned night heron -*Nycticorax nycticorax* (Linnaeus, 1758)

- Slender-billed gull - *Chroicocephalus genei* (Breme, 1839)
- Little Egret - *Egretta garzetta* (Linnaeus, 1758)
- European Shag -*Gulosus aristotelis* (Linnaeus, 1758)
- Black winged stilt - *Himantopus Himantopus* (P. L. Statius Müller, 1776)
- Barn Swallow - *Hirundo rustica* (Linnaeus, 1758)

In particular, Eleonora's Falcon was identified as the species whose presence on the island is the most prominent. Additionally, Eleonora's Falcon is classified as "Vulnerable" in IUCN red list (IUCN, 2024), and, as specified in paragraph 1.1.4, being a resident raptor on San Pietro Island makes its risk of collision is high. Thus, the data relative to its occurrences were selected between 2014 and 2023 (GBIF, 2024). Eleonora's falcon (*Falco eleonorae* Gené, 1839) is a regular passage migrant and breeder in Italy, where, as estimated, 500 pairs breed in ten colonies between Sicily and Sardinia (ISPRA, 2024). The falcons depart from Carloforte at the end of October, crossing the Mediterranean Sea heading south-east towards Madagascar where they will spend the wintering period. Instead, the spring migration from Madagascar to Carloforte (see Figure 2-1) starts around the end of April, and usually the falcons reach the island from southwest between June and July (Gschweng et al., 2008). Therefore, the breeding season is spent on Carloforte, in that timeframe they nest on the island's cliffs. When in Carloforte, the falcons depart from the colony for hunting far offshore. When leaving the nesting cliffs, they use either active or gliding soaring flight, switching between circling and straight flight. Falcons in soaring flight usually fly in circular patterns either over the open sea or above the nesting cliffs. The mean altitude of the soaring falcons is 298 m (Rosé N et al., 2002). Given the height at which they fly and their hunting behavior, particular attention must be paid towards these birds when evaluating the impacts of an offshore wind turbine.

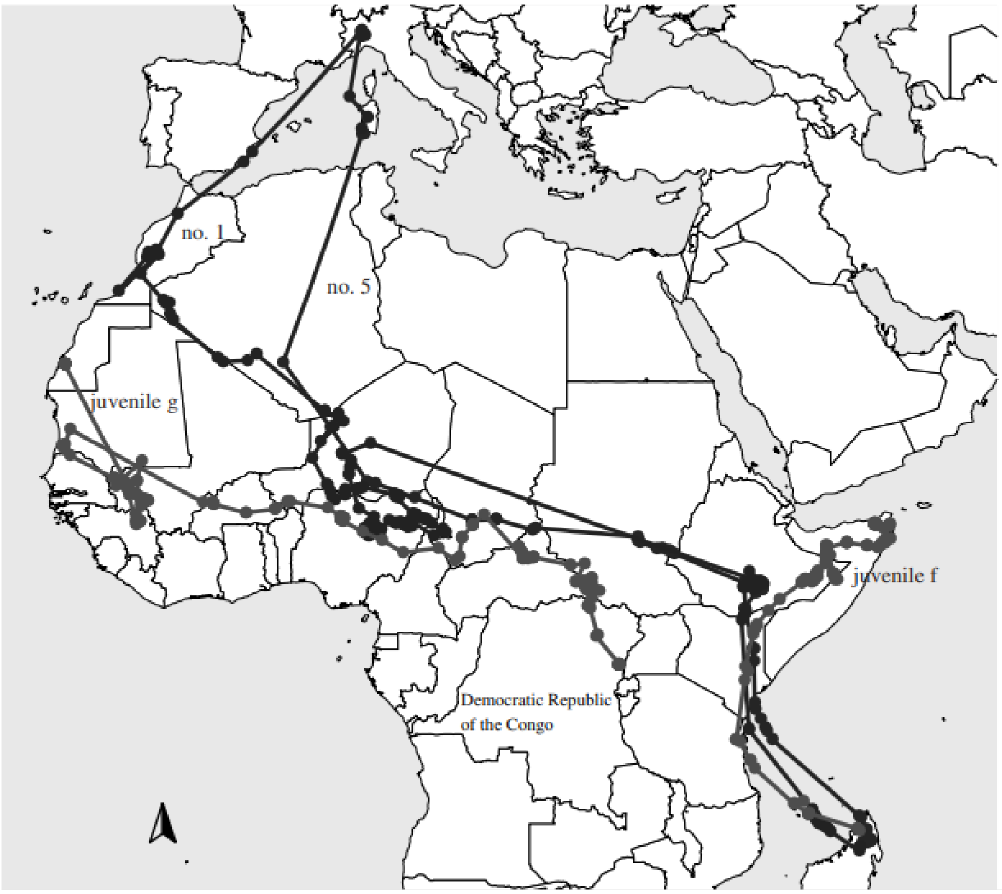

Figure 2-1- Spring migration of Eleonora's falcon toward Carloforte (Gschweng et al., 2008)

As to marine species, bibliographic research helped to understand which taxa are present in the selected area. ACCOBAMS Survey Initiative (henceforward, ASI) (Accobams, 2001) is a large-scale investigation realized in 2018 and completed thanks to aerial and boat surveys, it mapped the cetacean distribution in the

Mediterranean Sea and Black Sea (Cañadas et al., 2023). Its data were used to identify which cetacean's species occurred in the study area and therefore needed to be investigated in detail. These were: Striped Dolphin (*Stenella coeruleoalba,* Meyen, 1833) and Bottlenose Dolphin (*Tursiope truncatus*, Montagu, 1821). ASI was useful to understand also which other marine mammals could be occasionally present in the area. These are: Fin Whale (*Balaenoptera physalus,*Lacépède, 1804) and Sperm Whale (*Physeter macrocephalus,* Linnaeus, 1758). Occurrence data were downloaded both from ASI database and from GBIF. The first pertained to the year 2018, the second to the time span of 2017-2023. Moreover, from the website of European Commission Joint Research Centre (JRC), it was possible to retrieve information regarding the favorable feeding habitat of Fin Whales, which was daily identified linking their ecological traits with environmental variables from the satellite remote sensing (European Commission, Joint Research Centre, 2020). The daily results were then clustered in a monthly average: these averaged data was the one downloaded and used in the analysis.

As to elasmobranchs, instead, the starting point of the investigation was the Sardinian Large Elasmobranch Database (henceforward, SLED). SLED is a project which run from 1990 to 2009 (Storai et al., 2011), and which gathered in a database information relative to the bycatch of large elasmobranchs in six tuna traps distributed along the Sardinian coast. The species caught in Carloforte's tuna traps were:

- *Hexanchus griseus*
- *Alopias vulpinus*
- *Cetorhinus maximus*
- *Isurus oxyrinchus*
- *Carcharhinus brachyurus*
- *Prionace glauca*
- *Sphyrna zygaena*
- *Mobula mobular*

Occurrence data of all the above-cited species were searched on GBIF, but no results were found except for the *Cetorhinus maximus.* The analysis of Clò et al., 2010 suggests that the Basking Shark (*Cetorhinus maximus,* Gunnerus, 1765) are seasonal visitors in the coastal water of Northern Sardinia, although their presence was also registered near San Pietro Island. Therefore, the occurrences of this species from 2017 to 2023 were downloaded from GBIF. The only other available data concerned the Blue Shark (*Prionace glauca*, Linnaeus, 1758) foraging habitat, which was recovered from JRC (European Commission, Joint Research Centre, 2022).

Besides the Basking shark and the Blue shark, the Spotted Catshark (*Scyliorhinus canicular,* Linnaeus 1758) was investigated as well. This was deemed appropriate because Cau et al., 2017 revealed the presence of Spotted Catshark nursery grounds on a rocky elevation (Carloforte Shoal) located 11 nautical miles from the western coast of the island of San Pietro. The occurrences data of the Spotted Catshark from 2017 to 2023 were downloaded from GBIF.

The area hosts another nursery ground. News (Vitiello, 2023) reported the presence of nursery ground of loggerhead turtles on Carloforte's shore. The nest was identified as belonging to loggerhead turtle (*Caretta caretta,* Linnaeaus, 1758). The loggerhead turtle is listed by IUCN (IUCN, 2024) as "Vulnerable": thus, with a view to making a conservative analysis, also the coordinates of the nest were added to the study. The occurrences of this taxon from 2017 to 2023 were downloaded from GBIF.

Addis et al., 2016 highlights instead the presence of reproductive Atlantic Blue Fin Tuna (*Thunnus Thynnus,* Linnaeus 1758), which, from late April to mid-June, migrate along the western coast of Sardinia. Their presence in the coastal water of Carloforte is further confirmed by the two tuna traps present on the island. Therefore, Atlantic Blue Fin Tuna occurrence data from 2017 to 2023 were retrieved from GBIF, while data relative to its feeding habitat (European Commission, Joint Research Centre, 2020) and spawning habitat (European Commission, Joint Research Centre, 2020) from JRC.

Marine flora data has also been considered, for if their presence constitutes a protected habitat the construction of an offshore floating turbine would not be feasible. Two species were investigated: Posidonia Seagrass (*Posidonia ocenica,* Delile, 1813), as it is the most important endemic seagrass specie, and Smooth black coral

(*Leiopathes glaberrima,* Esper, 1788), which is a rare black coral the coral present on Carloforte Shoal. IUCN classifies the first as "Least concern" (IUCN, 2024)and the latter as "Endangered" (IUCN, 2024). Seagrass data were retrieved thanks to the European Marine Observation and Data Network (EMODnet) portal (European Commission, 2024) where seagrass meadows occurrence in Europe is reported as "Biogenic substrate in European waters". The latter shows the currently known extent of the biogenic substrate in European waters. Instead, Smooth black coral data were harder to find. As said above, Cau et al., 2017 found a nursery ground of the Spotted Catshark over a rocky elevation (Carloforte Shoal) and also reported that the Spotted Catshark laid eggs on a *L.glaberrima* colony. Angiolillo et al., 2015 revealed the exact coordinates of the Carloforte Shoal along with other two shoals not far from the western coast of San Pietro Island. Therefore, the coordinates of Carloforte Shoal were retrieved, and the coordinates of the other two shoals were considered as well to make the analysis conservative: the presence of the coral over those elevations is not proven but it cannot be excluded.

2.1.2 Commercial Fish data

It is known that one of the most exploited fishery stocks on the island is the Atlantic Blue Fin Tuna (henceforward, ABFT) one. In Carloforte the ABFT is fished with the aim of two tuna traps, known as "Tonnare". The traps are composed by a system of five chamber, each made of nets (Addis et al., 2016). This system is created to entrap tunas in the last chamber from which they are fished. This system is created to entrap tunas in the last chamber, from which they are fished. The first trap, placed on the north-western coast of the island, is bigger and permanent – meaning that the nets that create the five chambers are permanently installed. Conversely, the second tuna trap, momentarily placed on the eastern coast of the island, is smaller and its coordinates vary year by year depending on the license that the Sardinia region grants. It was possible to retrieve the coordinates of the first trap thanks to *Prot. N.6747 del 30/04/2020 Determinazione N.207*(Assessorato dell'agricoltura e riforma agro-pastorale, 2020)*,* while the coordinates of the seasonal traps were retrieved from *Prot. N.5437 del 29/03/2022*(Direzione generale Servizio Pesca e Acquacoltura, 2022).

2.1.3 Seabed integrity data

Seabed data were also found on EMODnet (European Commission, 2024) portal by downloading the layer named "Seabed Substrate, Multiscale-folk 7". The layer identifies seven substrate classes: mud, sandy mud, muddy sand, sand, coarse sediment, mixed sediment and rock and boulders.

2.1.4 Human activity data

It was deemed necessary to gather data to assess the socio-economic impact that the construction of an offshore floating turbine would have on the island. The construction and decommissioning of an offshore facility entails the employment of different vessels to transport both the necessary supply materials and the personnel. Therefore, data relative to the density of all types of vessels were downloaded to monitor the most trafficked paths. In fact, traversing the already busy routes would decrease the impact that the abovementioned vessel would have both on wildlife and on marine traffic. Even in this case, the data were provided by EMODnet portal, from which the layer named "Vessel Density- Annual Averages 2017-2023" was downloaded. It contains maps showing the shipping density in 1x1 kilometers cells of a grid covering all European waters: density is expressed as hours per square kilometer per month.

2.2 Technical data collection

The installation of an Offshore Wind Turbine (henceforward, OWT) represents not only an engineering endeavor but also a significant economic asset. To assess the project's feasibility, the study has examined parameters directly related to the technical performance of the OWT.

It is the Ichnusa Wind Power project, a 504 MW floating wind implant planned approximately 36 kilometers away from the San Pietro's western coast. It will contribute to the Italian government's target of 20 GW of operational wind by 2030. The project is also designed to support local supply chain development by the second half of the decade. (COP- Coopenhagen Offshore Partners , 2024)

To support the technical choices made in this analysis (see the rest of the present chapter), the environmental impact assessment of the Ichnusa Wind Power project was used as a model. The latter is a 504 MW floating wind implant planned approximately 36 kilometers away from the San Pietro's western coast (COP- Coopenhagen Offshore Partners , 2024). Due to the proximity to San Pietro Island, the area that the Ichnusa Wind Power project would occupy is well comparable with the one under analysis. Thus, the project was used as an example to apply the elaborated methodology to a real case.

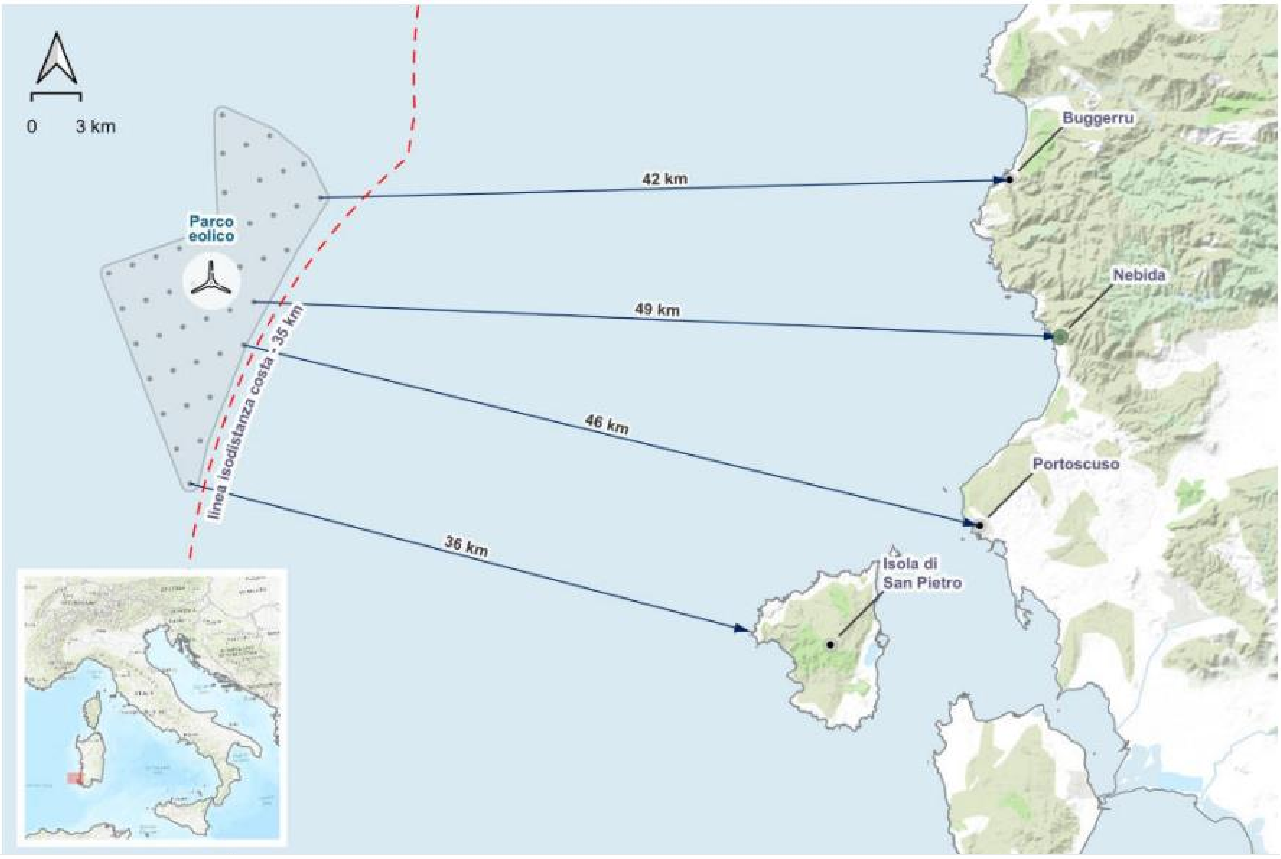

Figure 2-2- Ichunusa Wind Power (Dott. Ing. Luigi Severini, 2023)

2.2.1 Bathymetry data

The siting of an offshore wind turbine strongly depends on the bathymetry, for the increment of the depth makes the installation operations harder. Moreover, the sea depth impacts the economic feasibility of the project, which increases both in the initial investment and in the maintenance cost (Tahir et al., 2023). Additionally, the bathymetry typically influences the length of the mooring lines for any offshore device, which in turn significantly impacts the overall cost, as noted by Giglio et al., 2023.

Furthermore, bathymetry clearly delineates the range of feasible substructures. There are two macro-classes of substructure which contain multiple types of technologies (see Figure 2-3):

- Bottom fixed substructure
- Floating substructure.

The former can be exploited in areas where the maximum water depth is up to 60 m, whereas some technologies belonging to the second macro-class can be implemented in regions were the bathymetry reaches up to100-120 meters.

The substructure chosen in this case study is floating. Multiple considerations informed the decision:

- Unlike the bottom fixed structures, the construction of an offshore structure would cause less disruption on the seabed surface and in general on the benthic population. The implementation of a fixed structure, in fact, might require drilling and/or grouting (Meinardi Cesare, 2023).
- The bathymetry of the sea surrounding the island is not suitable for a bottom fixed structure.

The adequacy of the choice was confirmed by the fact that the Ichnusa Wind Power project opted for floating substructures as well.

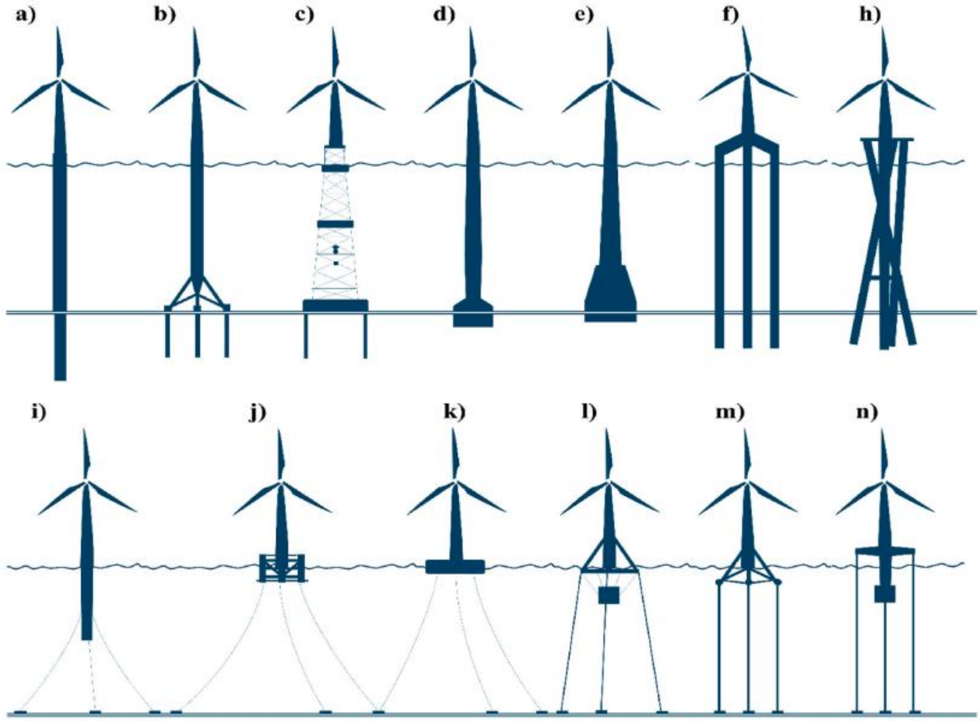

Figure 2-3-Bottom fixed: (a) Monopile (b) Tripod (c) Jacket (d) Suction caisson (e) Gravity base (f) tripile (h) Twisted jacket. Floating; (i) Spar buoy (j) Semisubmersible (k) Barge (l) Pendulum floater (m) Tension leg platform (n) Advanced spar (Rezaei et al., 2023)

There are three macro-clusters of floating structures classified by the reaction they provide to wind turbines and wave forces (Bracco, 2023), and namely:

- Buoyancy stabilized
- Ballast stabilized
- Mooring-line stabilized.

The choice of a specific kind of substructure would have little impact on the analysis at hand. Thus, to follow the path of Ichnusa Wind Power project, a ballast stabilized platform was chosen (see Figure 2-6). This is a hybrid between a ballast stabilized platform and a mooring-line stabilized one. It derives from the TetraSub®

model and was developed by Stiesdal Offshore (SO). This platform is optimal for turbines up to 15 MW. The entire structure of the Ichnusa Wind Power (turbine + platform) is docked with taut moorings (see Figure 2-4- example of taut mooring), constituted by six mooring lines, two for each vertex of the floating substructure. Each mooring line is attached to a punctual anchor made of steel poles (Dott. Ing. Luigi Severini, 2023). For the present analysis, though, it was hypothesized to use catenary mooring (see Figure 2-5) stabilized by weighted anchor. This mooring configuration would stabilize the substructure only with the catenary and anchor weight, without inserting steel pools on the terrain, and hence without modifying the seabed structure.

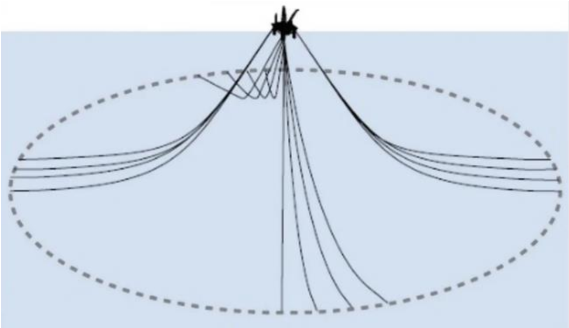

Figure 2-5 example of catenary mooring (Wang, 2022)

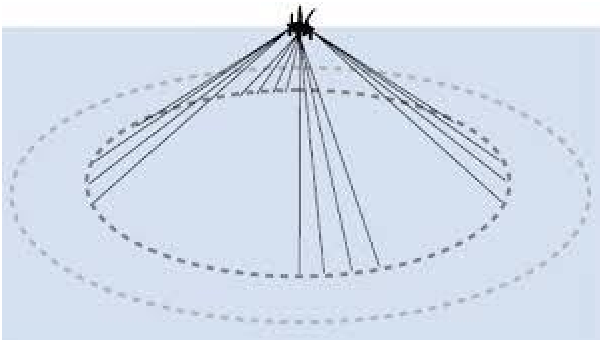

Figure 2-4- example of taut mooring (Wang, 2022)

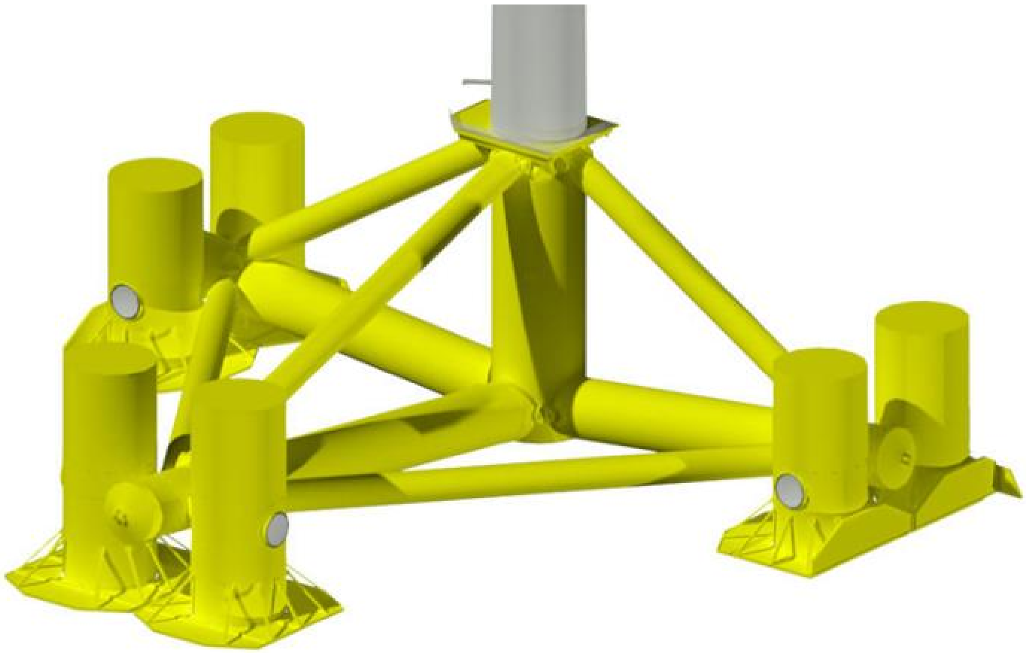

Figure 2-6- Floating structure (Dott. Ing. Luigi Severini, 2023)

Bathymetry data were found on the EMODnet (EMODnet, 2024) portal by downloading the layer named "Mean depth in multi color (no land)", which is a multilayer bathymetric product for Europe's Sea and overseas basin covering.

2.2.2 Wind data

First, the wind speed must reach the value of cut-in speed, necessary for the turbine's actuation. Second, the total annual energy extraction, dependent both on the turbine capacity and on the wind speed, must be worth the initial investment.

Wind speed data were downloaded from the Global Wind Altas (henceforward, GWA), by selecting the "Mean Wind Speed layer" (Technical University of Denmark, 2024). GWA is a free, web-based application developed to identify high-wind areas for wind power generation and perform preliminary calculation (Technical University of Denmark, 2024). The GWA uses a downscaling process that begins with large-scale wind climate data and ends with microscale wind climate data.

From GWA were downloaded also two terrain surface layers: the "Roughness Length" and the "Orography" (Technical University of Denmark, 2024). Wind speed depends both on height (with positive increment) and terrain (with negative increment). The friction created between the wind and the terrain causes a slackening of the wind speed that varies depending on the terrain's orography and roughness. When considering an offshore facility, the terrain characteristics are constant all over the area of interest, making wind speed values mostly unvarying. However, orography and roughness were still considered to make the analysis conservative and replicable.

AEP calculation

A parameter more significant than the wind speed is the AEP, which, given the wind speed and the terrain data, estimates how much energy a given turbine can produce in a year.

The estimation of the AEP was performed on WAsP 12, a State-of-the-art software for wind resource assessment, siting and energy yield calculations for wind turbines and wind farms (Technical Univestity of Denmark , 2024).

The first step in calculating the AEP on WAsP 12 was creating the "elevation map", a vector map (GML file) that contains both the orography and the roughness maps. The elevation map was created using WAsP Map Editor 12, where the two maps were merged forming a vector map with a 9x9 kilometer extension.

The second step consisted in choosing the turbine size. The choice fell on a turbine of 15 MW with a rotor diameter of 240 m, and a default height of 150 m. The Clean Energy Transition Agenda (CETA) outlines a bottom-up approach that identifies the necessary steps for the Island of San Pietro to achieve climate neutrality by 2050 (Vargiu et al., 2022). This strategic document, developed within the framework of the Clean Energy for EU Islands Secretariat, defines the optimal energy mix that will enable the island's energy system to reach zero CO2 emissions by 2050. Among the predominant energy sources identified are wind and solar power (European Commission, 2024). Therefore, exploring the potential of a single but highly productive turbine offshore seemed optimal for the following reasons:

1. Small turbines are not economically viable
2. The wind blowing on the coastal waters surrounding the island is very strong, with a mean speed of almost 8 m/s, which is not appropriate for small size turbines
3. Building a big size turbine offshore would prevent the exploitation of the land. The other option would be building an onshore farm that, to produce the same power, would be composed of several smaller turbines. In fact, the mean wind speed on the ground is usually smaller than the one experienced at open sea. The space that the hypothetical onshore farm would occupy would be incompatible with the limited space of the island.

By inserting the turbine model and the climate data provided by GWA on WAsP 12, it is possible to visualize the turbine's power curve. The power extractable from the wind is proportional to the air density and to the cube of the wind speed as expressed in Equation 1:

$$Power = \frac{1}{2}\rho A u^3$$

Equation 1

A is the area swept by the rotor expressed as Equation 2:

$$A = \pi r^2$$

Equation 2

WAsP 12 uses the IEC 61400-12 method to correct power curves given at the standard air density of 1.225 kg/m^3, thus the power curves have to be adapted to higher or lower site-specific air densities. The air density of the present case is 1.196 kg/m^3, therefore it is lower than the standard air density. The IEC 61400-12 method might overpredict the values of AEP for densities lower than the standard one, hence, the computed AEP might be overpredicted up to 5% (Vej Niels Jernes, 2010).

Figure 2-7Figure 2-8Figure 2-9 show the turbine power curve.

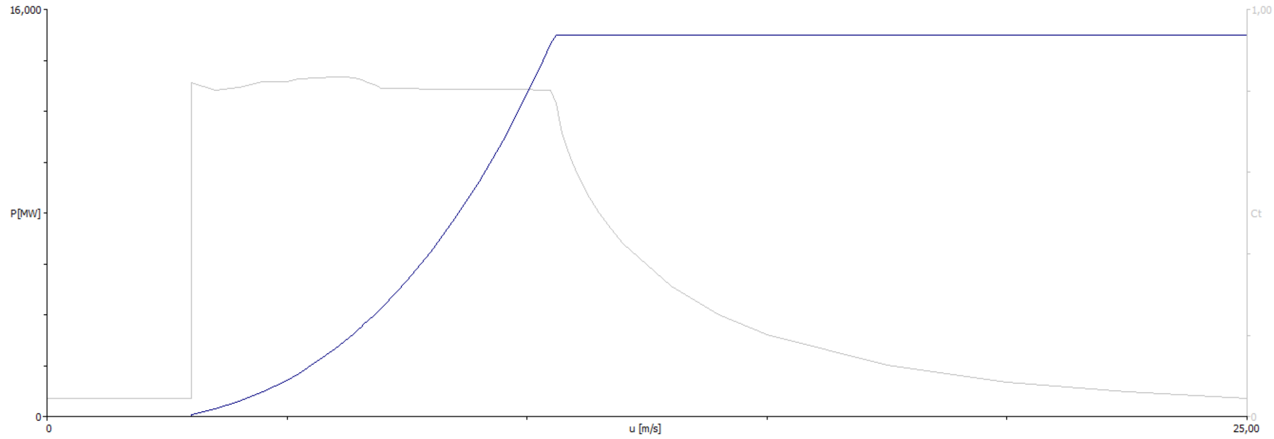

Figure 2-7- Turbine Power curve

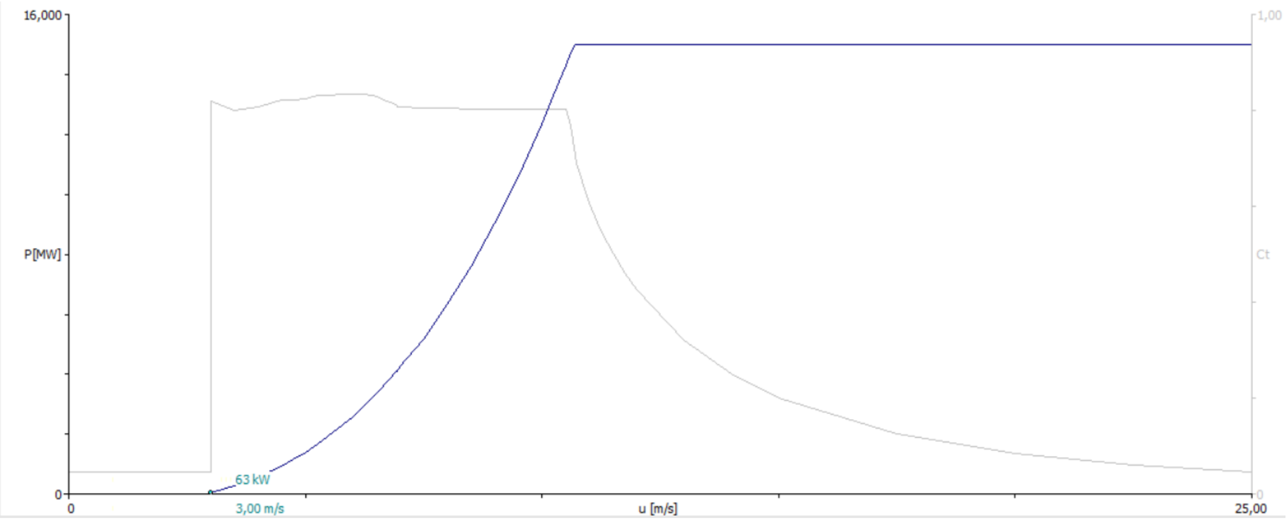

Figure 2-8- Cut-in speed

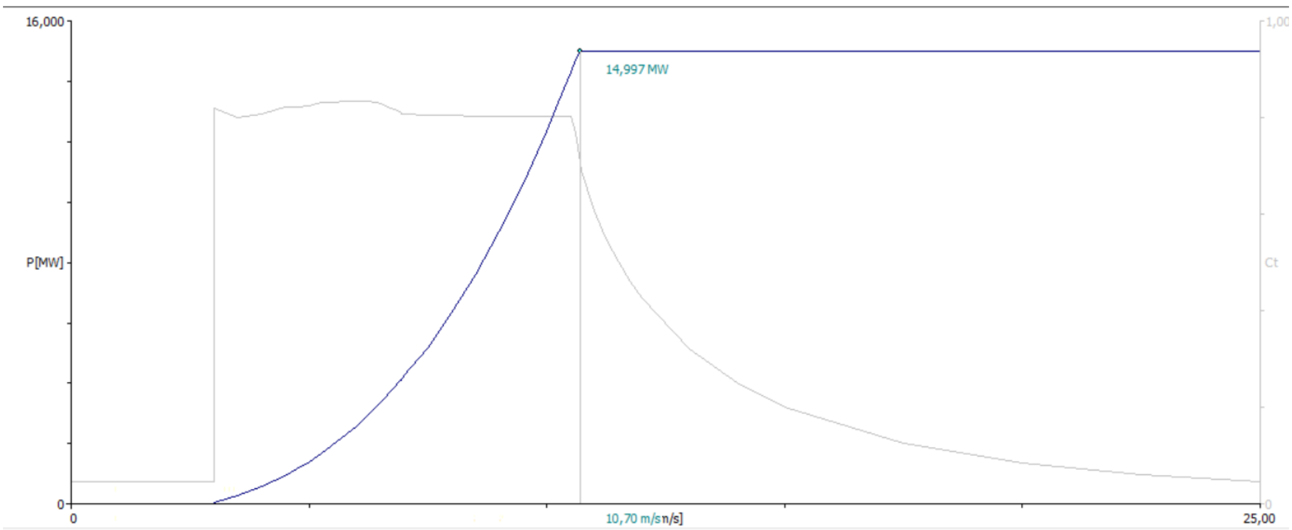

Figure 2-9- Nominal power speed

In Figure 2-8 the cut-in speed is highlighted; it shows that with a wind speed of 3 m/s the turbine starts functioning producing 63 kW. The nominal power is reached at 10.70 m/s (Figure 2-9) and it is maintained until the value of 25 m/s is achieved, which is, in fact, the cut-out speed. The cut-out speed represents the limit at which the turbine stops functioning due to safety and mechanical reasons.

WAsP 12 can identify the maximum, minimum and mean value of AEP that can be reached in the selected site. These are:

- maximum AEP: 61.795 GWh
- minimum AEP: 36.204 GWh
- mean AEP: 51.836 GWh.

WAsP 12 tool was particularly useful to calculate the resource grid of the selected area. The latter is a rectangular shape grid with a resolution of 100 m, meaning that each square that composes the grid measures 100x100 m. The result of the resource grid calculated for the AEP is reported Figure 2-10.

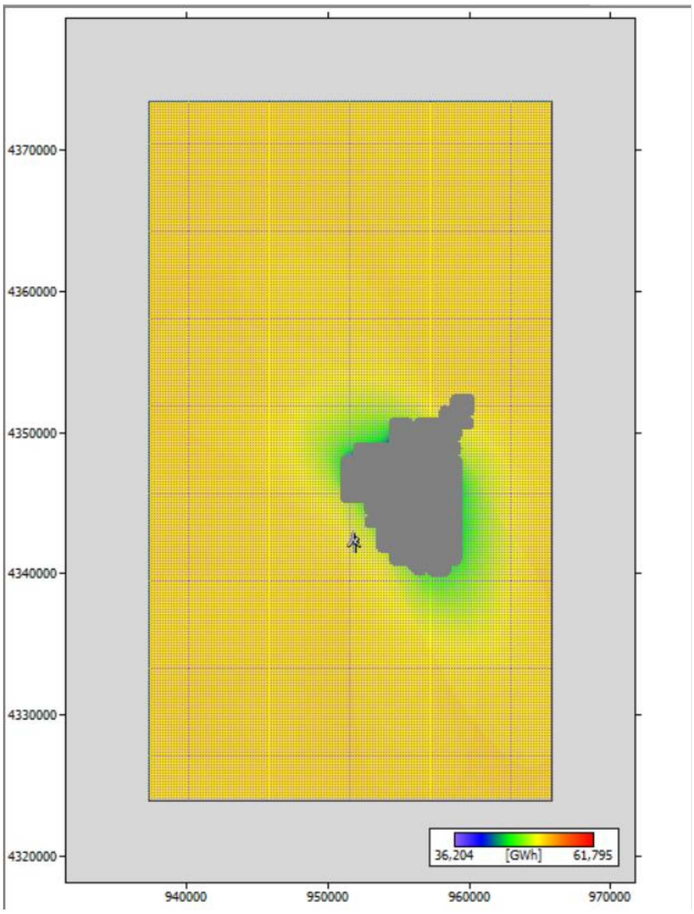

Figure 2-10- Resource grid

It is important to specify that the turbine position in Figure 2-10 was randomly chosen, for it does not interfere with the calculation of the grid. The map clearly shows low variability of the resource in the selected area: the less productive zones are close to the coast, while the rest of the map is homogeneous. The explanation of this phenomenon must be searched in the nature of the terrain which, in fact, is constituted by seawater that has constant roughness and homogeneous characteristics all over the area.

2.3 Data processing and implementation on QGIS software

The gathered data are of two different typologies:

- raster format
- shapefile format

Both shapefile and raster are types of spatial referenced data group. Vector data come in shapefile format and the geographic data are represented as points, lines, or polygons. On the other hand, raster data represents geographic data as a matrix of cells each containing an attribute value. Therefore, raster data have a resolution while shapefile data do not (Dempsey, 2024).

It was necessary to transform them into a unique format to make them comparable, and to unify them into a single layer to be used later in the study for the multicriteria analysis. This data transformation process was done on QGIS software, an open-source software that deals with spatial information, hence with georeferenced data (QGIS, 2024).

The project on QGIS was created using as coordinate reference system EPSG:32632-WGS 84/UTM zone 32N.

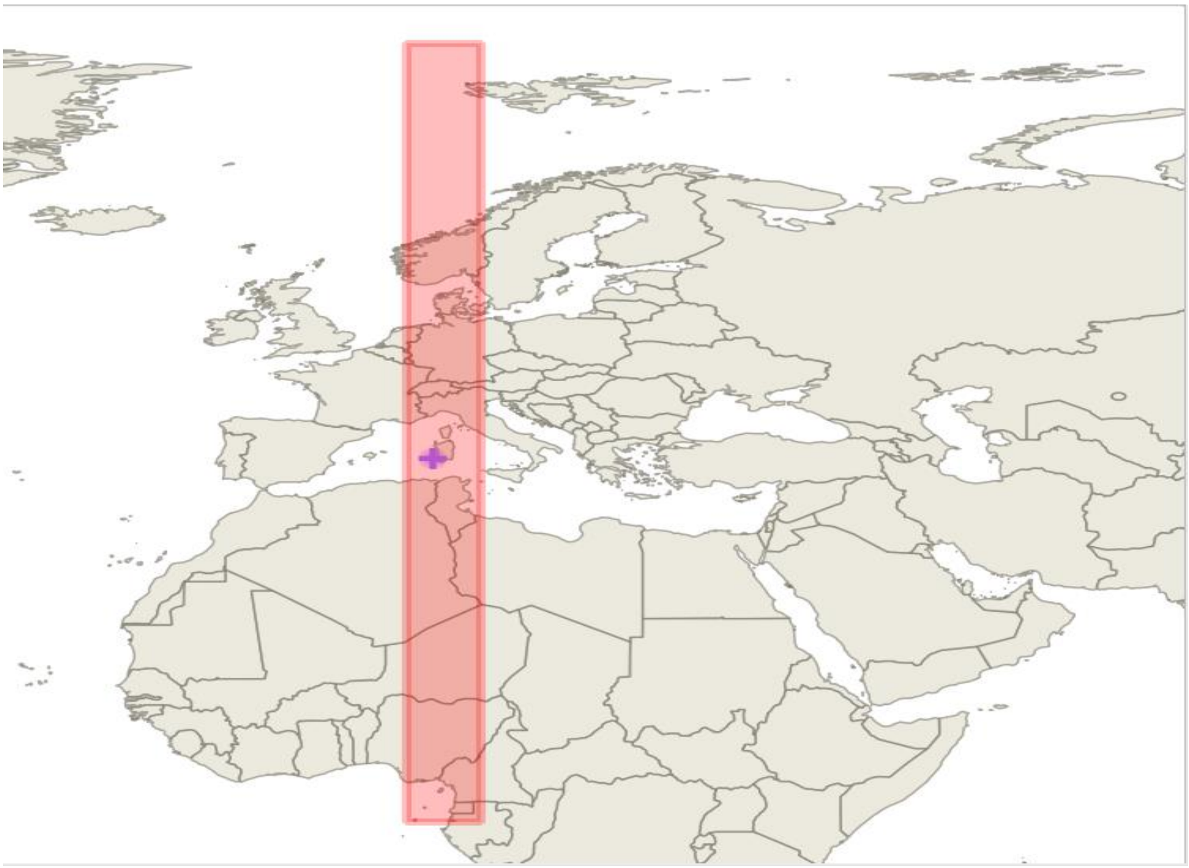

Figure 2-11- The red rectangle indicates the dimension of RS WGS 84/UTM zone 32N

The area of interest was delimited by imposing a suitable "mask" (a polygonal vector) able to be representative of the thesis purposes. It has a rectangular shape, and its dimensions were chosen lest the point suitable for the turbine construction be too far from the shore. The dimension of the mask was calculated by approximately computing the distance from the most prominent point of each coast:

- 25 km from the western coast.
- 22 km from the southern coast.
- 4 km from the eastern coast.
- 31 km from the northern coast.

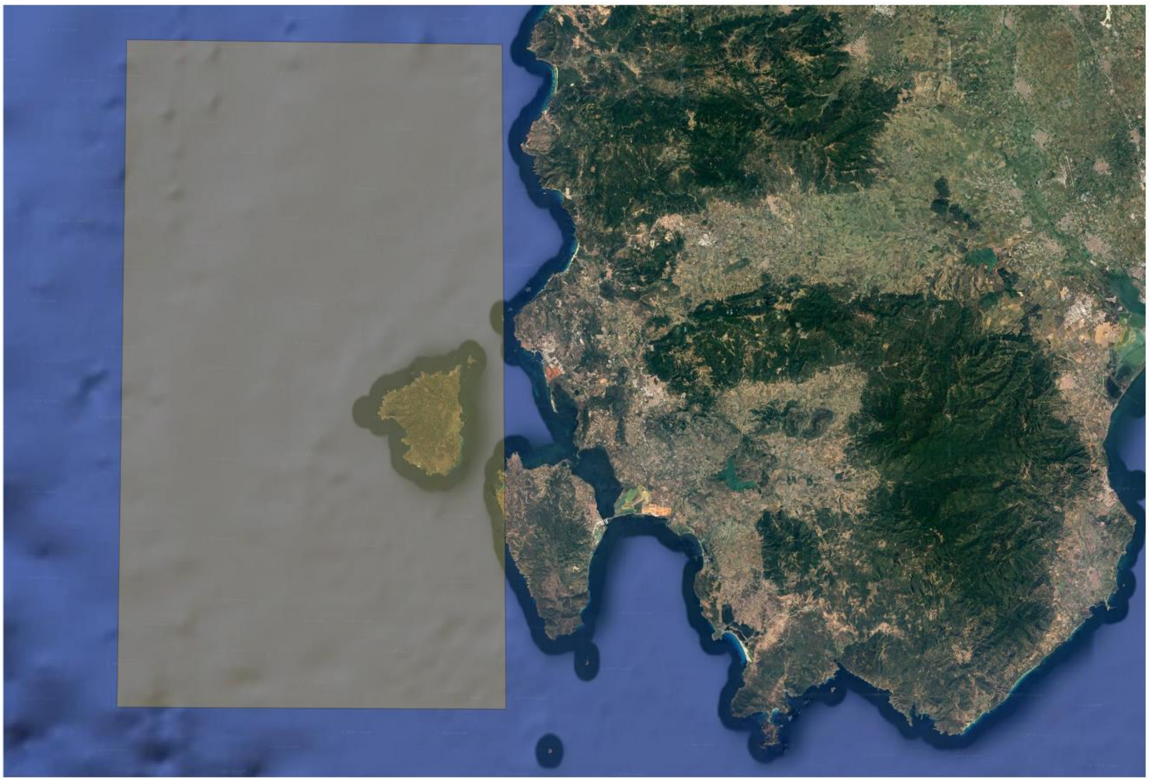

Figure 2-12- In yellow the rectangular mask over Carloforte

The area of interest of the case study was then defined as the area inside the rectangle (see Figure 2-12).

To perform a spatial analysis a grid was built with the same size as the mask and a resolution of 100 m, meaning that each square composing the grid is 100 m x 100m in size (see Figure 2-13). Although the mesh size was chosen arbitrarily, it is sufficient to capture significant variations in the parameters of interest while keeping computational costs manageable. A tradeoff analysis was not conducted, as it was beyond the scope of this thesis.

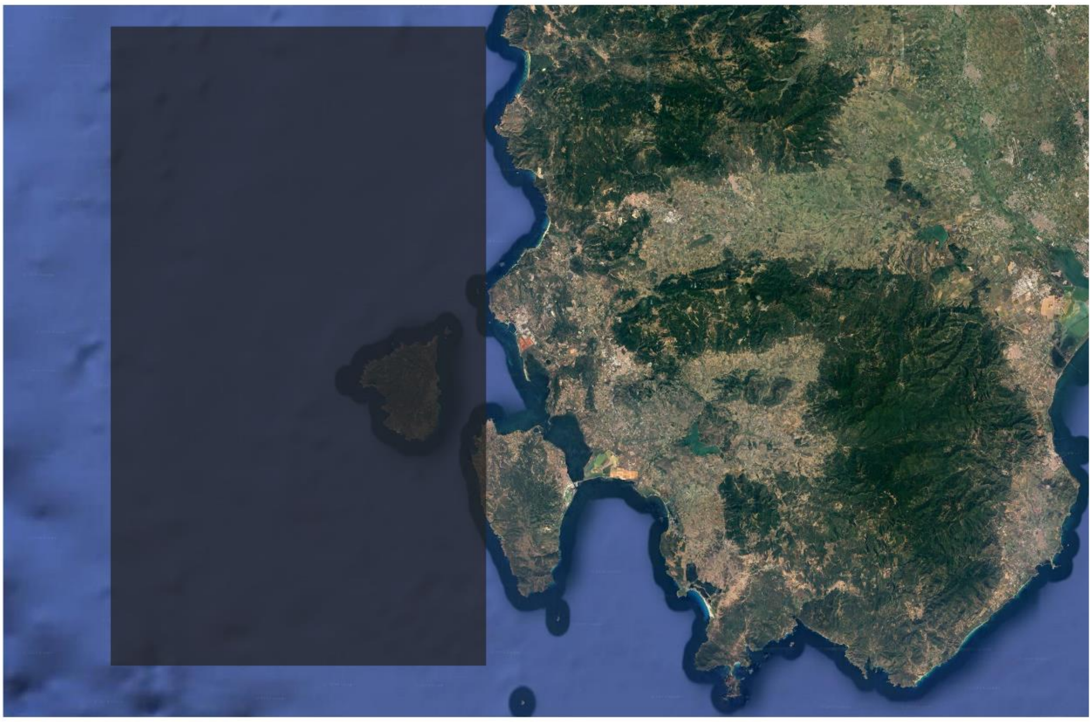

Figure 2-13- Grid with 100 m resolution

As said, the data needed to be transformed into a unique format, that is the shapefile format, the only one that allows to unify the data in a single layer. In this way, the unified layer will have the same size as the grid. To reach this goal, each data was treated differently, depending on their relevance and on the different typologies of their format.

2.3.1 Raster format Data

The data retrieved from JRC were in raster format, as well as the vessel density and the bathymetry layers provided by EMODnet and the AEP grid created on WAsP 12. As mentioned above, JRC supplied information relative to the favorable feeding habitat (henceforward, FH) for Fin Whales, Blue Sharks and ABFT, as well as the favorable spawning habitat (henceforward, SH) for ABFT. Raster files containing the information of FH for Fin Whales, Blue Sharks and ABTF were available for each month of the years from the 2003 to 2014. Hence, a single raster layer for each species' properties was created by performing the mean of the monthly raster files of the year 2014. The mean was performed by QGIS tool "Cell Statistics", which calculates statistics for each cell based on input raster layers and writes the resulting statistics to an output raster for each cell.

Figure 2-14, Figure 2-15 and Figure 2-16 show the probability of finding a favorable FH to the different species. In the first two cases the scales start from 0, meaning that the are some areas in the mask where the probability of finding a FH is null, on the other hand, the probability of finding a favorable FH for blue sharks is always different than zero in the area enclosed by the mask.

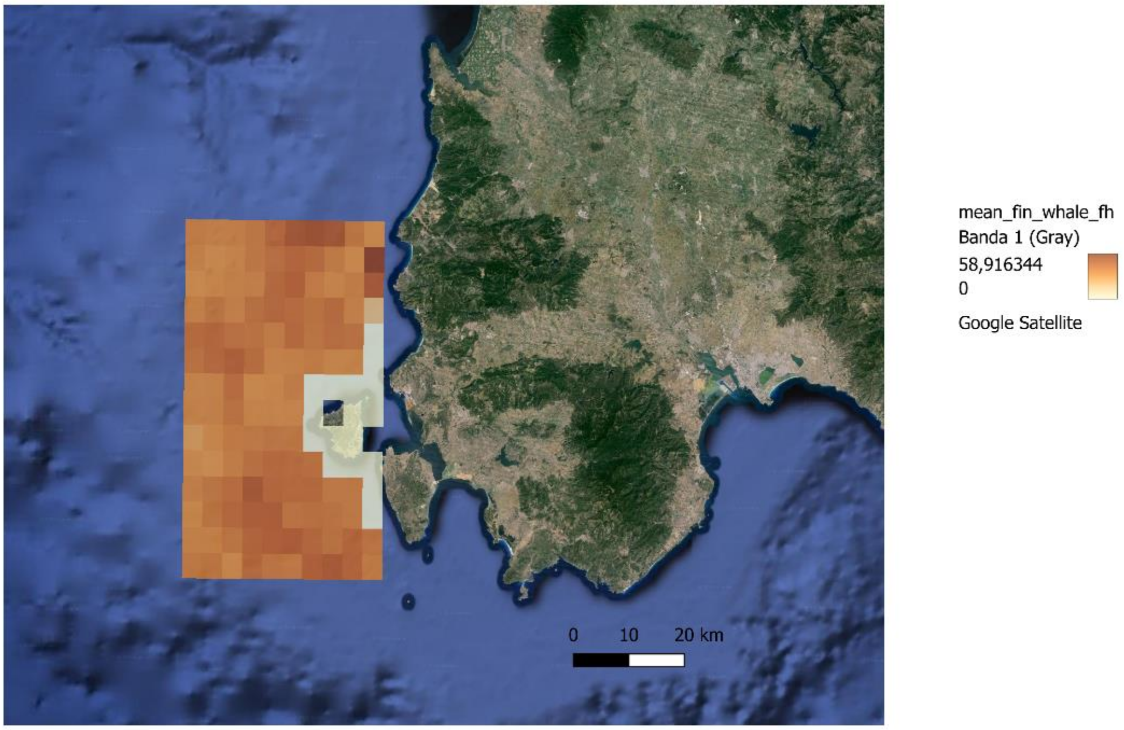

Figure 2-14- Mean fin whale feeding habitat

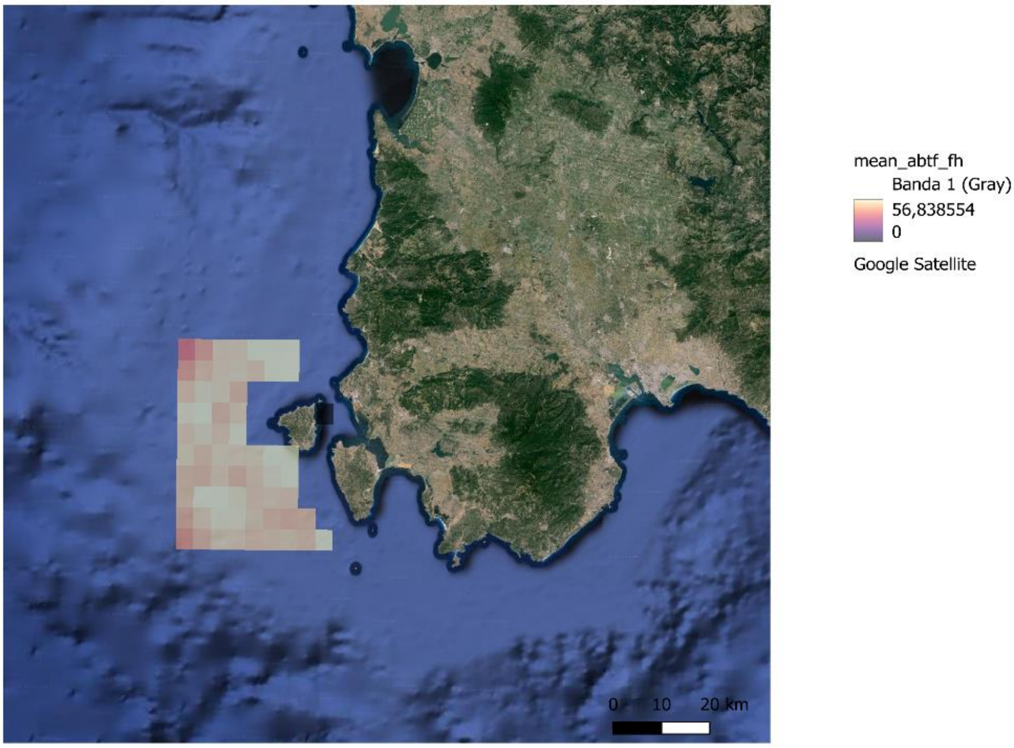

Figure 2-15- Mean ABFT feeding habitat

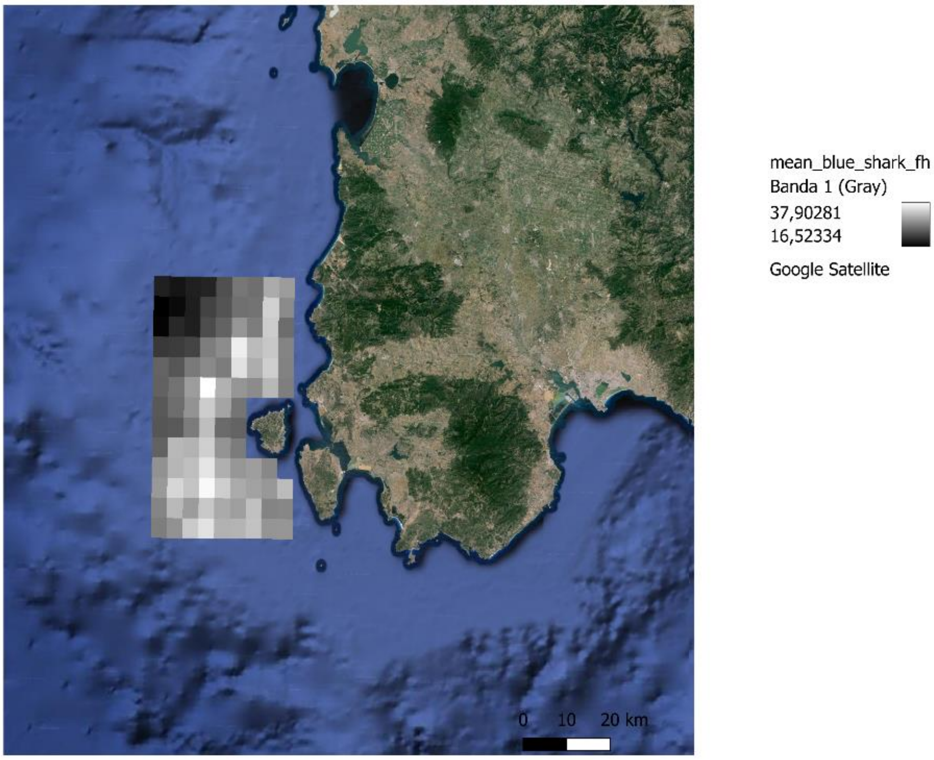

Figure 2-16- Mean Blue Shark feeding habitat

Addis et al., 2016 highlighted the presence of reproductive ABFT from late April to mid-June. Therefore, the mean of the monthly SH raster files was performed only for April, May and June of the year 2014. Figure 2-17 shows that the most favorable spawning habitat areas are distant from the coast.

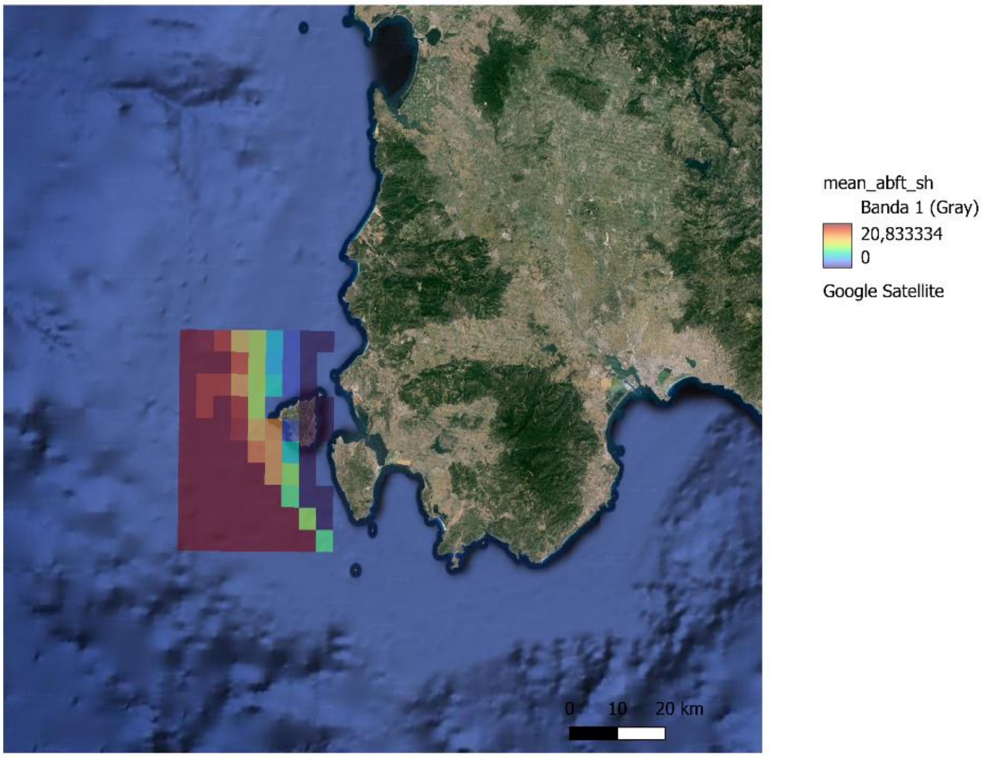

Figure 2-17- Mean of ABFT spawning habitat

Instead, the density vessel layer was downloaded as a single file containing the average of the months of the year 2023 (see Figure 2-18).

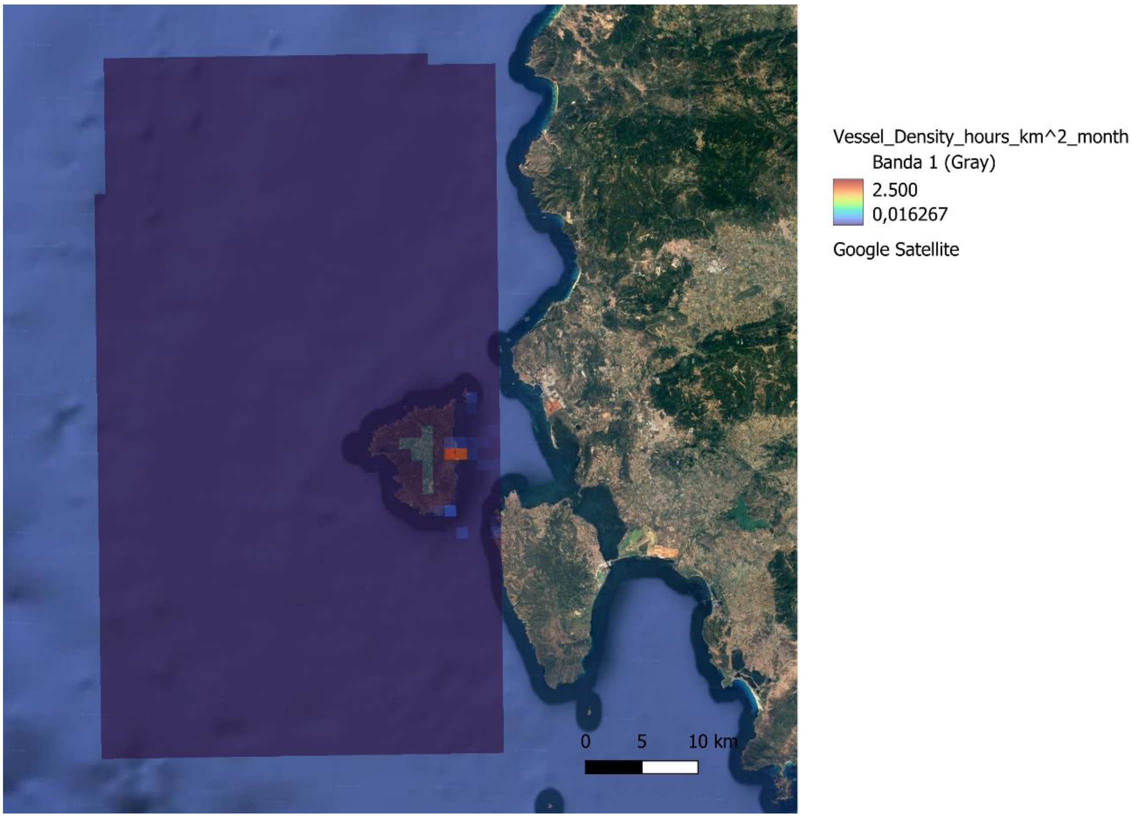

Figure 2-18- Vessel hours per square kilometer per month

The bathymetry layer (see Figure 2-19) was independent from the year of the measurement, averaging calculation were not needed.

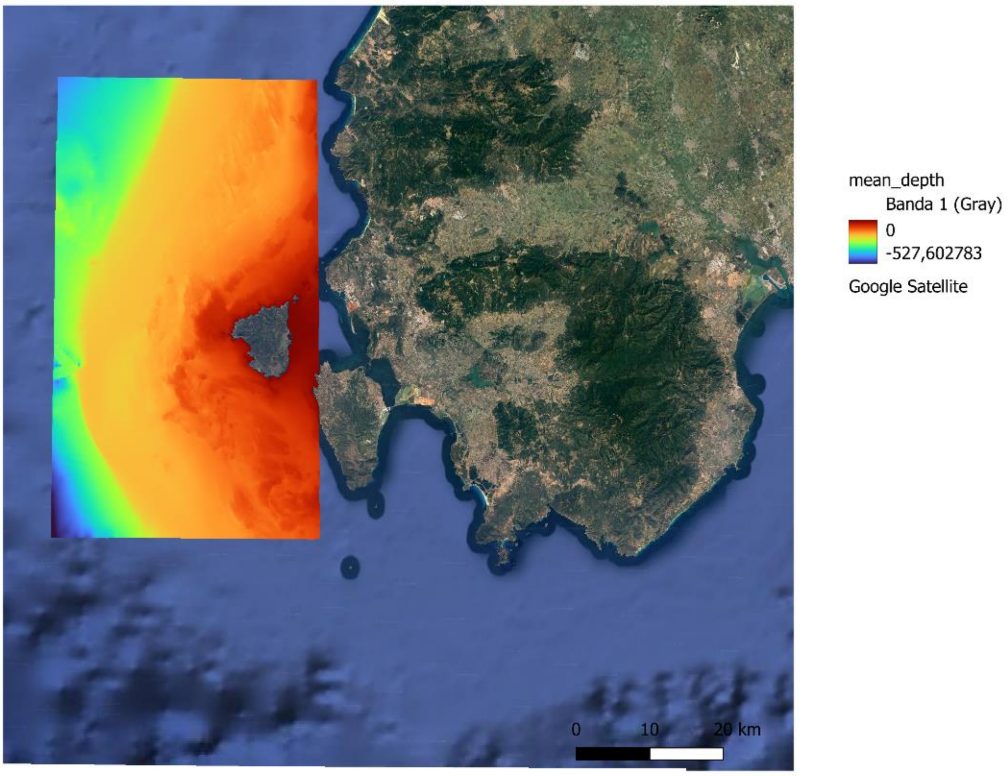

Figure 2-19- Bathymetry

The last raster file to be described is the one representing the AEP (Figure 2-20): by exporting it on QGIS its shape remains similar to the represented in Figure 2-10.

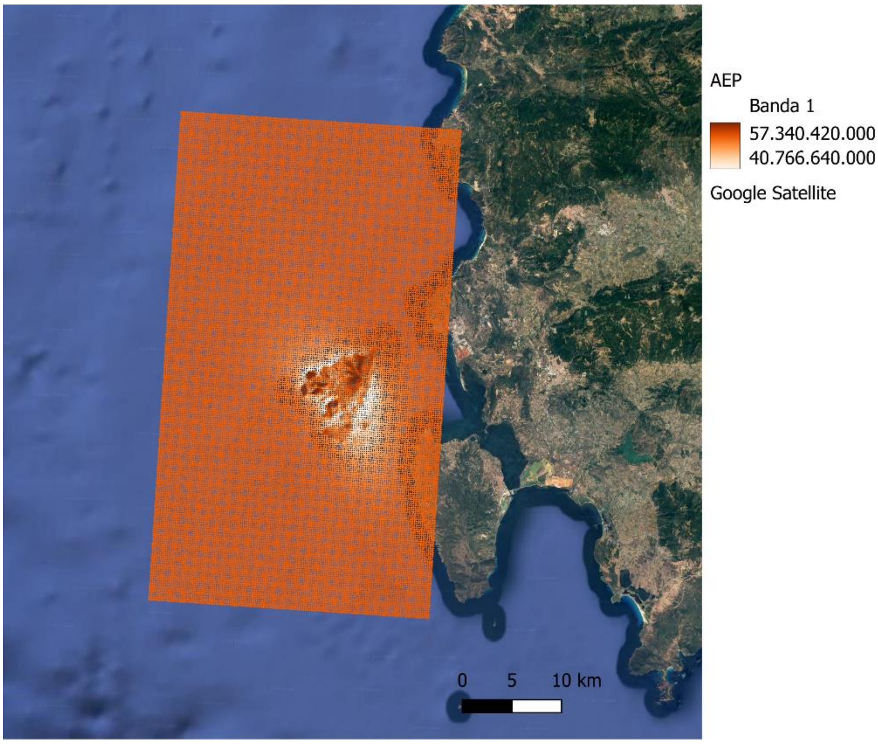

Figure 2-20- AEP

The transformation into a shapefile of each layer, was performed with QGIS tool "Cell statistics algorithm" which calculates a value for each cell in the output layer. At each cell position, the output value is defined as a function (in this case was the mean) of all overlapping cell values of the input raster. The extent and resolution of the output layer are defined by a reference layer that was chosen to be the grid layer (QGIS, 2024).

2.3.2 Shapefile format Data

Many of the collected data were organized as georeferenced vectors, hence as shapefiles. These were the data regarding:

1. The position of 3 rocky shoals
2. The position of loggerhead turtles' nest
3. The position of both the seasonal and the permanent tuna traps
4. The presence of Posidonia
5. The seabed quality
6. The presence of striped dolphins
7. The presence of bottlenose dolphins
8. The presence of basking sharks
9. The presence of spotted catsharks
10. The presence of loggerhead turtles
11. The presence of Eleonora's falcon
12. The presence of birds.

Data regarding the position respectively of Carloforte and the other two shoals, loggerhead turtle's nest, and seasonal and permanent tuna traps were treated in the same way. It was deemed appropriate to enhance the importance of each point by creating a circular buffer[9] with a radius of 1 kilometer. Increasing the area covered by each point boosted, in fact, the relevance of the latter in the analysis (see Figure 2-21).

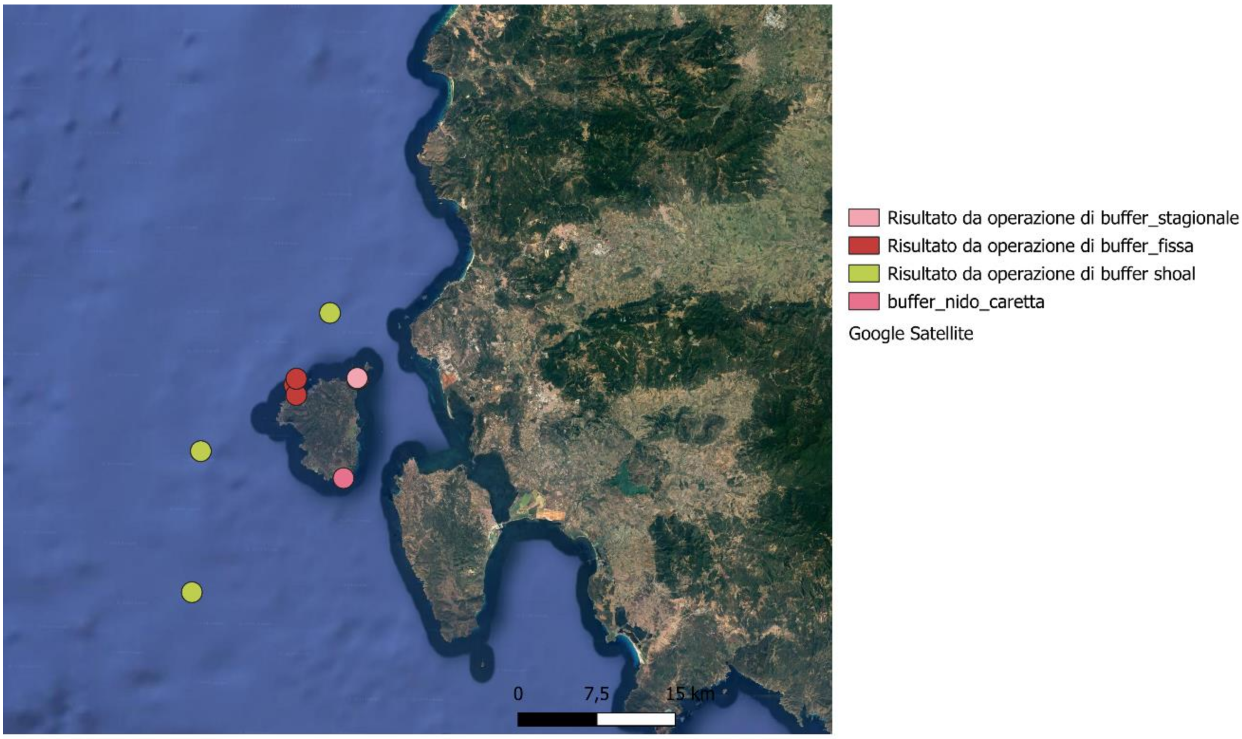

Figure 2-21- Buffer results

Instead, the vector containing the information about the presence of Posidonia is a categorical data[10] vector, hence it was necessary to find a way to transform it into a numerical vector. An encoding process was performed by adding a new column to the attribute table[11] of the vector and by writing in it the number one whenever a row of the column named "bio_detail" had written "*Posidonia oceanica* meadows" or "live *Posidonia oceanica* meadows". The first rows of the attribute table are provided for clarity in Figure 2-22.

gid	bio_detail	src_name	label_enco
69070	Posidonia oceanica meadows	EUSeaMap 2016 seabed substrate	1
69071	Posidonia oceanica meadows	EUSeaMap 2016 seabed substrate	1
69073	Posidonia oceanica meadows	EUSeaMap 2016 seabed substrate	1
565	dead mattes of Posidonia oceanica	Individual habitat maps from surveys - EUNIS classification syst...	0
572	dead mattes of Posidonia oceanica	Individual habitat maps from surveys - EUNIS classification syst...	0

Figure 2-22- excerpt of Posidonia presence table

[9] A buffer in QGIS is a tool used to create a zone of influence around a geographic feature, such as a point, line, or polygon. This zone can be used for spatial analysis, like determining which features are within a certain distance from a point of interest.

[10] Categorical data is a type of data that is used to group information with similar characteristics (Garg, 2024)

[11] The attribute table displays information on features of a selected layer. Each row in the table represents a feature, and each column contains a particular piece of information about the feature. Features in the table can be searched, selected, moved or even edited. (QGIS, 2024)

The fifth vector to analyze is the one containing information regarding the seabed type. It was incomplete (see Figure 2-23), so the data contained in it did not cover the area of the rectangular mask.

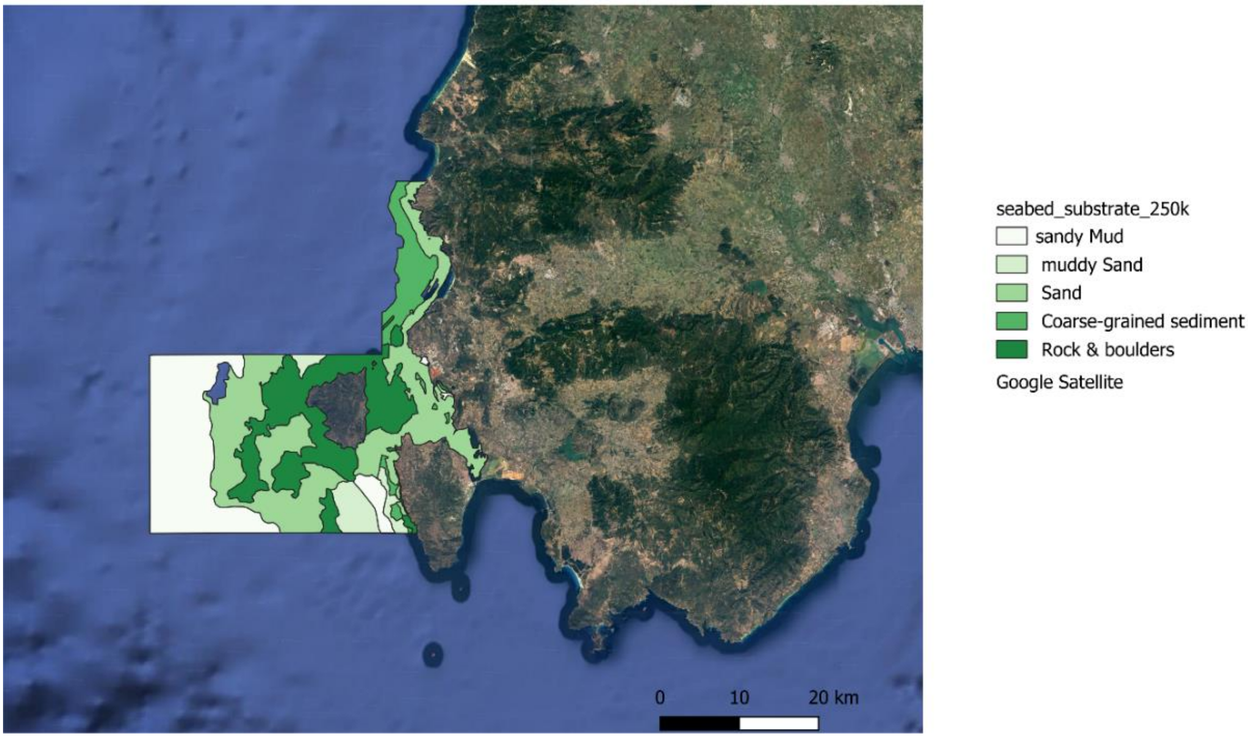

Figure 2-23- Seabed quality

Having a complete dataset was necessary to perform a complete analysis in the selected area. The solution was found by creating a complementary map by following the elevation curves extracted from the bathymetry dataset. The rationale behind this choice is based on evidence from the available data, which indicates that a specific type of seabed tends to be consistently present within two or more contour lines. In contrast, changes in seabed type are marked by significant elevation differences. By combining these observations with the existing data, it was possible to approximate and complete the seabed data with a reasonable degree of accuracy. Starting from the original seabed dataset (Figure 2-23), the perimeter that each seabed typology occupied had been outlined following the elevation curves. The fulfillment of the map represents an approximation (see Figure 2-24).

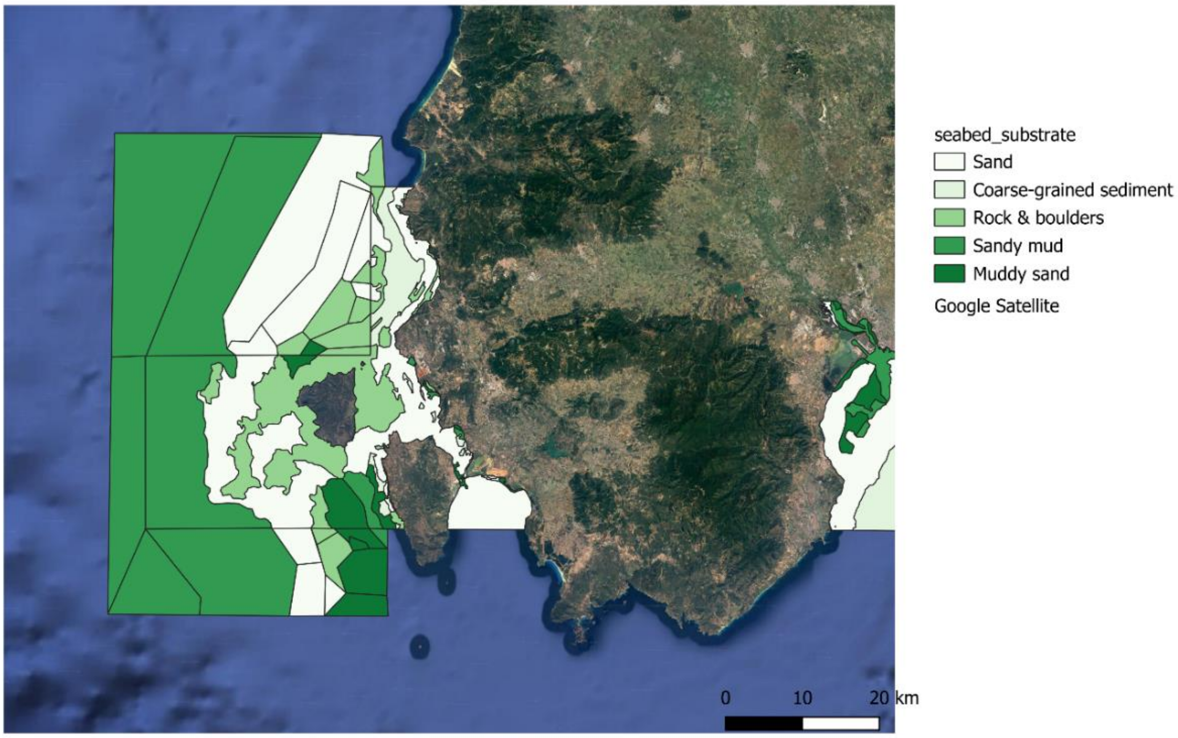

Figure 2-24- Complete seabed

An encoding process, similar to the one implemented for Posidonia presence, was developed to deal with the categorical data contained in the dataset. Seabed quality data are, in fact, divided into seven categories:

1. Mud
2. Sandy Mud
3. Muddy sand
4. Sand
5. Coarse-grained sediment
6. Mixed sediment
7. Rock and boulders.

Starting from "Mud" and following the order of the list above, a number from 1 to 7 was assigned to each category. A new column containing the number going from 1 to 7 was added to the attribute table. The assignment of a scale ranging from 1 to 7 establishes a relationship between the most favorable condition, rated as 1 and assigned to muddy sand, and the least favorable condition, rated as 7 and assigned to rocky substrate. This grading reflects the suitability of the substrate for the installation of an OWT and does not indicate the intensity or quality of the seabed.

As to marine wildlife, the presence of Striped Dolphin, Bottlenose Dolphins, Basking Sharks, Spotted Catsharks, and Loggerhead Turtles was defined by the occurrences data downloaded from ASI or GBIF. Not all the species were found to be presence in the area delimited by the mask (see Figure 2-25)

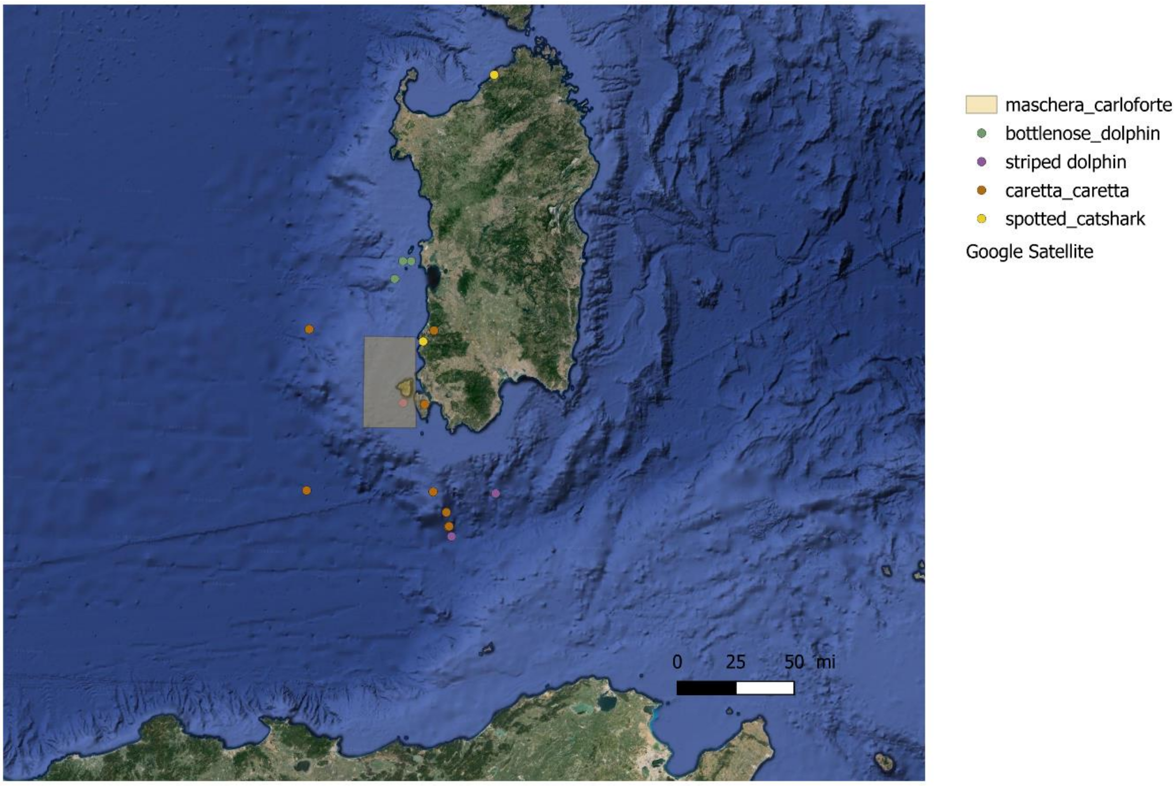

Figure 2-25- Occurrences data

Figure 2-25 shows that only the Striped Dolphin was registered within the limit of the mask. Instead, the Basking Shark is not showing on the map, meaning that there are no available data in the selected area. Therefore, the Striped Dolphin occurrence was the only one included in the next step of the analysis. As the occurrences are single sighting events that occurred over several years, it would have been incorrect and not significant to use these data as they are, for they happened at different times in different years. To make them comparable, and hence meaningful, it was decided to transform them in raster format by mean of the QGIS tool "Rasterize (from Vector to Raster)", which converts vector geometry into raster image. Once a raster was created for every year data, the mean of all the raster was perform with the function on QGIS "Cell Statistics", which calculates statistics for each cell based on input raster layers and writes the resulting statistics to an output raster for each cell. At each cell position, the output value is defined as a function (in this case, the mean) of all overlapping cell values of the input raster (QGIS, 2024). Once a unique raster was created it was necessary to transform it back into a shapefile, this process was performed with QGIS tool ("Cell statistics algorithm") which calculates a value for each cell in the output layer. This process was performed for each dataset containing annual occurrences.

Being Eleonora's falcon a species of interest on Carloforte island, data regarding its occurrences were more abundant. Seen the relevance that the species has, it was deemed appropriate to download data going from 2014 to 2023 (see Figure 2-26). Being the dataset constituted by annual occurrences, the rasterization process and the calculation of the mean of the created annual raster were performed. Once again, the created raster was transformed back into a shapefile.

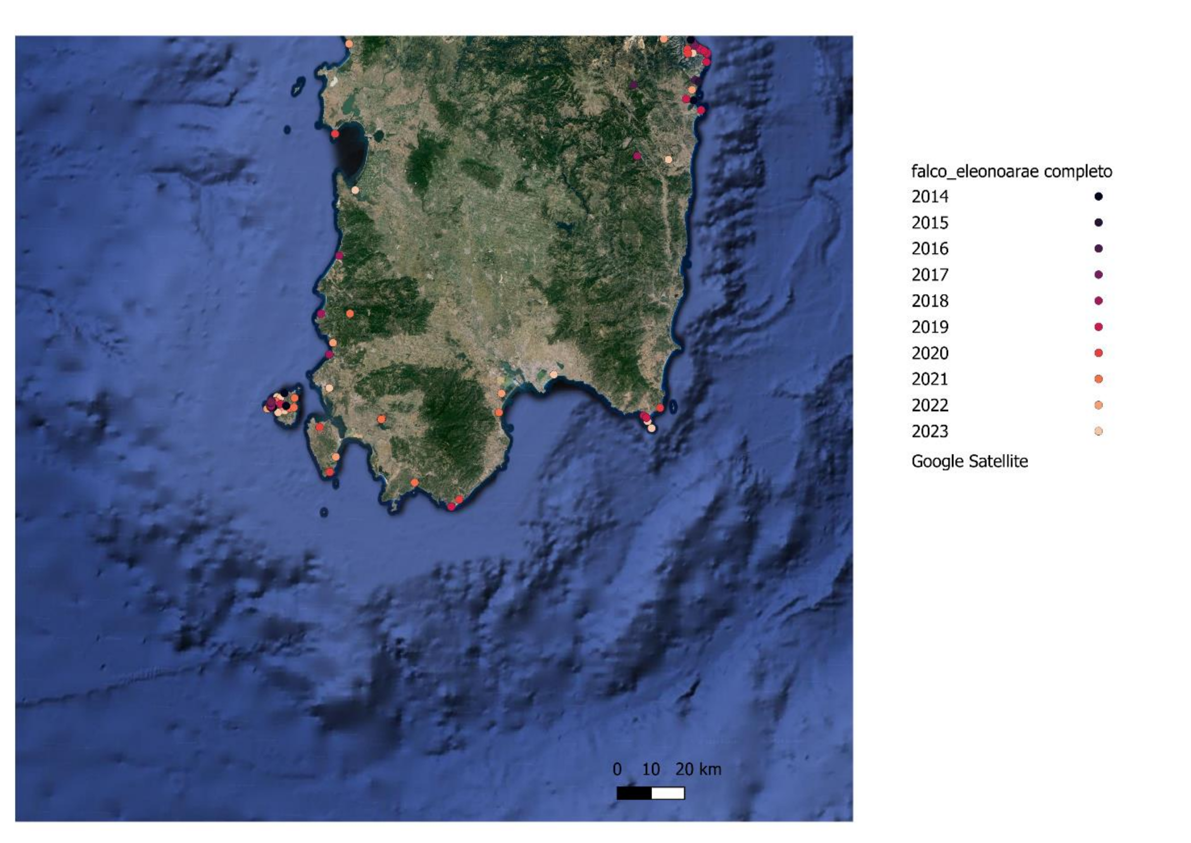

Figure 2-26- Eleonora's falcon presence

In order to process birds' dataset extra work was required. First, it was necessary to identify which species could be present on the island. Thus, bibliographic research was made to recognize the avian species both stationary on the island and migratory over it. Two were the principal sources used for the research: eBird site (eBird , 2024) and ISPRA "Atlante della migrazione uccelli in Italia" (ISPRA, 2024). The former is an open-source site where birdwatchers can register their observations, while the latter is a national atlas containing all the avian migratory routes over Italy.

It was possible to download from eBird the lists of the birds seen on Carloforte island. The species reported in the lists were classified in: *Vulnerable (VU*), *Endangered (EN*), *Critically Endangered (CR*), *Near Threatened (NT), Least concern (LC)* or *Data Deficient (DD).* This classification (see Figure 2-27) derives from IUCN Red list of Threatened Species (IUCN, 2024).

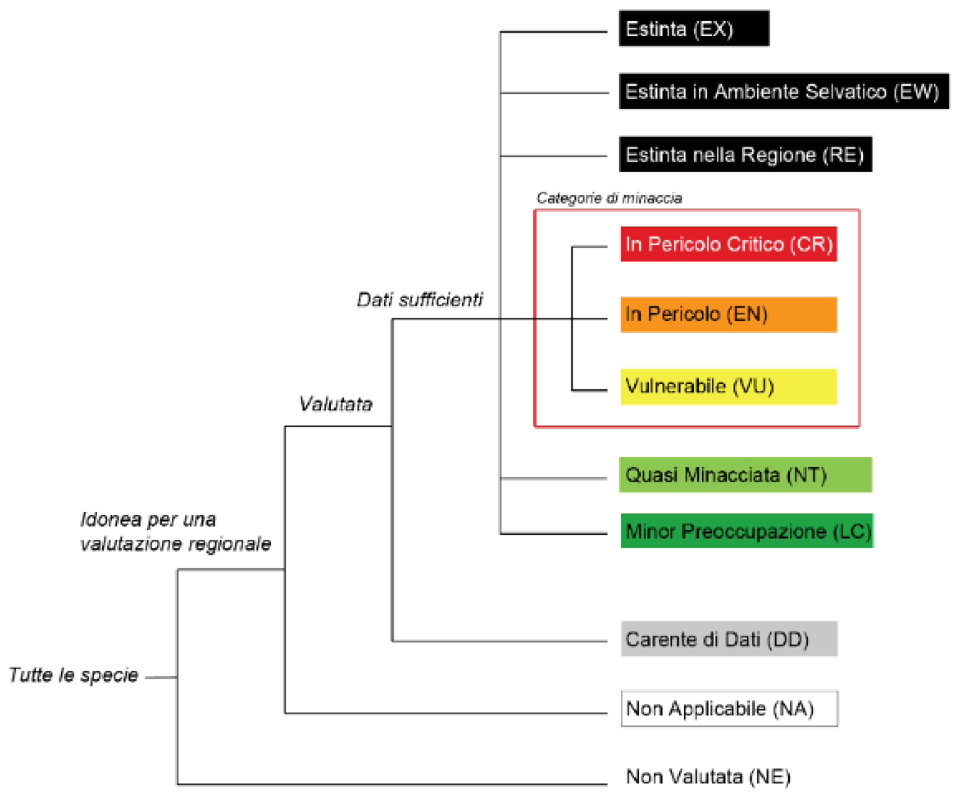

Figure 2-27- IUCN classification (IUCN, 2024)

Each species present on the lists was searched in IUCN database and categorized in one of the abovementioned classes. Whenever IUCN did not have any information on a particular species, more detailed search was done through specific literature.

Once the species of interest were found, their presence on the island was verified with the Italian migration atlas by ISPRA (ISPRA, 2024). It was deemed appropriate to understand if the occurrences registered on eBird were isolated events or if the spotted species was either a permanent resident on the island or a migrant whose route crossed the island. The research brought the following conclusions:

- Curlew Sandpiper (NT) - *Calidris ferruginea:* it does not migrate over the island, its sighting can be considered as an isolated case, therefore it will not be included in the analysis.
- Audouin's Gull (NT) - *Ichthyaetus audouinii (Payraudeau,1826)*: it breeds in Italy with an estimated population of almost 1000 pairs, mostly concentrated in Sardinia. It passes the wintering period mostly on the Atlantic coasts of Africa between Morocco and Senegal. The migration occurs through Gibraltar Strait during the winter period it migrates from Carloforte island towards south- west reaching Morocco's coasts. Its sighting will be included in the analysis.
- Little Tern (EN) -*Sternula albifrons (Pallas, 1764):* it is a localized breeder in Italy and a regular and locally abundant passage migrant, both in spring (along the coasts) and in autumn (northern Adriatic). During it autumn migration the Little Tern crosses San Pietro Island from north-east towards south-west. Its sighting will be included in the analysis.
- Great White Egret (NT)- *Ardea alba (Linnaeus, 1758):* it is now a regular breeder in a series of sites within the central and eastern Po plain. Birds migrating from Austria are mostly directed to Emilia-Romagna and Tuscany. The presence in Sardinia is rare but cannot be ignored. Its sighting will be included in the analysis.

- Western Marsh Harrier (NT) -*Circus aeruginosus (Linnaeus, 1758):* it is a regular breeder, passage and wintering migrant in Italy, it breeds also in Sardinia. The Western Marsh Harrier, during its winter migration reaches Carloforte from north-east. Its sighting will be included in the analysis.
- Barn Swallow (NT) - *Hirundo rustica (Linnaeus, 1758):* it is an abundant passage migrant and a rare wintering bird in Italy. The breeding population is widely distributed all across the country. The evidence suggests that the Barn Swallow arrives on Carloforte mainly from west, however, given the wide presence of the taxa all over Europe it is not possible to highlight a preferential migratory route. Its sighting will be included in the analysis.
- Northern House Martin (NT) - *Delichon urbicum (Linnaeus, 1758):* it is a common and widespread breeder and a regular passage migrant in Italy. The scanty national recoveries do not show specific pattern of movement. As there are not enough data to establish if the taxon is either present or not in the island, it was decided to include it in the analysis.
- Sand Martin (VU) - *Riparia riparia (Linnaeus, 1758):* it is a regular breeder and passage migrant in Italy, mainly distributed in the northern regions within the Po plains and along rivers of the northern Adriatic. It might be present on the island; its sighting will be considered in the analysis.
- Dartford Warbler (VU)- *Curruca undata (Boddaert,1783):* it is a regular breeder in Italy, with a population distributed in coastal areas from Liguria to Abruzzo, on the Tuscany archipelago and on the main islands. The Mediterranean population may migrate towards North Africa. As there are not enough data to establish if the taxon is either present or not in the island, but its presence in Sardinia is ascertained, it was decided to include it in the analysis.
- Stonechat (VU) - *Saxicola rubicola (Linnaeus, 1758):* it is a widespread and abundant breeder, a passage migrant and a winter visitor in Italy, where an estimated population breeds from the lower Alps southwards along the peninsula, on the main islands and on several small ones. As there are not enough data to establish if the taxon is either present or not in the island, but its presence in Sardinia is ascertained, it was decided to include it in the analysis.
- Northern Whetear (NT) -*Oenanthe Oenanthe (Linnaeus, 1758):* as there are not enough data to establish if the taxon is either present or not in the island, but its presence in Sardinia is ascertained, it was decided to include it in the analysis.
- Spanish Sparrow (VU)- *Passer hispaniolensis (Temminck,1820)*: the Spanish Sparrow is a regular breeder and a passage migrant in Italy, where it breeds extensively in Sardinia and Sicily, as well as in part of Apulia. As there are not enough data to establish if the taxon is either present or not in the island, but its presence in Sardinia is ascertained, it was decided to include it in the analysis.
- Yellow Wagtail (VU)- *Motacilla flava (Linnaeus, 1758):* it is a regular breeder and an abundant passage migrant in Italy, it breeds mainly across Po plain and along the peninsula, with higher densities in coastal areas of the central regions. It is also present in Sicily and Sardinia. As there are not enough data to establish if the taxon is either present or not in the island, but its presence in Sardinia is ascertained, it was decided to include it in the analysis.
- European Greenfinch (NT)- *Chloris chloris (Linnaeus, 1758):* it is a widespread and abundant breeder, a passage migrant and a winter visitor in Italy, the breeding population is distributed all across the country. As there are not enough data to establish if the taxon is either present or not in the island, but its presence in Sardinia is ascertained, it was decided to include it in the analysis.
- Eurasian Linnet (NT)- *Linaria cannabina (Linnaeus, 1758):* it is a widespread breeder and a regular passage migrant and a winter visitor in Italy. The evidence suggests that the during its winter migration the Eurasian Linnet, reaches Carloforte both from northeast and northwest. Its sighting will be included in the analysis.

- European Goldfinch (NT)- *Carduelis carduelis (Linnaeus, 1758):* it is one of the most widespread breeders in Italy, as well as a passage migrant and a winter visitor. During the winter migration towards Northen Africa the taxon crosses San Pietro Island form northwest towards southwest. Its sighting will be included in the analysis.

To verify the actual presence of these taxa in the island, the dataset containing the information of birds' presence on the island was downloaded from GBIF (GBIF, 2024) in its entirety. Data regarding the occurrences of every overcited bird species were found apart from data regarding the Eurasian Linnet and the Curlew Sandpiper. By further investigation, it was found that other birds' species were spotted on the island. Once again, the species were classified in IUCN categories, all the occurrences of species classified differently from *Least Concern* were included in the analysis. These were:

- The Eurasian stone curlew (VU) - *Burhinus oedicnemus (Linnaeus, 1758)*
- The Black crowned night heron (VU) -*Nycticorax nycticorax (Linnaeus, 1758)*

On the other hand, birds classified as *Least Concern* but whose presence is highly distributed over the island, were inserted in the analysis only if their behavior could have been impacted by the presence of an offshore turbine. These were:

- Little Egret (LC)- *Egretta garzetta (Linnaeus, 1758)*
- European Shag (LC) -*Gulosus aristotelis (Linnaeus, 1758)*
- Black winged stilt (LC)- *Himantopus Himantopus (P. L. Statius Müller, 1776)*
- Barn Swallow (LC)- *Hirundo rustica (Linnaeus, 1758)*

Once it was established which bird species would have been included in the analysis, it was possible to proceed with their implementation on QGIS software (see Figure 2-28).

The dataset of each birds' species contained occurrences from 2017 to 2023, hence, to make them relevant on a biological scale, the same process implemented for Eleonora's falcon was applied to each species' vector. A different raster was created from each different vector with QGIS tool "Rasterize (from Vector to Raster)". Having obtained a different raster for the data of every single year, they were unified into a unique raster with QGIS function "Cells Statistics". Once a unique raster was created it was necessary to transform it back into a shapefile, this process was performed with QGIS tool ("Cell statistics algorithm") which calculates a value for each cell in the output layer

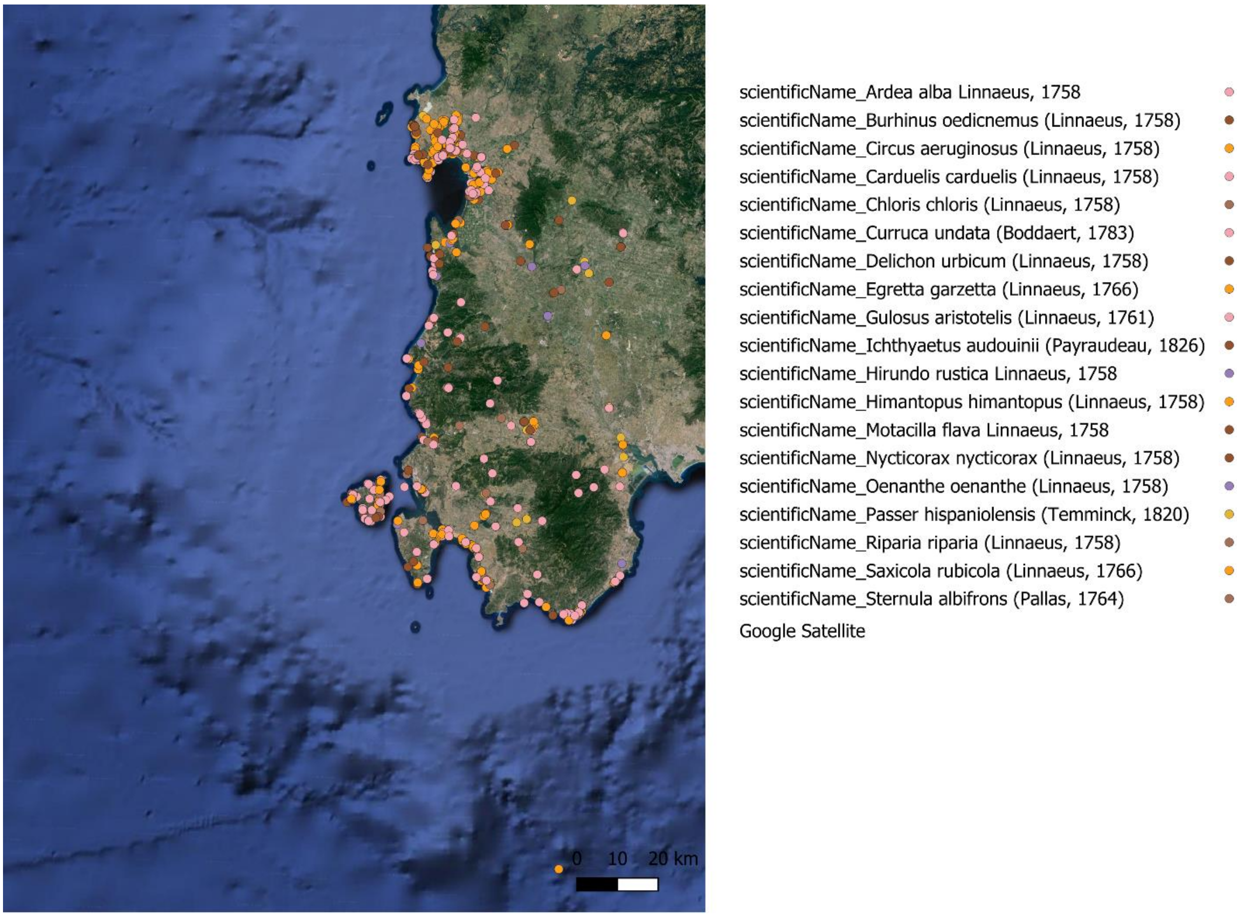

Figure 2-28- Birds data

2.4 Data results

The transformation of all the data in a unique file allowed their comparison and their merging into a single layer. There are some data that represent areas of exclusion, meaning that the possibility of building an offshore wind turbine in those regions is null. The exclusion areas are the following:

- Posidonia beds
- Rocky shoals
- Loggerhead Turtle's nest

Posidonia beds constitute a habitat inserted in Annex 1 list of Europe's Habitats directive, which consists of a series of measures that must be taken to preserve European flora and fauna(Commissione Europea, 1992). Neither the *L. glaberrima* present on Carloforte Shoal nor the habitats that the shoals constitute are inserted in Annex 1 list. Nevertheless, it was deemed appropriate to exclude these areas from the analysis to preserve the nesting areas. The construction of an offshore wind turbine would, in fact, permanently impact these regions.

The Loggerhead Turtle is classified on IUCN Red List (IUCN, 2024) as Vulnerable, therefore also its nesting area was excluded from the analysis.

These areas mentioned above were excluded from the analysis using two QGIS tolls. The first to be used was "Extract selected elements", which creates a layer with the data, previously selected, of an initial layer. "Difference (multiple)" tool was used to subtract from the grid the layer created from the extracted element. Once the real grid is formed, it possible to unify all the layers already transformed in shapefile format. These are added to the real grid by means of the QGIS tool "Merge attribute by position". This algorithm takes an input vector layer (the real grid) and the layer that has to be merged. It creates a new vector layer that contains in its attribute table the original vector and the additional attributes contained in the second layer (QGIS, 2024).The result is shown in Figure 2-29.

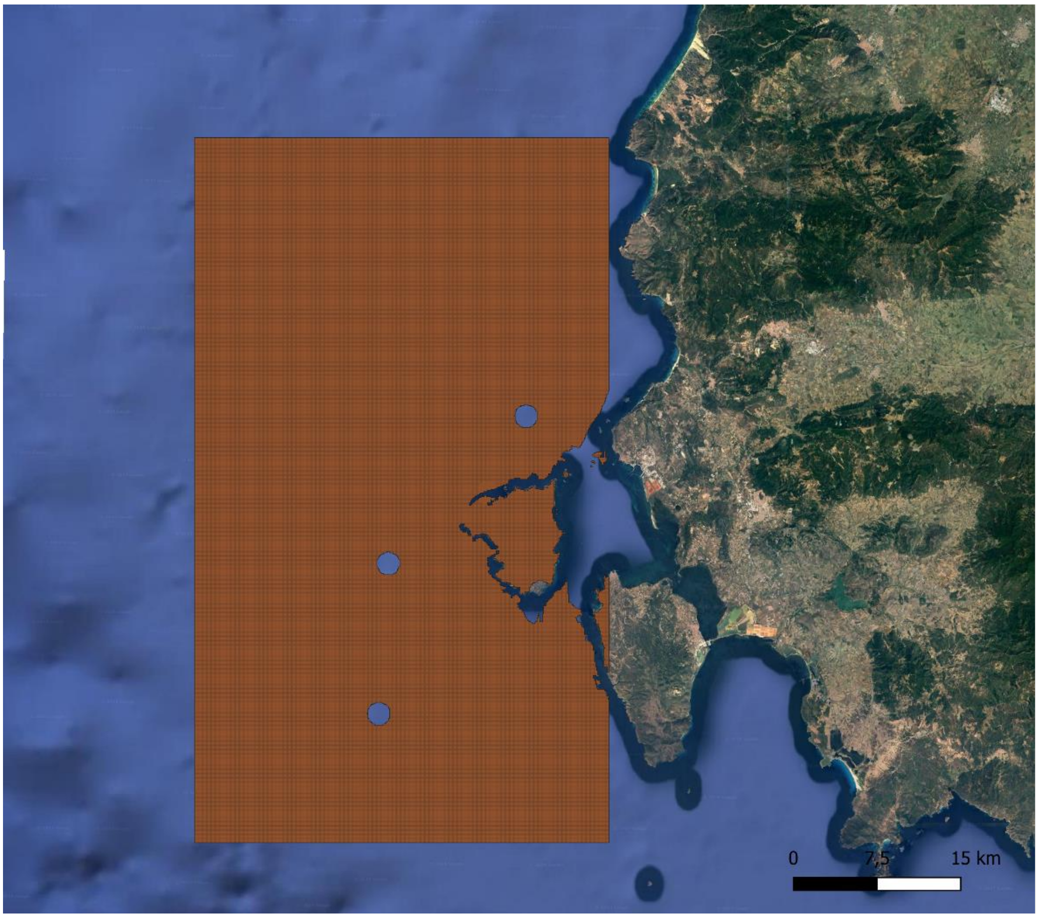

Figure 2-29- Cut out grid

The attribute table of the unified layer will be exported as a csv file and used in the next steps of the analysis. The csv file contains an id column, that reports for each point an identifying code, while the rest of the columns reports information respectively of:

- Vessel per hour per square hour per km
- ABTF feeding habitat
- Blue Shark feeding habitat
- Fin Whale feeding habitat
- Eleonora's Falcon occurrences
- Striped Dolphin occurrences
- Great White Egret occurrences
- Eurasian Stone Curlew occurrences
- European Goldfinch occurrences
- Western Marsh Harrier occurrences
- European Greenfinch
- Dartford Warbler
- Little Egret
- European Shag
- Black winged stilt
- Barn Swallow
- Audouin's Gull
- Yellow Wagtail

- The Black crowned night heron
- Northern Whetear
- Spanish Sparrow
- Sand Martin
- Stonechat
- Little Tern
- ABFT spawning habitat
- Seabed integrity
- Permanent tuna traps
- Seasonal tuna traps

3 Multicriteria method analysis

Multi-criteria analysis (henceforward, MCA) comprehends different classes of methods, techniques and tools that explicitly consider multiple objective and criteria in decision making problems (Dean, 2020). Thus, being the present study an analysis that comprises multiple factors, each of different importance and typology, it was necessary to implement an MCA to include them all. The method used is the Criteria Importance Through Intercriteria Correlation (henceforward, CRITIC), it aims to determine the objective weights of relative importance in MCA problems (Diakoulaki et al., 1995) .

Figure 3-1 shows the steps taken to perform the analysis, thus, to identify the most suitable area for the implementation of an OWT. Except for the steps of "Data collection", "Data processing" and "Unified dataset", which were already described in paragraphs 2.1, 2.2 and 2.3, the remaining blocks will be described in the following paragraphs.

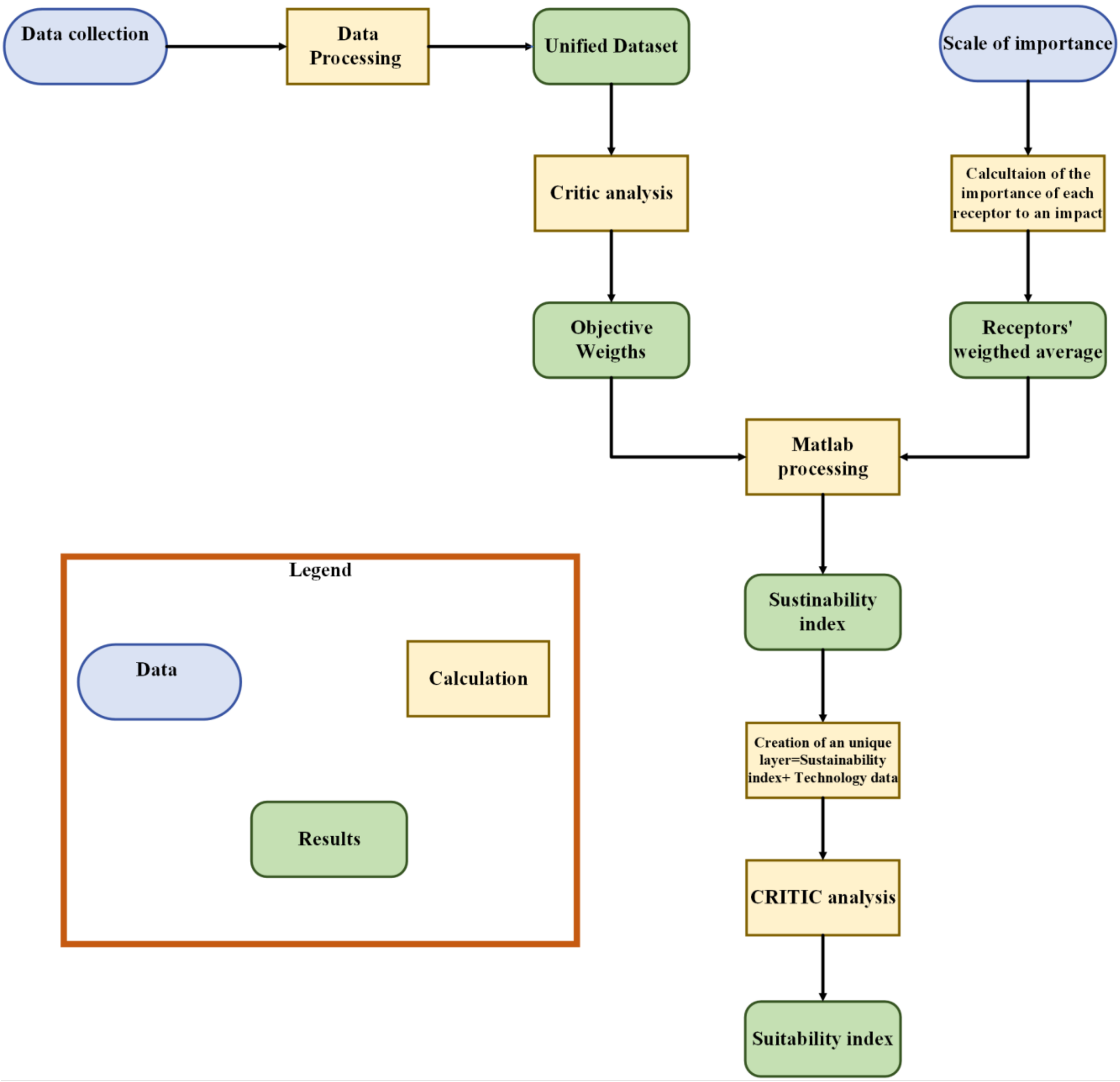

Figure 3-1 Workflow

3.1 CRITIC analysis for objective weights

As said, the transformation of the data in a unique format allowed their unification in a single dataset. However, the processing of the data did not change their significance, hence, each dataset contains very different information with different importances.

Thus, the first step was finding an objective measure that made them comparable and allowed to use them in mathematic calculation. This was done by calculating the objective weights of each dataset through the CRITIC method. The steps of the method are summarized below.

Diakoulaki et al., 1995 affirms that given a finite set *A* of *n* alternatives and a system of *m* evaluation criteria f_j, the general form of a multicriteria problems is the one that follows:

$$MAX\ \{ f_1(a), f_2(a), .., f_2(a) / a \in A \}$$

Equation 3

For every criterion f_j it is defined a function x_j that maps the values of f_j in the interval [0,1], this is possible thanks to the concept of ideal point f_j^*. Thus, Equation 4 expresses the distance of the alternative a from the ideal value f_j^*, which is the best performance for criterion *j* and the furthest point from the anti-ideal value f_{j*}, that represent the worst performance in criterion *j* (Diakoulaki et al., 1995).

$$x_{aj} = \frac{f_j(a) - f_{j*}}{f_j^* - f_{j*}}$$

Equation 4

By doing so, the initial matrix of evaluations is transformed into a matrix of relative scores with generic element x_{ij}: examining the *jth* criterion in isolation a vector x_{ij} is generated. The latter denotes the scores of all the *n* alternatives considered, and it is characterized by the standard deviation σ_j which represents the contrast intensity of the corresponding criterion (Diakoulaki et al., 1995).

The successive step of the CRITIC method consists in building a square matrix (*m* x *m*) containing the linear correlation coefficient (r_{jk}) between the vector x_j and x_k. r_{jk} is lower when the scores of the alternatives in criteria *j* and *k* are discordant. Now, the amount of information contained in the *jth* criterion can be determined by composing the measures expressed in the following way:

$$C_j = \sigma_j * \sum (1 - r_{jk})$$

Equation 5

The higher the value of C_j the larger the amount of information contained in the corresponding criterion, hence, the higher its relative importance for the decision-making process. To obtain the objective weights (w_j) of each criterion the following normalization is applied (Diakoulaki et al., 1995):

$$w_j = \frac{C_j}{\sum_{k=1}^{m} C_k}$$

Equation 6

CRITIC analysis was implemented on Matlab, a programming language used to perform calculations with matrixes and arrays (MATLAB, 2024). The unified dataset was imported on Matlab as a matrix having as dimensions the number of elements considered in the analysis and the number of points of the grid.

For each parameter its best and worst values were evaluated to estimate x_{aj}(Equation 4). Once x_{aj} vectors were created for each element, they were unified in a single matrix (X_{aj}), then the coefficient of correlation was estimated for X_{aj}. By implementing a for loop[12] over the columns of X_{aj}, a vector containing the values of C_j of each element was estimated.

The objective weights of each element were estimated by applying Equation 6 in a for loop over the columns of X_{aj}.The results of the process are reported in Table 4, they are the objective weights calculated for each criterion.

Vessel per hour per square km	ABTF feeding habitat	ABTF spawning habitat	Blue Shark feeding habitat	Fin whale feeding habitat	Eleonora's falcon	Striped Dolphin	Great White Egret
0.0125	0.1660	0.1655	0.1655	0.1122	0.0833	0.0010	0.0072
Eurasian stone curlew	European Goldfinch	European Greenfinch	Western Marsh Harrier	Dartford Warbler	Northen House Martin	Little Egret	European Shag
0.0073	0.0091	0.089	0.0104	0.0091	0.0075	0.008	0.0036
Black winged stilt	Barn Swallow	Audonis' Gull	Yellow Wagtail	Black crowned night heron	Northern Whetear	Spanish Sparrow	Sand Martin
0.0082	0.0081	0.0053	0.0069	0.0056	0.0086	0.0065	0.0102
Stonechat	Little tern	Seabed	Seasonal tuna traps	Permanent tuna traps			
0.01020	0.0050	0.1577	0.0261	0.0262			

Table 4- Objective Weights

3.2 Use of GES as data clustering

In the left part of Figure 3-1 there are shown the first steps of the analysis concerning the data processing and the CRITIC methodology. Looking at the right, the first step is "Scale of importance", which is the passage in which the effects of the different impacts on a specific receptor are estimated.

The first step for the understanding of the impacts' importances consisted in identifying the stressors concerning an OWT. As anticipated in paragraph 1.1, there are different impact concerning each of the three phases in which the lifecycle of an OWT is divided: construction, operation and decommissioning. Table 5 summarizes the impacts there were considered in the present analysis:

Construction					
Vessel: noise	Vessel: pollution	Mooring: noise	Mooring: seabed integrity	Cable: routing	OWT: obstruction

Operation									
Turbine: noise	Turbine: bird strike	Turbine: bird displacement	Mooring: Metallic pollution	Substructure: Reef effect	Substructure + mooring: Fish entanglement	Substructure + mooring: noise	Substructure + mooring: Spillover effect	Cable routing: EMF	OWT: obstruction

[12] In Matlab a for loop is used to repeat a group of statements a specified number of times

Decommissioning					
Vessel: noise	Vessel: pollution	Mooring: noise	Mooring: Pollution	Cable removing: seabed integrity	OWT: obstruction

Table 5- Impacts included in the present analysis

Once the impacts were identified a scale to evaluate their importance for each receptor was needed. Zarzavilla et al., 2022 presented the "Scale of importance" which identifies ten "Aspects" each with a "Weighting", hence, ten qualities to which a numerical scale is assigned.

The numerical scale is a geometric sequence[13] with common ratio 2. The qualities considered by Zarzavilla et al., 2022 and the scales associated to each of them are summarized in Table 6.

Qualities	Description	Scale
Intensity (IN)	It indicates the incidence of the action	Low:1 Medium:2 High:4 Very high: 8
Extension (EX)	The area of incidence of the impact	Punctual:1 Partial:2 Extensive:4
Moment (MO)	It is the time that elapses between the occurrence of the impact and the manifestation of its effects	Long:1 Medium:2 Immediate:4
Persistence (PE)	It indicates the time between its appearance and the time the environment returns to its initial conditions	Fleeting: 1 Temporary: 2 Permanent: 4
Reversibility (RV)	It refers to the possibility of reconstruction of the affected environmental factor	Short-term:1 Medium-term:2 Irreversible:4
Synergy (SI)	It indicates that the manifestation of the single effects acting simultaneously has a greater impact than the ones separately created by the effects	No synergy:1 Synergy: 2 Very synergistic:4
Accumulation (AC)	It concerns the increase of the manifestation of the effects whenever the source than generates them persists	Simple:1 Cumulative:4
Effect (EF)	It refers to the way an impact affects the receptors	Indirect:1 Direct:4
Periodicity (PR)	It refers to the manifestation in time of the effect	Not predictable:1 Regular or periodic:2 Continuos:4
Recoverability (MC)	Possibility of total or partial reconstruction of the environment as a consequence of the project	Immediate:1 Medium-term;2 Mitigable:4 Irrecoverable:8

Table 6- Scale of importance

[13] Knowing the first element a_1 and the common ratio q each element a_k is calculated as: $a_k = a_1 * q^{k-1}$

A few changes have been made to adapt the scale to the present case. The changes are reported below:

- The scale of the “Extension” was modified by changing the scale indicators and adding the field “International”
- The scale of the “Persistence” was modified by changing the scale indicators and adding the attribute “Not persistent”
- The scale of the “Reversibility” was changed by adding the case “long-term”
- The scale of the “Synergy” was changed by removing the option “synergy”
- The quality “Vulnerability” was added

As to the added quality, the vulnerability, it was introduced to give different weight depending on the relevance of each receptor. The vulnerability expresses a property intrinsic to the receptor which, if impacted by a stressor, might bring important change to the environment. In this way by assigning to the quality “vulnerability” a four-level rating scale, that goes from “neutral” to “highly vulnerable”, it is possible to give different relevance to receptor that have a similar distribution but a different significance for the environment.

Table 7 shows the new scale, the changes made allows to better adapt the qualities and their ranking to the present study.

Qualities	Description	Scale
Intensity (IN)	It indicates the incidence of the action	Low:1 Medium:2 High:4 Very high: 8
Extension (EX)	The area of incidence of the impact	Local:1 Municipal:2 Regional:4 National:8 International:12
Moment (MO)	It is the time that elapses between the occurrence of the impact and the manifestation of its effects	Long:1 Medium:2 Immediate:4
Persistence (PE)	It indicates the time between its appearance and the time the environment returns to its initial conditions	Not persistent:1 Temporary:2 Persistent: 4 Permanent:8
Reversibility (RV)	It refers to the possibility of reconstruction of the affected environmental factor	Short-term:1 Medium-term:2 Long-term:4 Permanent:8
Synergy (SI)	It indicates that the manifestation of the single effects acting simultaneously has a greater impact than the ones separately created by the effects	No synergy:1 Very synergistic:4
Accumulation (AC)	It concerns the increase of the manifestation of the effects whenever the source than generates them persists	Simple:1 Cumulative:4
Effect (EF)	It refers to the way an impact affects the receptors	Indirect:1 Direct:4
Periodicity (PR)	It refers to the manifestation in time of the effect	Not predictable:1 Regular or periodic:2 Continuos:4

Recoverability (MC)	Possibility of total or partial reconstruction of the environment as a consequence of the project	Immediate:1 Medium-term;2 Mitigable:4 Irrecoverable:8
Vulnerability (VU)	Intrinsic quality of the receptor that if impacted results in a loss to the ecosystem	Neutral:1 Vulnerable:2 Medium- highly Vulnerable:4 Highly Vulnerable:8

Table 7- Modified scale

Once the scale was created the next step was to calculate the importance of each receptor with the following equation (Zarzavilla et al., 2022):

$$Importance\ (I) = \mp 3IN \mp 2EX \mp MO \mp PE \mp RV \mp SI \mp AC \mp EF \mp PR \mp MC \mp VU$$

Equation 7

In Equation 7 the sign depends on the effect of the impact: the sign minus was used whenever the impact had a positive effect on the receptor, while the sign plus was used whenever the impact had a negative effect on the receptor. It must be noted that the first two qualities, the intensity and the extension, are multiplied respectively for 3 and 2, by doing so a different relevance is assigned to them. In fact, as the parameters are arithmetically summed, they all have the same weight in the estimation of the importance except for the ones mentioned before. They both indicate the incidence of an impact, which is the most important aspect to consider: the first expresses it in terms of magnitude of the effects, the second in terms of geographical extension of the effects.

To make the calculation of the importance, the receptors were firstly divided and clustered according to the GES class they belong to. As explained in Chapter 2, the rationale behind the data retrieval was dictated by the GES directive which divides in eleven classes the marine environment factors that must be considered for an environmental impact assessment of an offshore facility.

As said, the classes considered in the present study are four out of the eleven present in the directive, these are: GES1, GES3, GES6 and GES11. Below a recap of the dataset belonging to each of them.

GES 1 Marine biodiversity:

- ABTF feeding habitat
- ABTF spawning habitat
- Blued Shark feeding habitat
- Fin Whale feeding habitat
- Striped Dolphin
- Eleonora's Falcon
- Great White Egret
- Eurasian stone curlew
- European Goldfinch
- European Greenfinch
- Wester Marsh Harrier
- Dartford Warbler
- Northen House Martin
- Little Egret
- European Shag
- Black Winged Stilt
- Barn Swallow
- Audoni's Gull
- Yellow Wagtail
- Black Crowned Night Heron

- Northen Whetear
- Spanish Sparrow
- Sand Martin
- Stonechat
- Little tern

GES 3 Commercial Fish and Shellfish:

- Permanent tuna traps
- Seasonal tuna traps

GES 6 Seabed Integrity:

- Seabed

GES 11 Energy Including Underwater noise

- Vessel traffic

Since there are 29 receptors to consider, gathering the dataset in “GES-clusters” allowed to identify some peculiarities of the different groups, especially for GES1 and GES 11.

As to GES 1, it was necessary to distinguish between the different vulnerabilities of the bird species which have a similar distribution but different relevance for the environment. The impact an OWT has on them is similar, however, the severity of the damage it has on a species rather than on another must be considered. Hence, a scale was created: it gives high relevance to raptors, medium-high relevance to seabirds, medium relevance to long migratory birds and standard relevance to the rest of the species. The rationale behind this choice is linked to what reported in paragraph 1.1.4, in fact, raptors are the species more prone to collision risk due to their flight behavior. On the other hand, seabirds hunting behavior can be pressured by an offshore facility. Long migratory birds, instead, being not permanent in the area might not understand the risk that the turbine creates, moreover their migratory routes might be deflected by the turbine if the species presents an “avoidant behavior”. The species belonging to the abovementioned classes are:

- Raptors: Eleonora’s Falcon and Wester Marsh Harrier
- Seabirds: European Shag, Black Winged Stilt, Audoni’s Gull and Little tern
- Long migratory birds: Yellow Wagtail, Black Crowned Night Heron, Northen Whetear and Sand Martin

Since the quality “Vulnerability” has been added, this scale was applied by considering raptors as “highly vulnerable”, seabirds as “ medium-high vulnerable”, long migratory birds as “vulnerable” and the remaining species as “ neutral” or “ vulnerable” when IUCN (IUCN, 2024) classified them as “Vulnerable” or “ Near threatened”.

As to GES 11, it is the only one in which the impact “OWT: obstruction” has an importance different than zero. This GES-cluster contains the receptor “Vessel traffic” which is the only impacted by the obstruction that the OWT constitutes. In fact, due to the presence of the substructure and the moorings, the vessel traffic is either prohibited or diminished around the OWT perimeter.

The scale reported in Table 7 was applied to each receptor undergoing all the impacts described in Table 5, therefore, a different importance resulted for each stressor applied to each element considered in the analysis. Hence, depending on the knowledge acquired regarding the response of each receptor to a particular stressor, the scale of importance was evaluated and the importance (xi) calculated by applying Equation 7.

Once the importances of each receptor undergoing the different impacts were evaluated, the second step was calculating the standard deviation σ. The latter was calculated with the excel function “STDEVPA”, which, by selecting the numerical values given to each quality, computed the standard deviation.

The purpose of this part of analysis is evaluating the weighted average (w_a) of each receptor, Equation 8 shows how it is computed. For each receptor it was evaluated the ratio between the sum of the ratio of the importance over the standard deviation, and the sum of the inverse of the square of the standard deviation. The letter k indicates the number of stressors, as said, in fact, both the importance and the standard deviation were calculated for each receptor undergoing the impacts reported in Table 5.

$$w_a = \frac{\sum_{i=1}^{k} \frac{xi}{\sigma i}}{\sum_{i=1}^{k} \frac{1}{\sigma i^2}}$$

Equation 8

In addition to the weighted average also the weighted standard (w_s) was evaluated (as reported in Equation 9) by considering the maximum and minimum values of the scale which were respectively set to 100 and -100. The maximum was calculated with Equation 7, the values chosen to be used in the equation were the maximum levels of each quality[14]. Since the importances can be positive or negative depending on the effect that the impact has on the receptor, the scale must be specular to zero, this is why the minimum value is -100.

$$w_s = \frac{(w_a - minimum)}{(maximum - minimum)}$$

Equation 9

All the obtained results are reported in the table below:

GES 1	ABTF FH	ABTF SH	Blue Shark FH	Fin Whale FH	Striped Dolphin	Elonora's Falcon	Great White Egret	Eurasian stone curlew
w_a	20.185	19.879	22.557	22.773	22.840	13.491	8.918	8.918
w_s	0.601	0.599	0.613	0.614	0.614	0.568	0.545	0.545
	European Goldfinch	European Greenfinch	Wester Marsh Harrier	Dartford Warbler	Northen House Martin	Little Egret	European Shag	Black Winged Stilt
w_a	9.713	9.713	14.330	9.253	9.713	9.713	11.403	11.403
w_s	0.549	0.549	0.572	0.546	0.549	0.549	0.557	0.557
	Barn Swallow	Audoni's Gull	Yellow Wagtail	Black Crowned Night Heron	Northen Whetear	Spanish Sparrow	Sand Martin	Stonechat
w_a	9.713	11.403	7.565	7.565	8.772	9.253	7.565	9.253
w_s	0.549	0.557	0.538	0.538	0.544	0.546	0.538	0.546
	Little tern							
w_a	9.874							
w_s	0.549							

Table 8- Results for GES1- cluster

[14] $maximum = 3\,max(IN) + 2\,max(EX) + max(MO) + max(PE) + max(RV) + max(SI) + max(AC) + max(EF) + (PR) + max(MC) + max(VU) = 24 + 24 + 4 + 8 + 8 + 4 + 4 + 4 + 4 + 8 + 8 = 100$

GES 3	Permanent Tuna trap	Seasonal tuna trap
w_a	21.683	21.683
w_s	0.608	0.608

Table 9- Results for GES3- cluster

GES 6	Seabed
w_a	22.281
w_s	0.611

Table 10- Results for GES 6- cluster

GES 11	Vessel traffic
w_a	32.507
w_s	0.663

Table 11- - Results for GES 11- cluster

3.3 Sustainability index

Looking at Figure 3-1, once the objective weights and the weighted averages were found the step "Matlab processing" is the next passage needed to find the sustainability index. In order to calculate the sustainability index, the first step was to evaluate the weighted norm (n_w) of each receptor which is estimated on Matlab by applying Equation 10: it is evaluated as the multiplication of the weighted standard with the objective weights.

Table 12, Table 13, Table 14 and Table 15 show the resulted of the weighted norm obtained for each cluster of data.

$$n_w = w_s * w_j$$

Equation 10

GES 1	ABTF FH	ABTF SH	Blue Shark FH	Fin Whale FH	Striped Dolphin	Elonora's Falcon	Great White Egret	Eurasian stone curlew
n_w	0.0624	0.0995	0.1014	0.0689	0.00512	0.0006	0.0039	0.004
	European Goldfinch	European Greenfinch	Wester Marsh Harrier	Dartford Warbler	Northen House Martin	Little Egret	European Shag	Black Winged Stilt
n_w	0.005	0.0049	0.0059	0.005	0.0041	0.0044	0.002	0.0046
	Barn Swallow	Audoni's Gull	Yellow Wagtail	Black Crowned Night Heron	Northen Whetear	Spanish Sparrow	Sand Martin	Stonechat
n_w	0.0045	0.003	0.0037	0.003	0.0047	0.0036	0.0055	0.0055
	Little tern							
n_w	0.003							

Table 12- Results of nw for GES1-cluster

GES 3	Permanent Tuna trap	Seasonal tuna trap
n_w	0.0159	0.0159

Table 13- Results of nw for GES3-cluster

GES 6	Seabed
n_w	0.0964

Table 14- Results of nw for GES6-cluster

GES 11	Vessel traffic
n_w	0.0083

Table 15- Results of nw for GES11-cluster

As for the application of the CRITIC method (paragraph 3.1), the unified dataset was imported on Matlab as a matrix called "Alternative matrix". The Alternative matrix was used to build an identical matrix (the "Binary matrix") in which the values of the Alternative matrix different from zero were substituted with 1 and the values equal to 0 remained unvaried.

In this way the Binary matrix indicates whenever a receptor is present or not in the points of the grid. By multiplying the Binary matrix with the vector containing the different n_w a matrix of the weighted norm of each receptor is obtained. Next, by implementing a for loop over the points of the created matrix, the sustainability is calculated as reported in Equation 11Equation 11: it is equal to 1 minus the sum of the weighted norms present in that point.

$$Sustainability = 1 - \sum_{i=1}^{k} n_{w,i}$$

Equation 11

The last step in the creation of the sustainability index, is to create a matrix that has the identifier of the points in the first column and the sustainability in the second. In this way a CSV file can be created and exported on QGIS. Once the index is exported on QGIS thanks to the function "Join" the Sustainability index is attached to the grid layer, in this way a georeferenced Sustainability index is obtained.

3.4 Suitability index

Once the most sustainable areas are found, it is necessary to add the layers regarding the technology: the bathymetry and the AEP layers. With QGIS tool "Merge attribute by position" the bathymetry and AEP layers were merged with the sustainability layer.

From the merged layer the points covering the land were removed. The choice was dictated by the impossibility of considering "suitable" the land area, the analysis is, in fact, mostly concentrated on the elements concerning the marine environment, for it is devoted to the assessment of the environmental impact of an OWT. This step was not made before because most of the birds' hotspots were found on shore, most of the occurrences, in fact, are spotted from the land, therefore, the coordinates associated with them are on the mainland. Moreover, the bird ringing and recapturing are recorded on land.

Another reason that corroborates the choice of excluding the mainland, is given by the bathymetry layer which, of course, does not cover that area. Therefore, performing an analysis that considers layers with different spatial extension would give biased results. Hence, despite the high relevance that the land has for the sustainability, the ultimate purpose of the present study is to find a suitable area for an offshore wind turbine, therefore the mainland must be excluded. The exclusion is performed thanks to QGIS tool "Difference", which removed from the previously unified dataset the area covered by the land.

This second unified dataset was imported on Matlab software as a matrix. A second CRITIC analysis was performed: the best and worst values of the three factors were selected to compute x_{aj} (Equation 4).

As for the first CRITIC method, the vectors were unified in a single matrix (X_{aj}) and its correlation coefficient was computed. With a for loop over the columns of X_{aj}, the vector containing C_j was calculated and, with it, the values of the objective weights that are reported in Table 16.

In accordance with what was expected, the parameter that has a higher objective weight is the sustainability, followed by the bathymetry and the AEP. The sustainability is, in fact, the parameter whose values are highly variable, hence, whose standard deviation is higher.

As reported in Equation 5 and Equation 6, the objective weight depends on the parameter C_j which is directly proportional to the standard deviation, therefore the objective weight increases with the variability of a parameter.

On the other hand, the bathymetry objective weight is also highly relevant as the bathymetry is also variable, conversely the AEP has a less relevant objective weight, for it is mostly constant over the sea.

Sustainability	Bathymetry	AEP
0.5229	0.3162	0.1609

Table 16- Objective weights values

The aim of this second CRITIC method is to estimate the values of the scores, which are equal to the sum of the total objective weights of each parameter times X_{aj}. To do so a nested for loop[15] was implemented: the first loop is implemented over the rows of X_{aj} while the second over the columns, at each cycle of the second loop the sum of the objective weights present in the columns is multiplied by the valued of X_{aj} in that specific position.

The result is a vector having as dimension the number of rows of X_{aj}. This vector represents the suitability. It contains the information that allow to understand which part of the area under analysis is more suitable, under an environmental and technical view, for the construction of an OWT.

The last step consists in creating a matrix that has the id of the points in the first column and the suitability on the second, it is then exported as a CSV file on QGIS. When on QGIS, the file is attached to the grid layer by means of “Join” function, this step allows to create a georeferenced suitability index.

[15] It consists of loop inside another loop. The inner loop runs completely every time while the outer runs once. It is used to deal with multi-dimensional data structures like matrices or tables.

4 Results

4.1 OWT most sustainable site

As reported in paragraph 3.3 the last step for the creation of the sustainability index was the creation of a georeferenced layer by means of QGIS. The realization of the latter allows the layer to be plotted: Figure 4-1 shows the Sustainability index of the area under analysis: it ranges between 0.562 and 1, the closer it is to 1 the more it is sustainable.

The sustainability index presents a very fragmented behavior, indicating areas that change the value of the sustainability within few meters. This "patchy" trend is due to the different typologies of species and their different distribution all over the area. In particular, thanks to the vulnerability quality that contributed to the estimation of the importance of each receptor, this fragmented trend is even more enhanced.

The division of the area in many different sub-areas, each with a different sustainability value, has a positive implication for the present study, in fact, due to this peculiarity, it is possible to identify multiple sustainable areas.

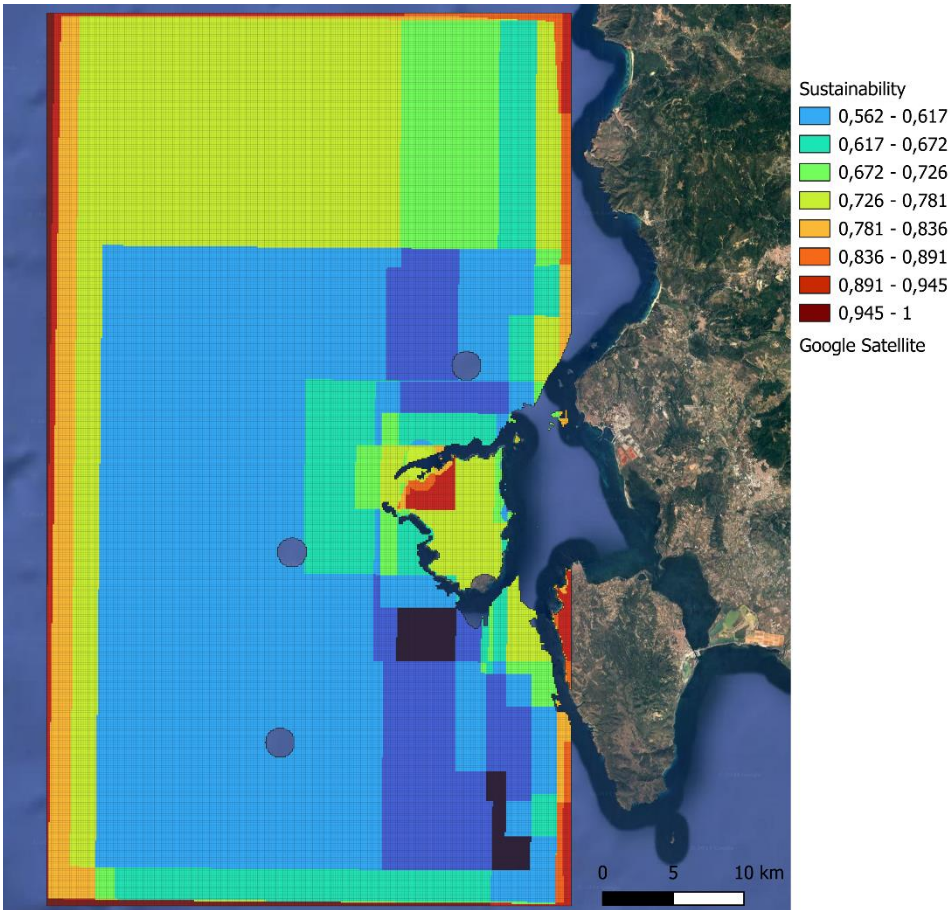

Figure 4-1- Sustainability index

Figure 4-2 shows the area that resulted to be more sustainable, they are highlighted by red dotted lines. There are in total six areas in which the sustainability index is close to 1, these are the zones in which the installation of an OWT would be less impactful.

Five out of the six identified zones are located on the borders of the rectangle delimiting the area of interest, this is because the presence of species is lower, and the seabed condition are more favorable being only mud or sandy mud.

On the other hand, the sixth area is on the mainland, in the portion of space that is not occupied by any bird's species. It might seem unlikely that a suitable area resulted to be on the mainland, however, the presence of this zone confirms the solidity of the method which, in fact, investigated for the most part the marine environment. Therefore, having just the data about the birds' presence on the mainland resulted in a higher suitability value.

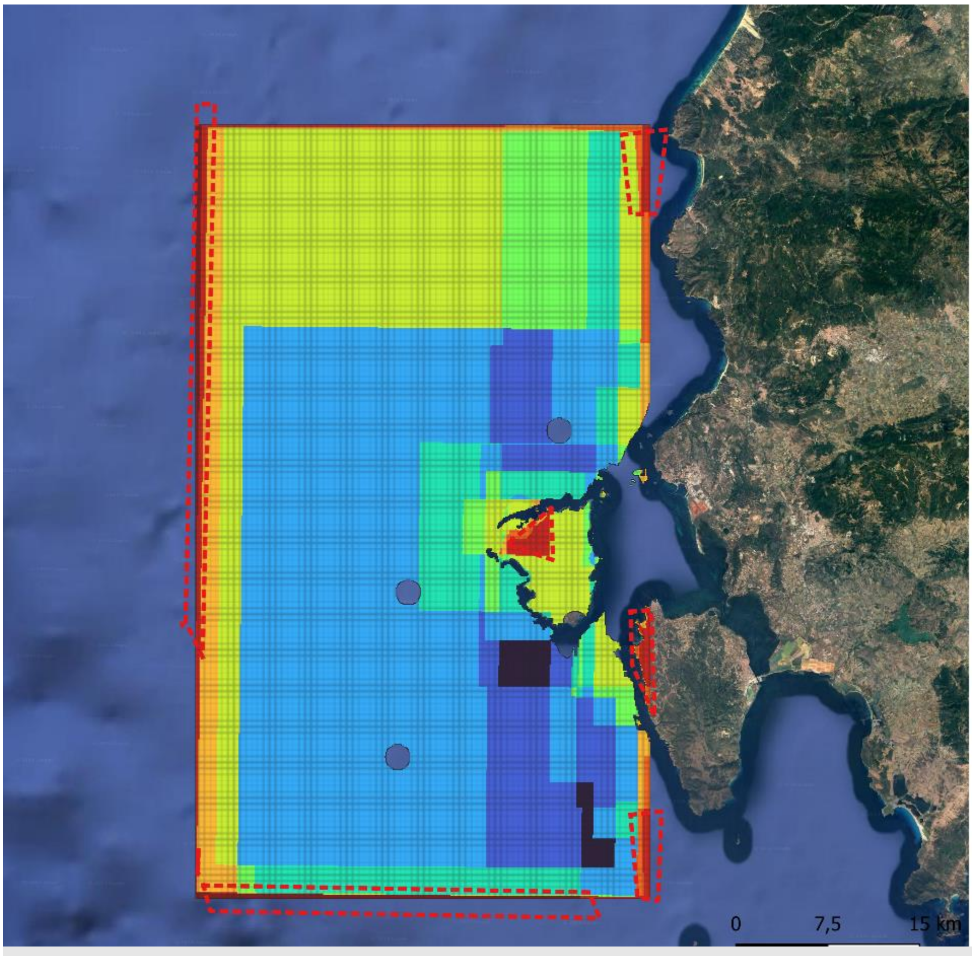

Figure 4-2- Sustainable areas

4.2 OWT most suitable site

Figure 4-3 shows the suitability index from which it is possible to deduce the best site for the construction of an OWT.

The suitability index ranges between 0.261 and 0.893, which are respectively the best and worst values. As anticipated in paragraph 3.4, the suitability strongly depends on the sustainability index and on the bathymetry.

Looking at Figure 2-19- Bathymetry (page 39) and Figure 2-19Figure 4-1- Sustainability index (page 63), it is possible to make a comparison between them and the suitability index represented in Figure 4-3. The suitability index plot clearly shows the same contour lines visible on the bathymetry layer, moreover the presence of suitable areas very close to the coast can be explained by the selection of " best" and "worst" values chosen in the CRITIC analysis described in paragraph 603.4.

The best value chosen for the bathymetry was, in fact, the smallest, hence the closest to the coastline, for lower bathymetry values are preferrable under an economic and technical point of view. Indeed, having a shorter distance between the floating substructure and the seabed surface implies shorter moorings lines and electrical cables, which would make the installation and maintenance easier and more feasible under an economic perspective.

On the other hand, the strong influence of sustainability index in the choice of the best-site can be seen in the fragmentation of the map representing the suitability index (Figure 1-1Figure 4-3). The suitability map shows a patchy behavior similar to the one visible in Figure 4-2Figure 4-1, this fragmentation implies that there is more than one area suitable for the installation of an OWT.

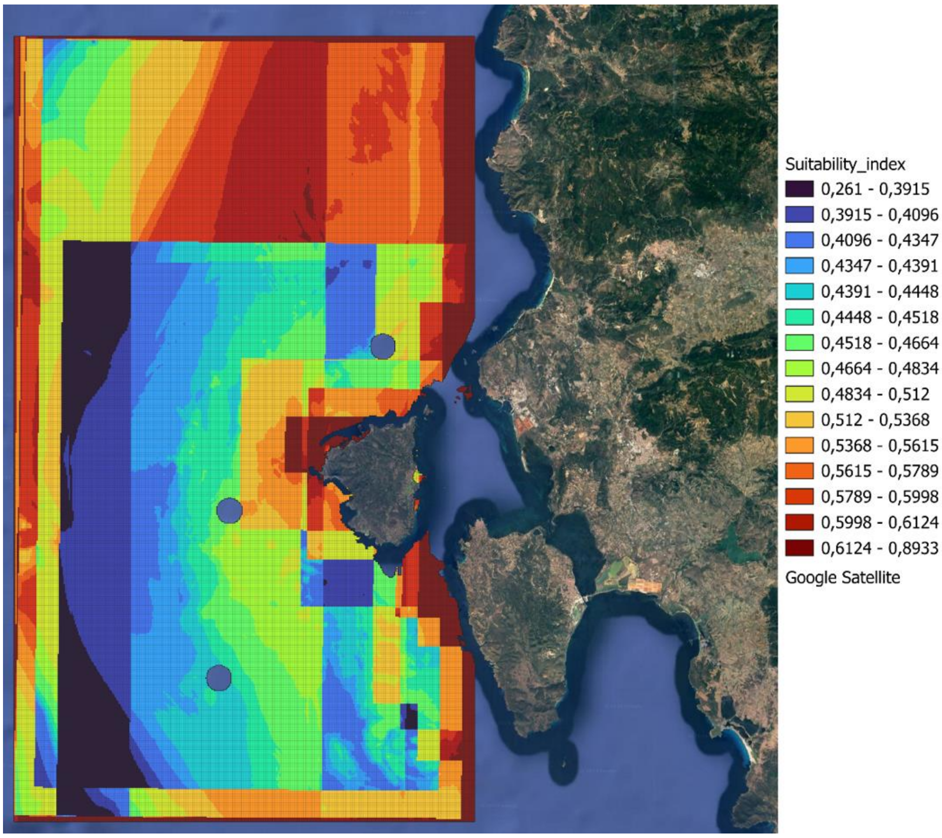

Figure 4-3- Suitability index

In Figure 4-4 the most suitable sites are highlighted by black dotted lines: seven are the sites identified to be suitable for a OWT installation around the perimeter of San Pietro Island.

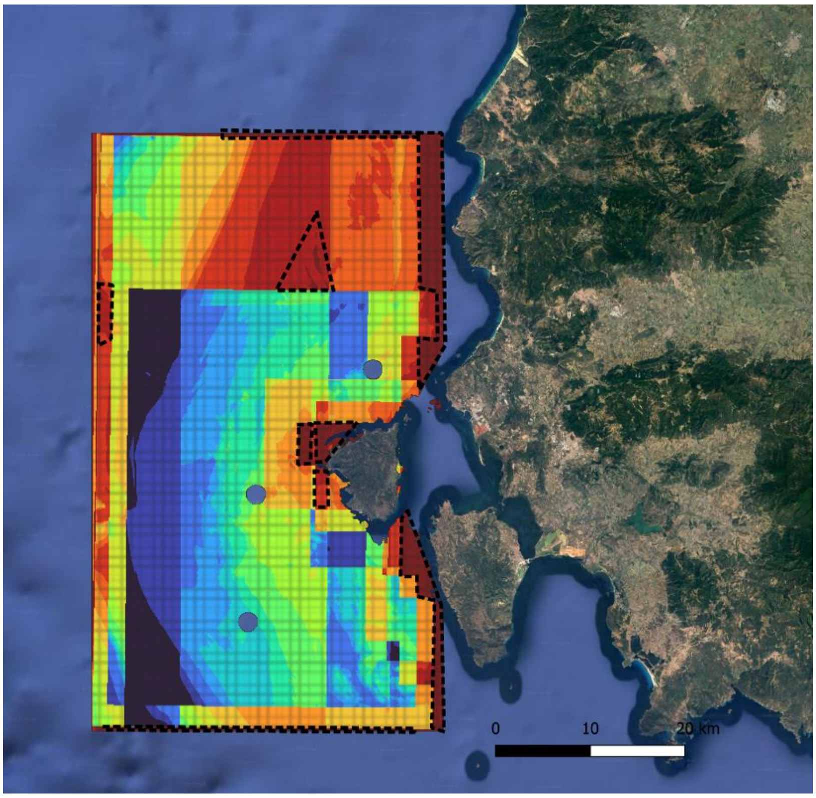

Figure 4-4- Most suitable sites

As the study brought to the identification of multiple suitable sites a rationale must be established to choose the optimal option.

The choice of the most suitable area among the ones mentioned can be supported by the socio-economic impact that the OWT would have. Two are the aspects to consider: the intervisibility and the initial cost of investment, more specifically, the cost of submarine power cables. The former refers to the condition where two or more objects can be seen from each other's position. According to Moscoloni et al., 2024, under clear sky conditions, only 50% of a target's size is visible from a distance of 10 km. Consequently, a target located 10 km away does not constitute a visual obstacle.

On the other hand, submarine cables represent the largest cost factor when estimating the initial investment cost for any offshore installation (Giglio et al., 2023). Moreover, Giglio et al., 2023 affirms that there are different cost functions that can be used to estimate the total price of a submarine cables, they can depend on the voltage the cables are designed to carry or the materials the latter are made of. As to the function chosen by Giglio et al., 2023, it links the reference cost of 200 $\frac{€}{m}$ to the voltage. Hence, even if the cables' voltage dimensioning is above the scope of this analysis, it is reasonable to assume that the distance between the site of the OWT and the mainland, where the power is brought to be used, has a high relevance in the initial economic investment of the project: the greater the distance the higher the cables' cost.

Therefore, distance has both a positive and negative relevance when considering intervisibility and initial cost of investment. To find the mathematical optimum that combines these two aspects a multi-objective model should be built. However, since the estimation of the intervisibility of an area from different points requires a more in-depth study, this will address for further studies. The present study focuses on a more qualitative trade-off between the aforementioned socio-economic impacts.

As said, since both the intervisibility and the cable cost depend on the distance from the coast, the latter will be measured for each of the identified areas. Clearly, for the sites that are near also to Sardinia's coast and/or San Antioco's coast, it is necessary to compute the distance also from the other two islands.

When considering intervisibility, in fact, the point from which the OWT can be visible are not only on the area under analysis but also on any neighboring coasts. Hence, to give an estimation of the distances between the most prominent point of the neighboring coast and the area of interest the tool "Measure length area" was used on QGIS.

Figure 4-5 shows the distances of different points inside the suitable area located in the northern- east part of the map. Though the analysis of each segment, it possible to see that segment 1 measures 11.049 km, hence, from the most prominent point of the northern- east part of San Pietro (point a Figure 4-5) it would not be possible to spot an OWT located in point b. On the other hand, an OWT located in point b would be visible from Sardinia's southwest coast, segment 2 is in fact 6.214 km long. The same happens for the remaining points: they are all placed far enough from Carloforte but they would be all visible from the prominent points of Sardinia's coast.

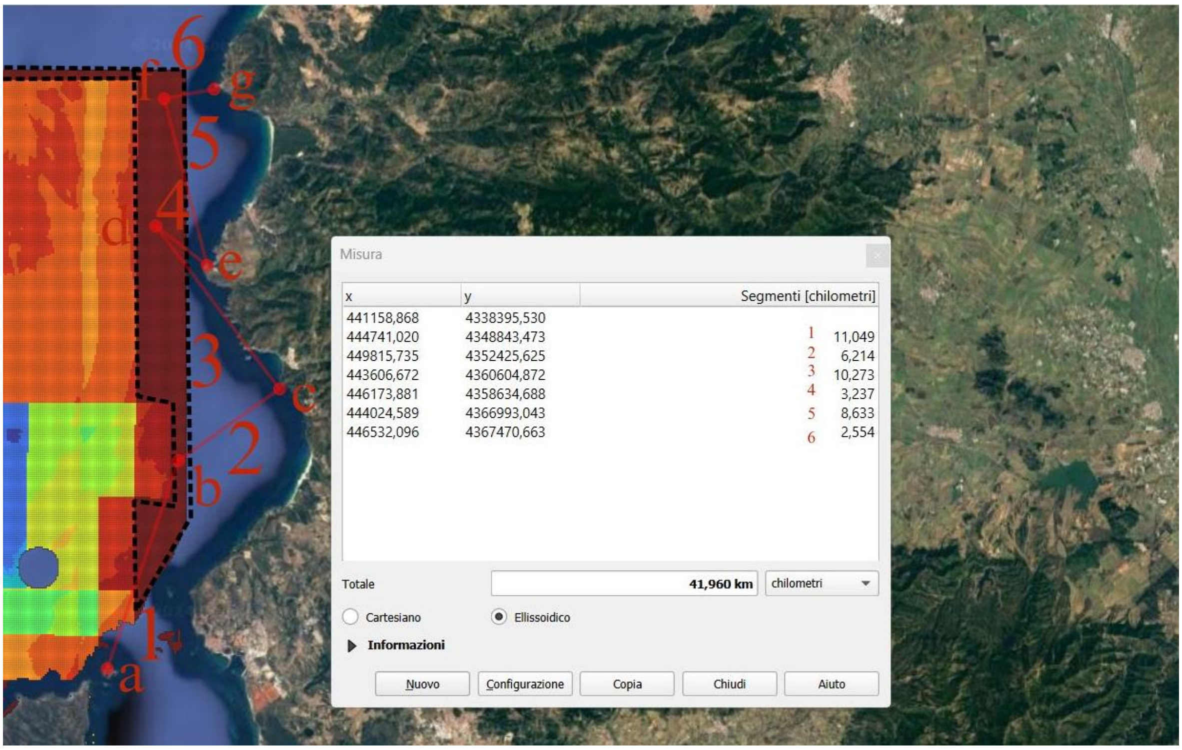

Figure 4-5- Suitable area (Northeast)

In Figure 4-6 the suitable area located in the northern part of the map is shown. The distance from both Sardinia's and San Pietro's coasts was calculated from point b, which is located in the middle of the area. Point b guarantees null intervisibility from both coasts, however, being 31.350 km far from Carloforte's coast, the cost of the submarine cables bringing the power produced by the OWT to the island, can become very high. Hence, the construction of an OWT in the north part of the island does not seem a feasible choice.

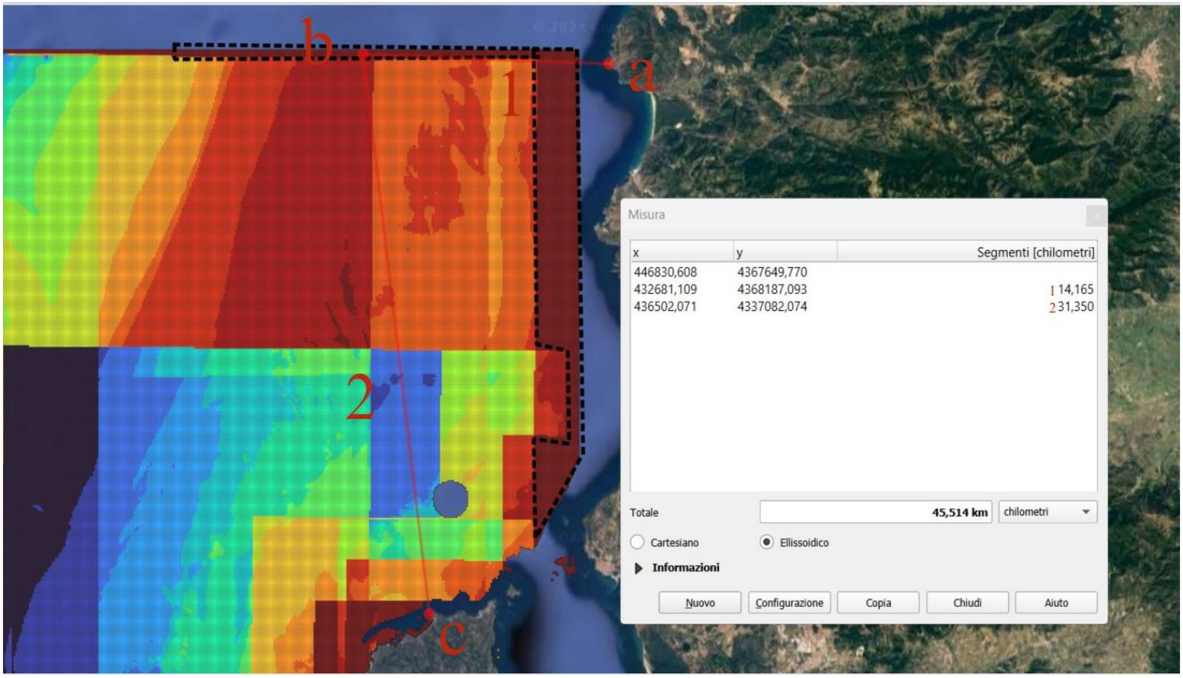

Figure 4-6- Suitable area (North)

In Figure 4-7 there is shown the suitable area located on the western side of the map. This area is not visible neither from Carloforte nor from Sardinia. If the OWT is to be built here, the submarine power cables should measure 27 km. This length represents, of course, a significantly high initial cost of investment, however, this site is preferrable to the northern one (Figure 4-6).

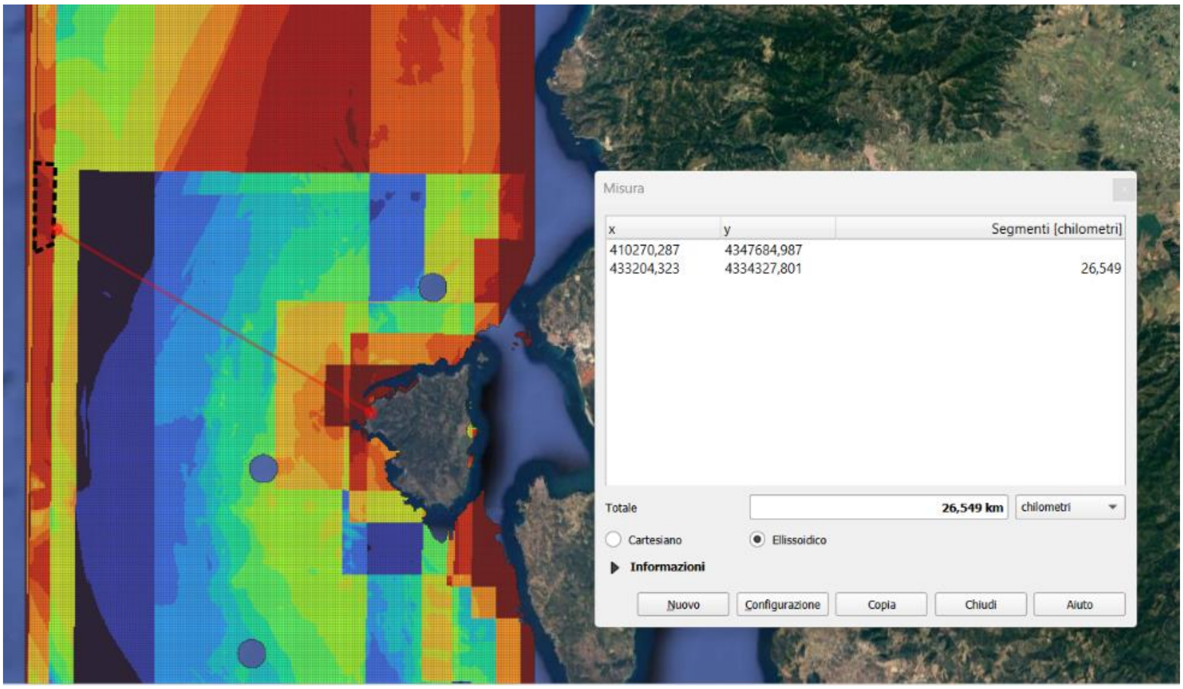

Figure 4-7- Suitable area (West)

In Figure 4-8 the suitable area placed in the southern part of the map is shown. To evaluate the distances from both Carloforte's and San Antioco's coasts point b was chosen: it is, in fact, the point closer to San Pietro that guarantees null intervisibility from both the islands. In this case, the submarine power cables would cover instead a distance of almost 22 km, therefore the area under analysis is better than the sites mentioned before (the northern and western sites).

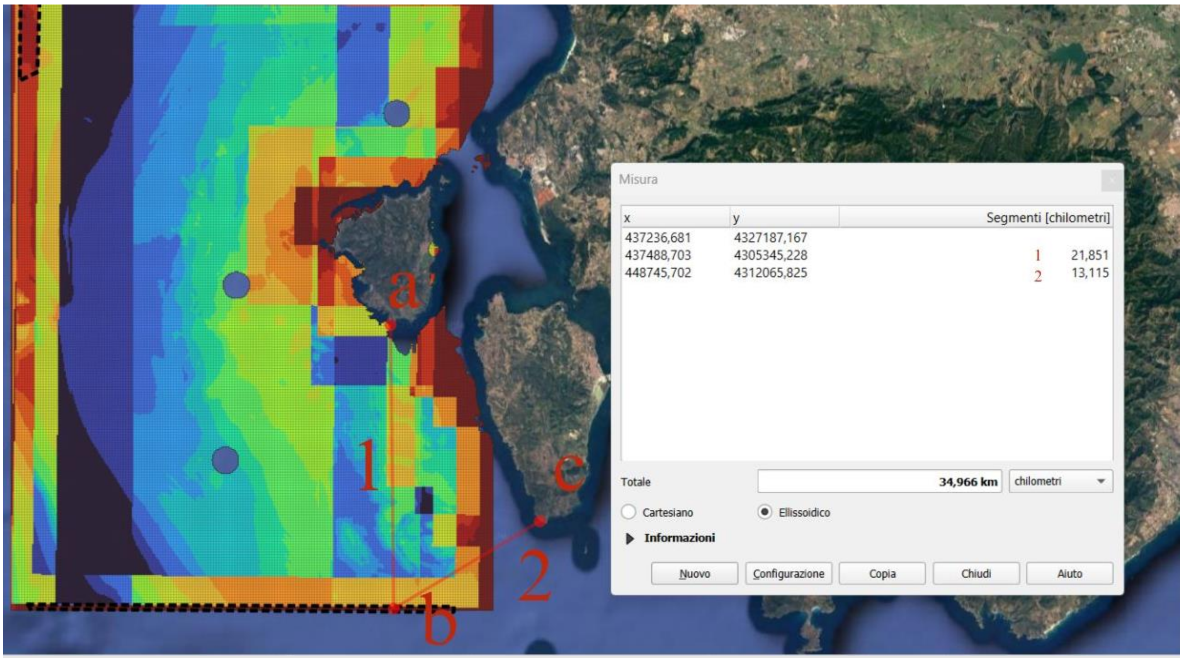

Figure 4-8- Suitable area (South)

The southern-east part of the map presents one of the suitable areas (Figure 4-9). Despite the large extension of the latter, all the points enclosed by the black dotted line are not sufficiently distant neither from San Antioco's nor from Carloforte's coasts. Hence, the southern east suitable area cannot be used for the construction of an OWT.

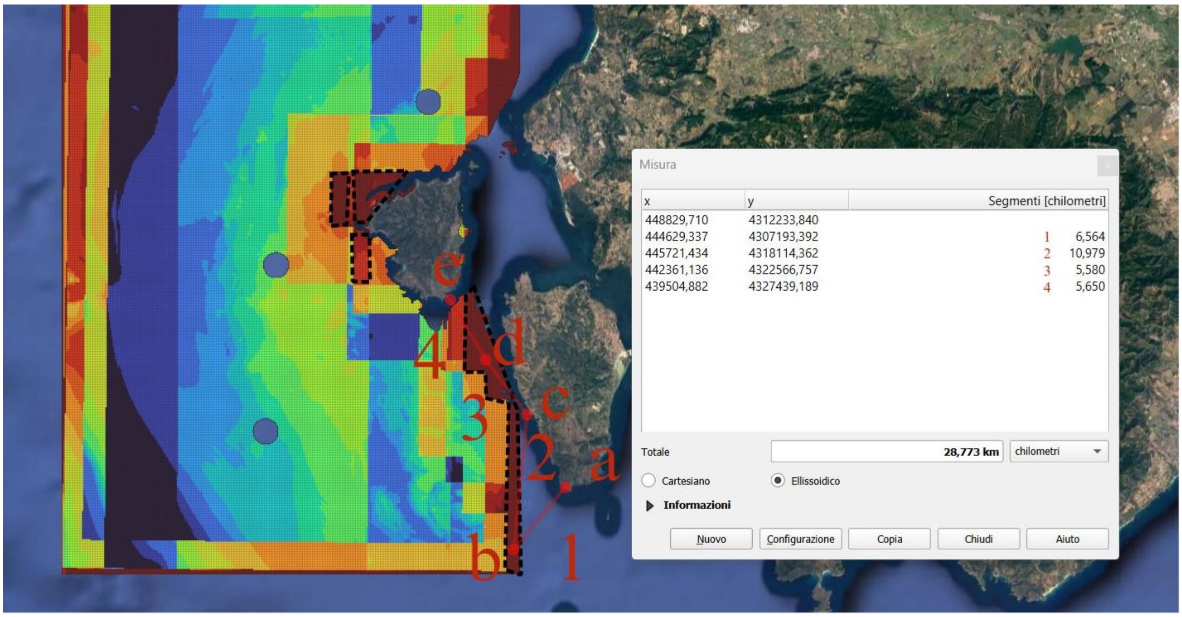

Figure 4-9- Suitable area (Southeast)

The same can be said for the three suitable areas present in the central part of the map. In Figure 4-10 it is possible to see how close the three areas are to the coast of Carloforte. It is safe to say that, despite the high suitability that the three all have, the construction of an OWT in one of these sites would constitute a relevant socio-economic impact.

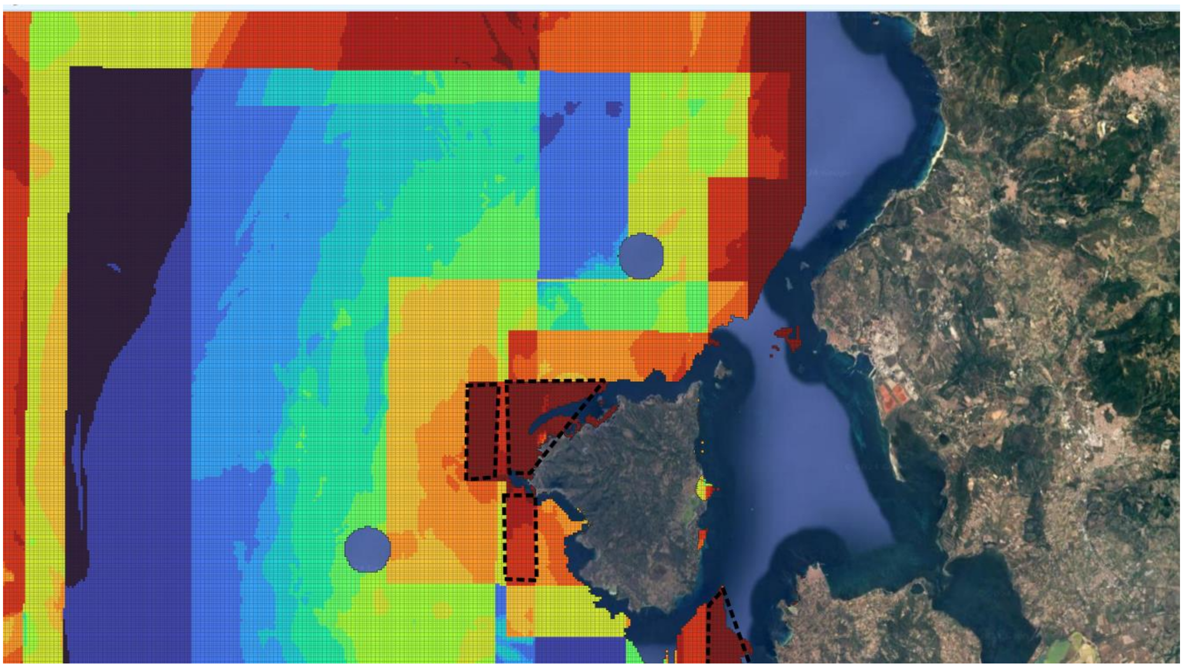

Figure 4-10- Suitable areas (Centre)

The seventh identified suitable area is the one place in the north-central part of the map. Point b is located 17.901 km from the most prominent point on the northern coast of San Pietro (point a) and 15.088 km from the most prominent point on the southwestern coast of Sardinia (point c). Hence, these two distances guarantee null intervisibility and an optimal tradeoff between distance and submarine power cables coast.

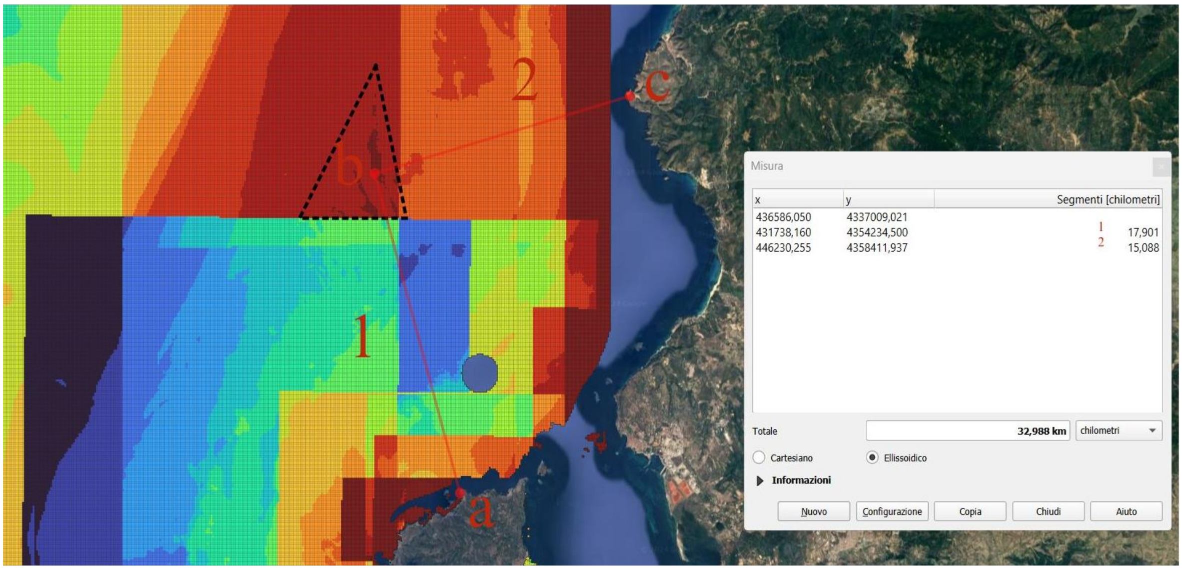

Figure 4-11- Suitable area (North-central)

The present study brought to the conclusion that in the north-central part of the map it is present the most suitable area for the construction of an OWT. The approximated average values of suitability, sustainability, bathymetry and AEP of the points enclosed by the black dotted line are the ones that follow:

Suitability	Sustainability	Bathymetry	AEP
-	-	m	GWh
0.613	0.733	157	52.4

Table 17- Results

As said the sustainability index takes into account the parameters included in GES 1, GES 3, GES 6 and GES 11 clusters, for each the objective weight, the importance, the weighted average, the weighted standard and the weighted norm were calculated. As to the weighted norm, it is the result of the multiplication between the weighted standard and the objective weight (Equation 10), hence, it is safe to say that it quantifies how much each factor weights, thus how much it is present over the area of interest. The results of the weighted norm are reported in Table 12, Table 13, Table 14, Table 15, it is possible to see that the weighted norm regarding the vessel traffic, the tuna traps and the avifauna are all pretty small, while higher relevance have ABFT FH, ABFT SH, Blue Shark FH and Fin Whale FH layers. To prove the validity of the presented method and to verify if the area identified as best location is truly suitable, the presence inside the mentioned area of all the considered factors will be verified.

Figure 4-12 shows the distribution of the avifauna over the area of interest, none is present in the triangular shaped area. Figure 4-13, instead, shows the occurrence of Striped Dolphin which lies very far from the triangular area. These evidences endorse the choice of the North-central area as the most suitable one, in fact, the lack of marine and terrestrial fauna implies that the risk of causing them any harm is low or null.

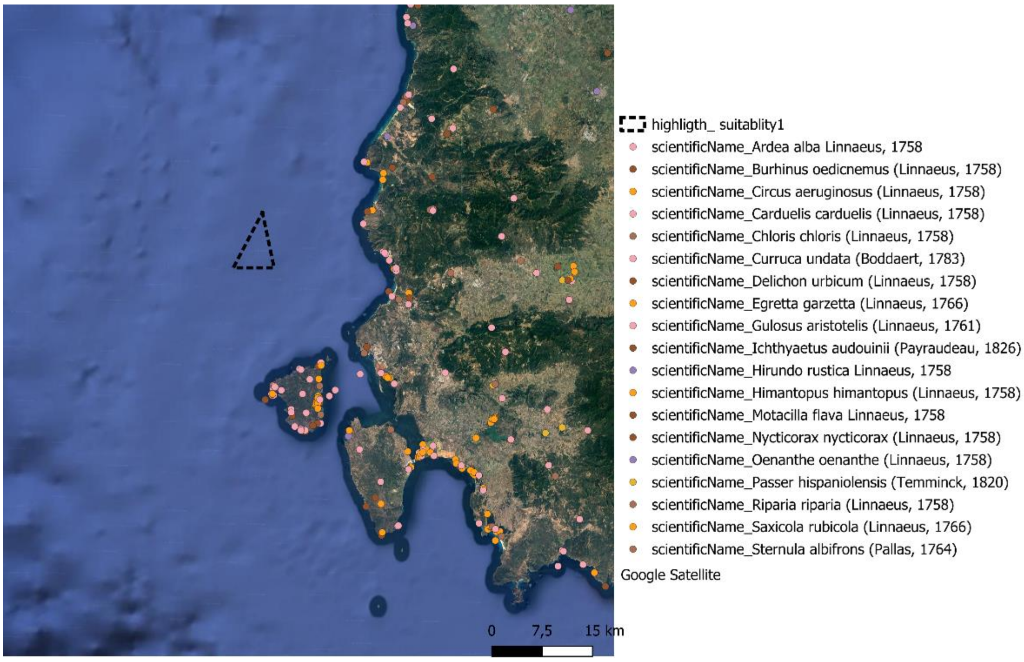

Figure 4-12- Avifauna presence in the most suitable area

Figure 4-13 Striped Dolphin presence in the most suitable area

The same happens in Figure 4-14: the tringle lies far from the area occupied by both tuna traps and the buffer that was made to amplify the area that they occupy.

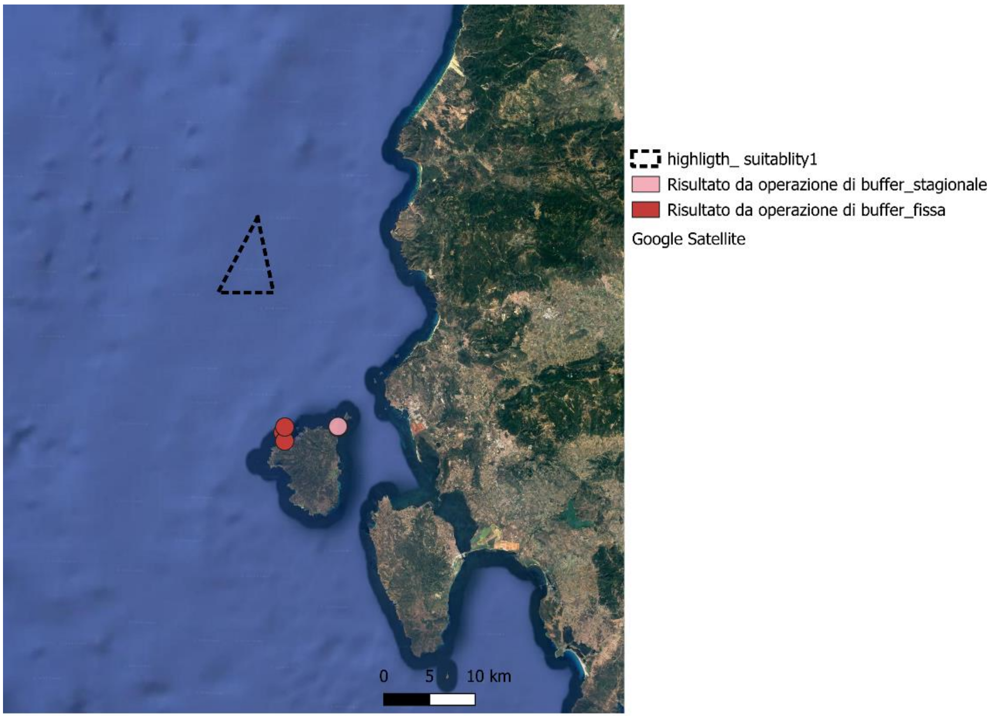

Figure 4-14- Tuna traps presence in the most suitable area

Figure 4-15 shows that the North-central suitable area lies over a sandy seabed which, with mud, is the type of soil which would be less impacted by an OWT. This result is very important as the seabed's weighted norm is equal to 0.0964, meaning that it highly influences the sustainability index and, as a consequence, the choice of the best site location. Hence, the fact that the North-central suitable area lies where the seabed is sandy endorses the validity of the method.

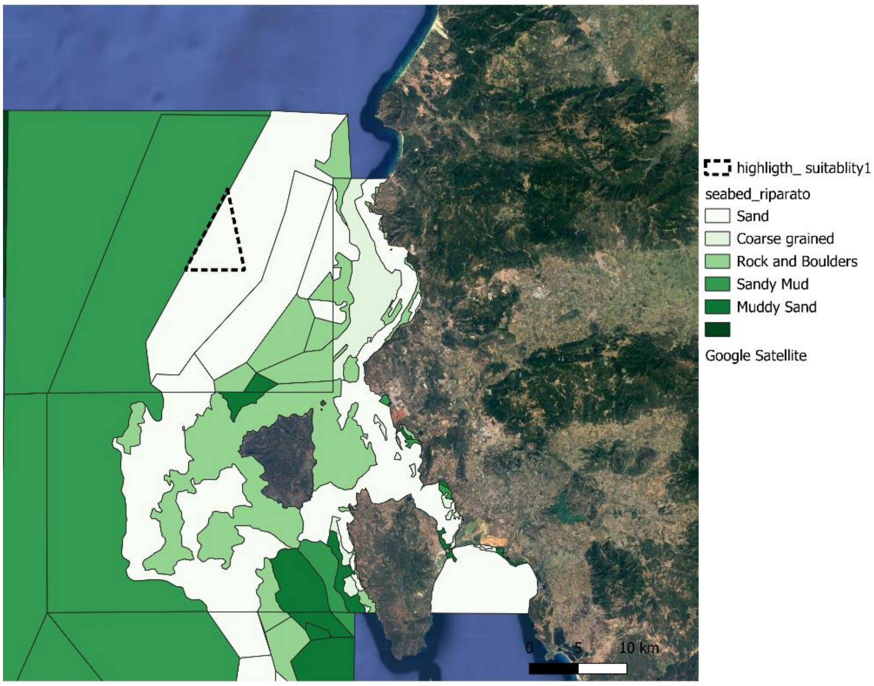

Figure 4-15- Seabed influence over the most suitable area

As to Fin Whale FH and Blue Shark FH layers, their weighted norm values are among the highest. Figure 4-16 shows the distribution of Blue Shark FH over the triangular shaped area, its value varies between 26 and 27 which, on a scale that goes from almost 16 to almost 38, represents the mean in terms of possibilities of finding a suitable feeding habitat. The lowest values are placed in the western part of the area of interest, where the suitable West area (Figure 4-7) is placed. The same happens for Fin Whale FH, represented in Figure 4-, which has values reaching almost 30, which represents the overall mean value, and is equal to zero exactly where the North (Figure 4-6) and the Centre (Figure 4-10) suitable areas lie.

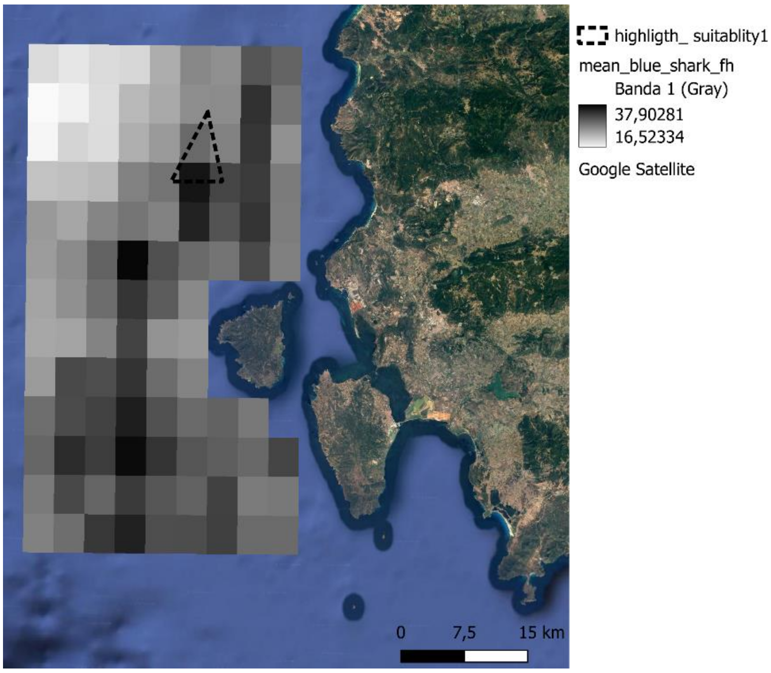

Figure 4-16 Blue Shark FH influence over the most suitable area

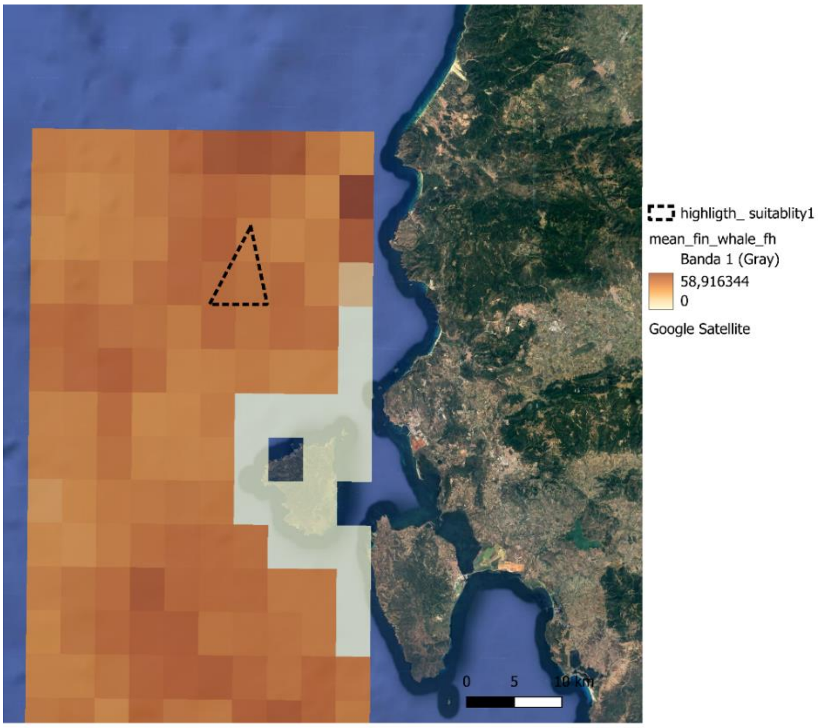

Figure 4-17- Fin Whale FH influence over the most suitable area

Unfortunately, due to the lack of data, the ABFT FH and ABFT SH layers' extension do not cover the area enclosed by the triangle, however, their influence can be studied in the other areas targeted as suitable.

In Figure 4-17 and Figure 4-18 it is possible to notice that the dotted lines that enclose all the areas identified as suitable lie outside the perimeter occupied by the ABFT SH and ABFT FH layers, this happens for almost every dotted line apart from the ones of the rectangle delimiting the Centre suitable area. This is a positive result: these two layers have, in fact, high values of the weighted norm which implies that the presence of possible ABFT spawning or feeding habitat would decrease the chances of finding a suitable area. Hence, all the areas that were found to be suitable do not lie in a possible ABTF feeding or spawning habitat. As to the only portion of the suitable area that was found over the layer of ABTF SH, this lies where the layer has a value of almost 5, thus a small value.

If Figure 4-17 and Figure 4-18 are confronted with Figure 4-1 and Figure 4-2, it is possible to notice that both the sustainability and suitability decrease when encountering the possible ABFT SH and FH areas.

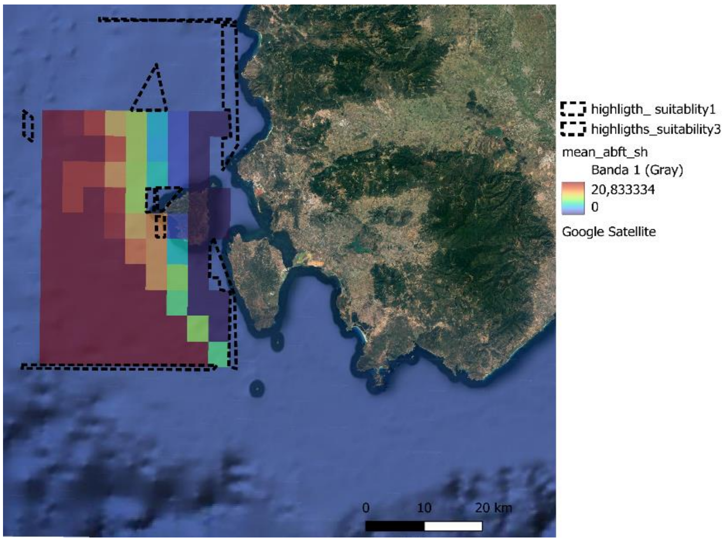

Figure 4-17- ABFT SH influence over the suitable areas

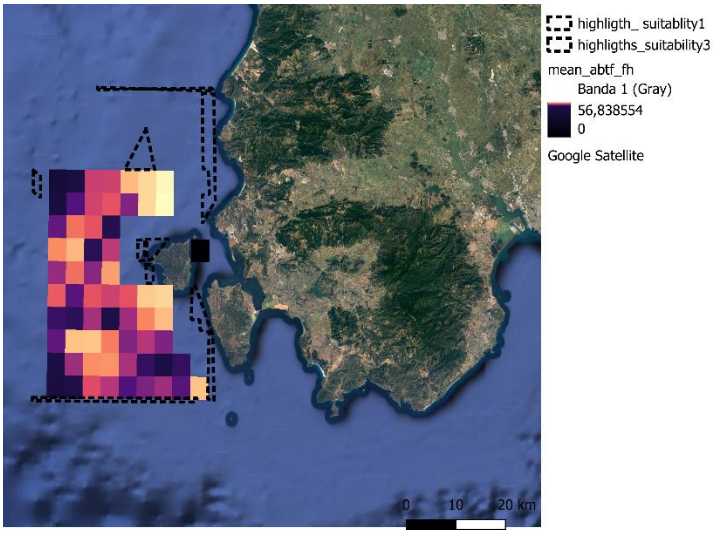

Figure 4-18- ABFT FH influence over the suitable areas

As to the vessel traffic layer influence over the suitable areas represented in Figure 4-19, it seems not to have particular relevance in the identification of the best locations. As reported in Table 15, in fact, the weighted norm of the vessel traffic parameter is equal to 0.0083, hence, a negligible value. This result confirms the low incidence that vessel traffic has in the identification of the area suitable for the construction of an OWT.

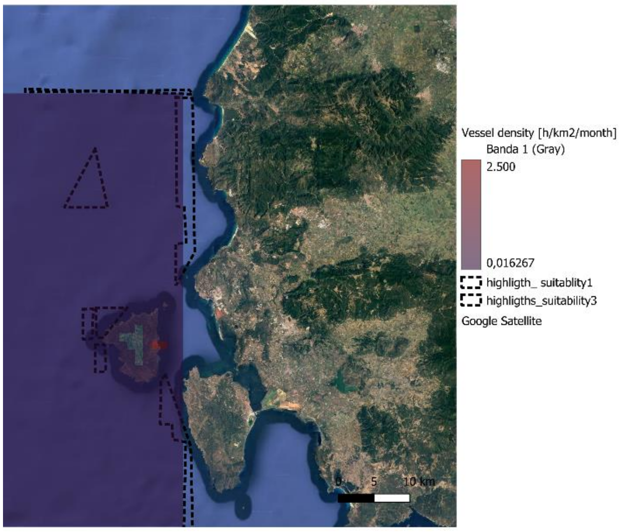

Figure 4-19- Vessel traffic influence over the suitable areas

Each of the mentioned parameters could reach values indicating better conditions than the ones listed above. However, as the present study's aim is to find the optimal site by considering multiple attributes, the presented results represent a satisfying trade-off between all the involved factors.

5 Discussion

The present study provides a novel approach to develop a site selection analysis for installing an OWT. The current framework was created with the purpose of unifying the environmental and technological characteristics involved in the construction of an OWT.

This method was developed to create a more realistic understanding of the factors influencing the site selection for the installing of an OWT. The holistic approach adopted in the implementation of the present method allows to identify a suitable site and the pressures that an OWT would bring to the former. The output of the proposed method provides a mapping of the impact levels of an OWT, allowing the selection of a site with a lower associated magnitude. This would, in principle, streamline the permitting process as the impact assessment itself is integrated into the siting analysis.

Moreover, the absence of specific details regarding the environmental impacts caused by an OWT often leads government agencies to request additional environmental investigations. These integration requests often delay the licenses issuing and, consequently, the construction of the facilities; thus, this method was built in the view of preventing waiting periods as it offers in-depth analyses regarding the environmental aspects involved.

As it was done by Abramic et al., 2022, the presented method was developed starting from the Marine Strategy Directive Framework and, in particular, by considering the eleven descriptors that contribute to the maintenance of the Good Environmental Status of the marine environment. As it was illustrated in paragraph 1.2, the descriptors list all the marine factors that need to be monitored and protected to maintain a good environmental status. Hence, being the GES part of a European Directive, all the EU nations must monitor the elements included in the descriptors and provide a review and update this strategy every 6 years.

In particular, Italy, to be in line with the Marine Strategy Directive Framework, actuated two programs: the “Programmi di monitoraggio” and the “Programma di misure” (Ministero dell'Ambiente e della Sicurezza Energetica, 2023). These programs serve to monitor the various marine subregions and collect data so that their GES can be evaluated. However, nowadays, national surveys do not always provide details on monitoring programs with the parameters needed for the application of the present method or, more in general, for an EIA.

Thus, the choice of using the GES descriptors as a starting point for the development of the present method is corroborated by the gathering of marine data that should be collected a priori by EU nations to be in line with the Directive. Hence, data collection being a crucial part of the methodology, the presence of an already existing dataset provided by national agencies, would certainly improve the application of the present method.

Moreover, as it was also proposed by Abramic et al., 2022, the use of GES descriptors for the evaluation of a suitable site for the implementation of an OWT, would promote the engagement of the private sector as an actor that can contribute to the monitoring of the marine environment and the maintenance of its GES. The present work highlights which are the marine elements to monitor and/or protect, hence, if this method is to be re-applied in private initiatives, these could contribute, with new data acquisitions and in situ surveys, to the national efforts aimed at protecting the marine environment in line with the Marine Strategy Directive Framework.

As to the present case study, the data provided by national agencies were not available for the chosen area of interest, thus, most of the datasets were retrieved from digital repositories. As it was not possible to conduct on-site surveys, a homogeneous set of data, in terms of date of observation and quality of the dataset, could not have been obtained. Therefore, it was necessary to retrieve the datasets from multiple sources, this had implied considerable post-production work that was aimed at standardizing the data, thus at creating comparable sets. Hence, the modified data could have been put together to form a unique set needed for the successive steps of the analysis.

This passage was one of the most complex and time-consuming due to the peculiarities of each dataset, in fact, each set needed to be thoroughly analyzed and transformed in order to be homologous to the others. This process might have created different mismatches which could have been avoided by performing in situ surveys.

For example, for what concerns the occurrence of the different species, described in paragraph 2.3.2, they indicate the absence or presence in a specific point of the area under analysis. This type of information is not always useful as it gives knowledge of the species' presence in a specific point of time and space, however, that same species might not be present at different moments and vice versa. Hence, this kind of data are not always reliable. This is why extensive literature research was performed to understand which were the species whose presence in the area under study was ascertained and needed to be investigated. These were the species permanently present both on the island or in coastal waters surrounding it, or species cyclically migrating over the area of interest. To overcome the problem of patchy data from real observations, ecological or niche models would be more suitable, as they provide suitability or probability indices for the presence of certain species based on their biology. The validity of these models is proven by the layers indicating possible feeding or spawning areas for ABFT, Fin Whales and Blue Shark, the former, in fact, did not need any post processing work as they already provide sufficient information, and their dimensions already covered the area under analysis. However, as happens for ABTF FH and ABTF SH layers, the availability of this type of data is limited.

Once the presence of a species in the area of interest was assured, if the only available information regarded its occurrences in different years, a process that averaged this information over the year was performed as explained in paragraph 2.3.2. Being a normalization process, this post-processing work might have constituted a source of error. On the other hand, data regarding the possible areas of spawning or feeding of a species represents a more reliable source and must be preferred to the previous type.

Once all the data were made comparable and a unique dataset was created, it was necessary to find a value that could objectively weigh the different factors, this need brought to the application of the CRITIC method. However, before applying the mentioned method, it was deemed appropriate to identify the "area of exclusion", portions of space where the construction of an OWT would not be possible due to the environmental relevance that these areas have. These were Posidonia beds, rocky shoals and loggerhead turtles' nests.

Later on, the idea of the data division into the GES clusters was the key to finding the successive steps of the methodology. In fact, once the objective weights were found it was necessary to understand which factors were more "important" for the analysis, hence, how the parameters were distributed over the area under study. The clusters allowed a much easier and organized development of the method, in fact, it was possible to create what can be defined as an "evaluation table" (reported in the Appendix paragraph Evaluation Tables) that contained, for each receptor: the "Scales of Importance", the weighted average and weighted standard.

The "Scale of Importance" was adapted from Zarzavilla et al., 2022, in particular the "vulnerability" quality index was included in the current study. The former allowed to add in the computation of the importance of each factor a property, intrinsic to each element, which evaluated the relevance that their presence has for the ecosystem. In this way, it was possible to diversify the importance that different elements had despite having a similar distribution pattern.

The first important result of this study was the development of the sustainability index. The significance of this index lies in the fact that it is georeferenced, hence, that it can be visualized over the map representing the area of interest. The visual representation of this value leads to a straightforward identification of sustainable areas on the map; furthermore, it helps to immediately identify exclusion zones due to their higher sensitivity to the OWT construction.

Although this first result was already very satisfactory, a further step was needed to conclude the development of the proposed methodology. In fact, to increase the effectiveness of the site-selection criteria, the technological assessment data must be added. In fact, it would be pointless to identify a highly suitable area from an environmental perspective but with low feasibility from a technological point of view, such as low productivity or great bathymetry.

This is one of the main differences between the present method and the one proposed by Abramic et al., 2022 that gave the initial idea for the development of this methodology. Abramic et al., 2022 study aimed to assess which GES qualitative descriptors could be more impacted by OWT in the area under analysis (in this case the Canary Islands), and to do so he uses the analytical hierarchy process (AHP). The result is the creation of an EIA-GES checklist that identifies the main impacts of the construction, operational, and decommissioning phases of OWT as well as the mitigation measures and spatial data needed to meet monitoring and assessment requirements.

Hence, Abramic et al., 2022 does not consider the technological aspects of an OWT and the key role they plan during the site-searching phase, the study is limited to the identification of the areas that would be less impacted by an OWT.

Considering the importance that the technological aspects have in the choice of a site for the implementation of an OWT, it was decided to add a further step to the present methodology. Once more, an objective evaluation of the parameters was needed, hence, the CRITC method was applied by considering only the sustainability index, the bathymetry, and the AEP. The results of this analysis lead to the suitability index, whose relevance lies in the fact that it is, again, georeferenced, hence a direct tool to easily identify suitable or unsuitable areas.

In the current case study, multiple suitable areas have been identified; for this reason, ~~a~~ further analysis was needed to help determine one area rather than another. This last part of the analysis was highly qualitative; intervisibility and cost of underwater cables were used as criteria to choose the preferred area. Both these parameters, which belong to the socio-economic impacts of an OWT, are simply dependent on the distance of the site from the coast. Hence, the most suitable site was the one where the distance was optimal for both parameters.

As said the ultimate choice of the most suitable site was qualitative, hence, not completely reliable. As one of the main purposes of this study is to propose a methodology for offshore wind site selection applicable to many case studies, no space should be left to qualitative considerations as they might not be valid for another application. On the other hand, the aim of this thesis was reached once the suitability index was found, hence, the deepening of the mathematical processes that should be performed to include the abovementioned socio-economic impacts will be the center of future studies.

Moreover, this study can be used as baseline for the development of a methodology for the siting of offshore wind farms. In fact, if the effects of a single OWT are not totally comprehended the ones of a farms are even less understood. It would be interesting to analyses the combined impacts of multiple turbines and understand if their pressures cumulatively combine to create unified effects on the marine environment. This type of study would be more useful as most of the projects regarding offshore wind involve a farm and not a single turbine.

Hence, the present work value stands in: the creation of a unique index that combines the environmental and technical aspects of an OWT and creates a simpler and immediate visualization of the areas suitable for the construction of a turbine, in the broad applicability that it has due to the vastness of parameters considered, and in the possible baseline that this work constitutes for the development of future analyses.

6 Conclusions

The purpose of the present thesis is to design a method to identify suitable areas for the construction of an offshore wind turbine. To do so, the environmental and technological characteristics involved in the construction of an OWT must be considered, the suitability increases when these parameters reach their optimal values.

The method was developed considering its re-applicability to another case study; hence, it is made to be as general as possible and to include all the parameters that could be involved in the construction of an OWT. However, the need of proving the validity of the methodology implied its applications to a case study which was chosen to be San Pietro Island. The choice was not the most fortunate as there are few data available for this area and the ones that are present are not always reliable or complete. On the other hand, the growing interest in Mediterranean Island’s wind energy capacity led to the choice of Carloforte as the case study.

As part of the methodology's value lies in the retrieving of data and in their use, the lack of data caused by the absence of a survey performed in the area of interest brought to an incomplete result. However, the method validity is proven by the creation of the suitability index and by its visualization on the map that would have been much more accurate, hence reliable, if all the needed data had been available.

In a possible re-application of the present method, to obtain a highly reliable result, it is strongly recommended to include data regarding all the parameters that might be impacted by an OWT, these are the one enlisted in paragraphs 1.1 and 1.2. In this view the present thesis can have multiple re-application functions, in fact, it can be either exploited for the gathered information regarding the impacts of an OWT and the factors to monitor when planning its construction, or it can be used to mimic the methodology illustrated.

Hence, the present thesis could be useful to consult when performing the site search for the construction of an OWT.

In conclusion, since the development of offshore wind will rapidly increase in the European countries to reach the zero-emission goal for 2050, the application of this methodology would allow an organic siting analysis that would prevent the requests for further investigation and, hence, would accelerate the bureaucratic processes. Italy especially lacks a Marine Spatial Planning and specific legislation regarding offshore wind, and it is often unclear which are the parameters need to be included when evaluating an environmental impact assessment. This method can be re-applied to other case studies including all the factors that are requested to be considered. It is possible to say that the development and application of the methodology presented in this thesis brought satisfactory results.

Appendix

1. Evaluation Tables

			Construction					Operation									Decommissioning				
	min	-310																			
	max	3100	Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			Blue shark (VU)	Blue shark (VU)	Blue shark (VU)	Blue shark (VU	Blue shark (VU)	Blue shark (VU)	Blue shark (VU	Blue shark (VU	Blue shark (VU	Blue shark (VU)	Blue shark (VU	Blue shark (VU	Blue shark (VU	Blue shark (VU	Blue shark (VU	Blue shark (VU	Blue shark (VU	Blue shark (VU)	Blue shark (VU
Intensità	Basso Medio Alto Molto alt	1 2 4 8	24	6	24	6	6	6	0	0	6	-24	18	18	-6	24	18	6	12	6	6
Estensione	Locale Comunal Regional Nazional ternazion	1 2 4 8 12	8	2	2	2	2	4	0	0	2	-2	2	2	-4	2	4	2	2	2	2
Momento	Lungo Medio mmediat	1 2 4	4	2	4	1	4	2	0	0	2	-2	4	4	-1	4	4	2	4	1	1
Persistenza	NP empofar Insistent ermanen	1 2 4 8	2	2	4	2	1	2	0	0	4	-2	2	4	-2	4	2	2	2	1	1
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	2	4	4	4	2	4	0	0	4	-2	8	4	-2	4	1	2	2	2	2
Cumulabilità	Semplice Cumulativ	1 4	4	4	4	1	1	4	0	0	4	-1	1	4	-1	4	4	4	4	1	1
Effetto	Indiretto Diretto	1 4	4	1	4	1	1	4	0	0	1	-1	4	1	bycatch -4	4	4	1	4	1	1
Propagazione	SP CP	1 4	1	4	1	1	1	1	0	0	1	-4	1	1	-4	1	1	4	1	1	1
Periodicità	Non Prev Regolare Continuo	1 2 4	2	1	4	1	1	4	0	0	1	-4	1	4	-1	4	2	1	1	1	1
Recuperabilità	mmediat edio term Mitigabile ecuperab	1 2 4 8	2	2	1	2	2	2	0	0	2	-2	2	2	-2	2	1	2	2	2	2
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	4	4	4	2	1	1	0	0	2	-2	4	4	-4	4	4	4	4	2	1
xi			57	32	56	23	22	34	0	0	29	-46	47	48	-31	57	45	30	38	20	19
Deviazione standard			6.220467416	1.504813214	6.097011868	1.504813214	1.53741223	1.504813214	0	0	1.553455226	6.336304943	4.769046199	4.477676493	1.705790791	6.042548857	4.58167388	1.482682403	2.93454771	1.402477147	1.420045396
Inv dev standard^2			0.025843657	0.441605839	0.026900845	0.441605839	0.423076923	0.441605839			0.414383562	0.024907369	0.043968023	0.04987634	0.343675418	0.027387958	0.0476378	0.454887218	0.11612284	0.508403361	0.495901639
xi/sigmai			1.473088424	14.13138686	1.50644731	10.15693431	9.307692308	15.01459854			12.01712329	-1.145738987	2.066497093	2.394064303	-10.6539379	1.561113626	2.14370079	13.64661654	4.41266795	10.16806723	9.422131148
			Blue shark																		
Media ponderata			22.55711165																		
Norma max-min			0.992723512																		
Norma pesata			0.164315906																		
Peso			0.165520313																		
Media pesata			3.73366018																		

Table 18- Evaluation Table Blue Shark FH

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutic	Mooring Nois	Mooring Sea	Cable routing	Turbine noise	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel noise	ssel polluti	ooring noi	Mooring Seab	oving - Seabe
			Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)	Fin whale (VU)
Intensità	Basso Medio Alto Molto alt	1 2 4 8	24	6	24	6	6	6	0	0	6	-24	18	18	-6	24	18	6	12	6	6
Estensione	Locale Comunal Regional Nazional ernazion	1 2 4 8 12	8	2	2	2	2	4	0	0	2	-2	2	2	-4	2	4	2	2	2	2
Momento	Lungo Medio mmediat	1 2 4	4	2	4	1	4	2	0	0	2	-2	4	4	-1	4	4	2	4	1	1
Persistenza	NP emporan Insistent ermanen	1 2 4 8	2	2	4	2	1	2	0	0	4	-2	2	4	-2	4	2	2	2	1	1
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	2	4	4	4	2	4	0	0	4	-2	8	4	-2	4	1	2	2	2	2
Cumulabilità	Semplice Cumulativ	1 4	4	4	4	1	1	4	0	0	4	-1	1	4	-1	4	4	4	4	1	1
Effetto	Indiretto Diretto	1 4	4	1	4	1	1	4	0	0	1	-1	4	1	-1	4	4	1	4	1	1
Propagazione	SP CP	1 4	1	4	1	1	1	1	0	0	1	-4	1	1	-4	1	1	4	1	1	1
Periodicità	Non Prev Regolare Continuo	1 2 4	2	1	4	1	1	4	0	0	1	-4	1	4	-1	4	2	1	1	1	1
Recuperabilità	mmediat edio term Mitigabile ecuperab	1 2 4 8	2	2	1	2	2	2	0	0	2	-2	2	2	-2	2	1	2	2	2	2
Vulnerabilità	Neutro o vulner Vulnerabil to vulner	1 2 4 8	4	4	4	2	1	1	0	0	2	-2	4	4	-4	4	4	4	4	2	1
xi			57	32	56	23	22	34	0	0	29	-46	47	48	-28	57	45	30	38	20	19
Deviazione standard			6.220467416	1.504813214	6.097011868	1.504813214	1.53741223	1.504813214	0	0	1.553455226	6.336304943	4.769046199	4.477676493	1.616035349	6.042548857	4.58167388	1.482682403	2.93454771	1.402477147	1.420045396
Inv dev standard^2			0.025843657	0.441605839	0.026900845	0.441605839	0.423076923	0.441605839			0.414383562	0.024907369	0.043968023	0.04987634	0.382911392	0.027387958	0.0476378	0.454887218	0.11612284	0.508403361	0.495901639
xi/sigmai			1.473088424	14.13138686	1.50644731	10.15693431	9.307692308	15.01459854			12.01712329	-1.145738987	2.066497093	2.394064303	-10.721519	1.561113626	2.14370079	13.64661654	4.41266795	10.16806723	9.422131148
			Fin whale																		
Media ponderata			22.33896978																		
Norma max-min			0.992793881																		
Norma pesata			0.111420875																		
Peso			0.112229615																		
Media pesata			2.507093976																		

Table 19- Evaluation Table Fin Whale FH

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird ste	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	ole routing	essel nois	essel polluti	ooring noi	ooring Polluti	oving - Seab
			Striped dolphin (LC)	Striped dolphin (LC	Striped dolphin (L	riped dolphin (L	Striped dolphin (LC)	triped dolphin (L	riped dolphin (L	riped dolphin (L	triped dolphin (L	triped dolphin (L	riped dolphin (L	riped dolphin (L	riped dolphin (L	riped dolphin (L	iped dolphin (	riped dolphin (L	iped dolphin (	Striped dolphin (LC	triped dolphin (L
Intensità	Basso	1	12	6	12	6	6	6	0	0	6	-24	18	18	-6	24	6	6	6	6	6
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	8	2	2	2	2	4	0	0	2	-2	2	2	-4	2	4	2	2	2	2
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ternazion	12																			
Momento	Lungo	1	4	2	4	1	4	2	0	0	2	-2	4	4	-1	4	4	2	4	1	1
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	2	2	4	2	1	2	0	0	4	-2	2	4	-2	4	2	2	2	1	1
	emporan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	2	4	4	4	2	4	0	0	4	-2	8	4	-2	4	1	2	2	2	2
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	4	4	4	1	1	4	0	0	4	-1	1	4	-1	4	4	4	4	1	1
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	4	1	4	1	1	4	0	0	1	-1	4	1	-1	4	4	1	4	1	1
Propagazione	SP	1	1	4	1	1	1	1	0	0	1	-4	1	1	-4	1	1	4	1	1	1
	CP	4																			
Periodicità	Non Prev	1		1	4	1	1	4	0	0	1	-4	1	4	-1	1		1	1	1	1
	Regolare	2	2														2				
	Continuo	4																			
Recuperabilità	mmediat	1	2	2	1	2	2	2	0	0	2	-2	2	2	-2	1	1	2	2	2	2
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	2	2	2	2	1	1	0	0	2	-2	2	2	-2	2	2	2	2	2	1
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			43	30	42	23	22	34	0	0	29	-46	45	46	-26	51	31	28	30	20	19
Deviazione standard			3.200477395	1.607275127	2.929732639	1.552328001	1.572330189	1.67497927	0	0	1.656217243	6.175669105	4.745612008	4.487637339	1.624465724	6.125425155	1.70579079	1.545603083	1.60727513	1.433720878	1.440968039
Inv dev standard^2			0.097627119	0.387096774	0.116504854	0.414985591	0.404494382	0.356435644			0.364556962	0.026219956	0.04440333	0.049655172	0.378947368	0.02665186	0.34367542	0.418604651	0.38709677	0.486486486	0.481605351
xi/sigmai			4.197966102	11.61290323	4.893203883	9.544668588	8.898876404	12.11881188			10.5721519	-1.20611799	1.998149861	2.284137931	-9.85263158	1.359244864	10.6539379	11.72093023	11.6129032	9.72972973	9.150501672
			Striped dolphin																		
Media ponderata			22.83976564																		
Norma max-min			0.99263233																		
Norma pesata			0.001005																		
Peso			0.001012505																		
Media pesata			0.023125387																		

Table 20- Evaluation Striped Dolphin

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutic	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seabe
			Falco eleonorae (VU)	alco eleonorae (VI	alco eleonorae (V	co eleonorae ('	Falco eleonorae (VU	lco eleonorae ('	co eleonorae (	lco eleonorae (	lco eleonorae ('	lco eleonorae ('	co eleonorae (	co eleonorae (	co eleonorae (	co eleonorae (	o eleonorae	co eleonorae (	o eleonorae	alco eleonorae (V	lco eleonorae (V
Intensità			0	12	0	0	0	24	24	12	3	-12	0	0	-12	0	0	6	0	0	0
	Basso	1																			
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ernazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	emporan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Pre	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	4	0	0	0	8	8	8	1	-4	0	0	-2	0	0	4	0	0	0
	o vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	26	0	0	0	63	72	55	14	-34	0	0	-29	0	0	20	0	0	0
Deviazione standard			0	3.104656002	0	0	0	5.959935682	6.150880696	4.751461763	0.687184271	3.05050087	0	0	3.040239391	0	0	1.598610508	0	0	0
Inv dev standard^2				0.103746398				0.028152493	0.026431718	0.044294063	2.117647059	0.107462687			0.108189331			0.391304348			
xi/sigmai				2.69740634				1.773607038	1.9030837	2.436173485	29.64705882	-3.653731343			-3.13749061			7.826086957			
			Falco eleonorae																		
Media ponderata			13.491328																		
Norma max-min			0.99564796																		
Norma pesata			0.082978																		
Peso			0.083340956																		
Media pesata			1.124380177																		

Table 21- Evaluation Table Falco Eleonorae

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	mooring Reef	mooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT	Ardea alba NT
Intensità	Basso Medio Alto Molto alt	1 2 4 8	0	3	0	0	0	3	3	3	3	-3	0	0	-3	0	0	3	0	0	0
Estensione	Locale Comunal Regional Nazional ernazion	1 2 4 8 12	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
Momento	Lungo Medio mmediat	1 2 4	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
Persistenza	NP emporan Insistente ermanen	1 2 4 8	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
Cumulabilità	Semplice Cumulativ	1 4	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
Effetto	Indiretto Diretto	1 4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP CP	1 4	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
Periodicità	Non Prev Regolare Continuo	1 2 4	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
Recuperabilità	mmediat edio term Mitigabile ecuperab	1 2 4 8	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	0	2	0	0	0	2	2	2	2	-2	0	0	-2	0	0	2	0	0	0
xi			0	13	0	0	0	34	43	38	13	-21	0	0	-18	0	0	13	0	0	0
Deviazione standard			0	0.715818898	0	0	0	1.378704626	2.810840879	4.185768885	0.715818898	1.2398347	0	0	1.067940011	0	0	0.715818898	0	0	0
Inv dev standard^2				1.951612903				0.526086957	0.126569038	0.057075472	1.951612903	0.650537634			0.876811594			1.951612903			
xi/sigmai				25.37096774				17.88695652	5.442468619	2.168867925	25.37096774	-13.66129032			-15.7826087			25.37096774			
			Ardea alba NT																		
Media ponderata			8.918439948																		
Norma max-min			0.997123084																		
Norma pesata			0.003713928																		
Peso			0.37%																		
Media pesata			0.03321801																		

Table 22- Evaluation Table Ardea Alba

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU	burhinus_VU
Intensità	Basso	1	0	3	0	0	0	3	3	3	3	-3	0	0	-3	0	0	3	0	0	0
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazionale	8																			
	ternazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	emporan	2																			
	Insistente	4																			
	ermanen	8																			
Reversibilità	reve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Prev	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	4	0	0	0	4	8	4	4	-2	0	0	-2	0	0	4	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	13	0	0	0	34	43	38	13	-21	0	0	-18	0	0	13	0	0	0
Deviazione standard			0	0.715818898	0	0	0	1.378704626	2.810840879	4.185768885	0.715818898	1.2398347	0	0	1.067940011	0	0	0.715818898	0	0	0
Inv dev standard^2				1.951612903				0.526086957	0.126569038	0.057075472	1.951612903	0.650537634			0.876811594			1.951612903			
xi/sigmai				25.37096774				17.88695652	5.442468619	2.168867925	25.37096774	-13.66129032			-15.7826087			25.37096774			

	burhinus_VU
Media ponderata	8.918439948
Norma max-min	0.997123084
Norma pesata	0.003126491
Peso	0.31%
Media pesata	0.027963874

Table 23- Evaluation Table Burhinus oedicnemus

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine noise	bine bird str	bird displa	ring metallic	mooring Reef	mooring Fish	+mooring N	oring Spill	le routing	essel noise	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT	carduelis_NT
Intensità	Basso Medio Alto Molto alt	1 2 4 8	**0**	**3**	**0**	**0**	**0**	**3**	**3**	**3**	**3**	**-3**	**0**	**0**	**-3**	**0**	**0**	**3**	**0**	**0**	**0**
Estensione	Locale Comunal Regional Nazional ternazion	1 2 4 8 12	**0**	**2**	**0**	**0**	**0**	**4**	**2**	**16**	**2**	**-2**	**0**	**0**	**-4**	**0**	**0**	**2**	**0**	**0**	**0**
Momento	Lungo Medio mmediat	1 2 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**2**	**1**	**-2**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Persistenza	NP empoRan Insistent ermanen	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**4**	**8**	**4**	**1**	**-1**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**4**	**8**	**4**	**1**	**-1**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Cumulabilità	Semplice Cumulativ	1 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**1**	**1**	**-1**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Effetto	Indiretto Diretto	1 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**4**	**1**	**-1**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Propagazione	SP CP	1 4	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**-4**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Periodicità	Non Prev Regolare Continuo	1 2 4	**0**	**1**	**0**	**0**	**0**	**4**	**1**	**1**	**1**	**-4**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Recuperabilità	mmediat edio term Mitigabil ecuperab	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**2**	**8**	**2**	**1**	**-2**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Vulnerabilità	Neutro o vulner Vulnerabil to vulner	1 2 4 8	**0**	**2**	**0**	**0**	**0**	**2**	**2**	**2**	**2**	**-2**	**0**	**0**	**-2**	**0**	**0**	**2**	**0**	**0**	**0**
xi			0	15	0	0	0	36	45	40	15	-23	0	0	-20	0	0	15	0	0	0
Deviazione standard			0	0.721687836	0	0	0	1.354006401	2.742413779	4.027681991	0.721687836	1.187317237	0	0	1.027402334	0	0	0.721687836	0	0	0
Inv dev standard^2				1.92				0.545454545	0.132963989	0.061643836	1.92	0.709359606			0.947368421			1.92			
xi/sigmai				28.8				19.63636364	5.983379501	2.465753425	28.8	-16.31527094			-18.9473684			28.8			
			carduelis_NT																		
Media ponderata			9.712503736																		
Norma max-min			0.996866934																		
Norma pesata			0.004004185																		
Peso			0.40%																		
Media pesata			0.039012892																		

Table 24- Evaluation table Carduelis carduelis

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	mooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt	Chloris nt
Intensità	Basso	1	0	3	0	0	0	3	3	3	3	-3	0	0	-3	0	0	3	0	0	0
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazionale	8																			
	ternazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	Immediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	emporan	2																			
	Insistente	4																			
	ermanen	8																			
Reversibilità	reve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1																			
	Cumulativ	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1						1	1	1	1	-4	0	0	-1						
	CP	4	0	1	0	0	0									0	0	1	0	0	0
Periodicità	Non Prev	1						4	1	1	1	-4	0	0	-1						
	Regolare	2	0	1	0	0	0									0	0	1	0	0	0
	Continuo	4																			
Recuperabilità	Immediat	1					0	2	8	2	1	-2	0	0	-2						
	edio term	2	0	1	0	0										0	0	1	0	0	0
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	2	0	0	0	2	2	2	2	-2	0	0	-2	0	0	2	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	15	0	0	0	36	45	43	15	-23	0	0	-20	0	0	15	0	0	0
Deviazione standard			0	0.721687836	0	0	0	1.354006401	2.742413779	3.967751952	0.721687836	1.187317237	0	0	1.027402334	0	0	0.721687836	0	0	0
Inv dev standard^2				1.92				0.545454545	0.132963989	0.063520071	1.92	0.709359606			0.947368421			1.92			
xi/sigmai				28.8				19.63636364	5.983379501	2.731363035	28.8	-16.31527094			-18.9473684			28.8			

	Chloris nt
Media ponderata	9.742825685
Norma max-min	0.996857153
Norma pesata	0.006063561
Peso	0.61%
Media pesata	0.059262472

Table 25- Evaluation table Chloris chloris

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	mooring Reef	mooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU	Circus VU
Intensità			0	12	0	0	0	24	24	12	3	-12	0	0	-12	0	0	6	0	0	0
	Basso	1																			
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ternazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	empora	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Prev	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	4	0	0	0	8	8	8	2	-4	0	0	-2	0	0	4	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	26	0	0	0	63	72	55	15	-34	0	0	-29	0	0	20	0	0	0
Deviazione standard			0	3.170108323	0	0	0	6.001377252	6.140234469	4.748205403	0.642824347	3.058655244	0	0	3.082877265	0	0	1.585054161	0	0	0
Inv dev standard^2				0.099506579				0.02776503	0.026523455	0.044354839	2.42	0.106890459			0.105217391			0.398026316			
xi/sigmai				2.587171053				1.749196879	1.909688733	2.439516129	36.3	-3.634275618			-3.05130435			7.960526316			
			Circus VU																		
Media ponderata			14.32975481																		
Norma max-min			0.995377498																		
Norma pesata			0.052710345																		
Peso			5.30%																		
Media pesata			0.76																		

Table 26- Evaluation Table Circus aeruginosus

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spill	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			curruca undata VU	curruca undata VU	curruca undata V	urruca undata V	curruca undata VU	urruca undata V	urruca undata V	urruca undata V	urruca undata V	urruca undata V	urruca undata V	urruca undata V	urruca undata V	urruca undata V	rruca undata	urruca undata V	rruca undata	curruca undata VU	urruca undata V
Intensità	Basso Medio Alto Molto alt	1 2 4 8	**0**	**3**	**0**	**0**	**0**	**3**	**3**	**3**	**3**	**-3**	**0**	**0**	**-3**	**0**	**0**	**3**	**0**	**0**	**0**
Estensione	Locale Comunal Regional Nazional ernazion	1 2 4 8 12	**0**	**2**	**0**	**0**	**0**	**4**	**2**	**16**	**2**	**-2**	**0**	**0**	**-4**	**0**	**0**	**2**	**0**	**0**	**0**
Momento	Lungo Medio mmediat	1 2 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**2**	**1**	**-2**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Persistenza	NP emporan Insistente ermanen	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**4**	**8**	**4**	**1**	**-1**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**4**	**8**	**4**	**1**	**-1**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Cumulabilità	Semplice Cumulativ	1 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**1**	**1**	**-1**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Effetto	Indiretto Diretto	1 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**4**	**1**	**-1**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Propagazione	SP CP	1 4	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**-4**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Periodicità	Non Pre Regolare Continuo	1 2 4	**0**	**1**	**0**	**0**	**0**	**4**	**1**	**1**	**1**	**-4**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Recuperabilità	mmediat edio term Mitigabile ecuperab	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**2**	**8**	**2**	**1**	**-2**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Vulnerabilità	Neutro o vulner Vulnerabil to vulner	1 2 4 8	**0**	**4**	**0**	**0**	**0**	**4**	**8**	**4**	**4**	**-2**	**0**	**0**	**-2**	**0**	**0**	**4**	**0**	**0**	**0**
xi			0	17	0	0	0	38	51	42	17	-23	0	0	-20	0	0	17	0	0	0
Deviazione standard			0	0.987525499	0	0	0	0.987525499	2.739367122	4.041111049	0.987525499	1.083306844	0	0	0.935966376	0	0	0.987525499	0	0	0
Inv dev standard^2				1.025423729				1.025423729	0.133259912	0.061234818	1.025423729	0.852112676			1.141509434			1.025423729			
xi/sigmai				17.43220339				38.96610169	6.796255507	2.571862348	17.43220339	-19.59859155			-22.8301887			17.43220339			
			curruca undata VU																		
Media ponderata			9.253384959																		
Norma max-min			0.997015037																		
Norma pesata			0.053030018																		
Peso			5.32%																		
Media pesata			0.49																		

Table 27- Evaluation table Curruca undata

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	ooring Polluti	oving - Seab
			Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt	Delichon Nt
Intensità	Basso Medio Alto Molto alt	1 2 4 8	**0**	**3**	**0**	**0**	**0**	**3**	**3**	**3**	**3**	**-3**	**0**	**0**	**-3**	**0**	**0**	**3**	**0**	**0**	**0**
Estensione	Locale Comunal Regional Nazionale ernazion	1 2 4 8 12	**0**	**2**	**0**	**0**	**0**	**4**	**2**	**16**	**2**	**-2**	**0**	**0**	**-4**	**0**	**0**	**2**	**0**	**0**	**0**
Momento	Lungo Medio mmediat	1 2 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**2**	**1**	**-2**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Persistenza	NP emporan Insistent ermanen	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**4**	**8**	**4**	**1**	**-1**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**4**	**8**	**4**	**1**	**-1**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Cumulabilità	Semplice Cumulativ	1 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**4**	**1**	**-1**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Effetto	Indiretto Diretto	1 4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**4**	**1**	**-1**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Propagazione	SP CP	1 4	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**-4**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Periodicità	Non Prev Regolare Continuo	1 2 4	**0**	**1**	**0**	**0**	**0**	**4**	**1**	**1**	**1**	**-4**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Recuperabilità	mmediat edio term Mitigabil ecuperab	1 2 4 8	**0**	**1**	**0**	**0**	**0**	**2**	**8**	**2**	**1**	**-2**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	**0**	**2**	**0**	**0**	**0**	**2**	**2**	**2**	**2**	**-2**	**0**	**0**	**-2**	**0**	**0**	**2**	**0**	**0**	**0**
xi			0	15	0	0	0	36	45	43	15	-23	0	0	-20	0	0	15	0	0	0
Deviazione standard			0	0.721687836	0	0	0	1.354006401	2.742413779	3.967751952	0.721687836	1.187317237	0	0	1.027402334	0	0	0.721687836	0	0	0
Inv dev standard^2				1.92				0.545454545	0.132963989	0.063520071	1.92	0.709359606			0.947368421			1.92			
xi/sigmai				28.8				19.63636364	5.983379501	2.731363035	28.8	-16.31527094			-18.9473684			28.8			
			Delichon Nt																		
Media ponderata			9.742825685																		
Norma max-min			0.996857153																		
Norma pesata			0.052683659																		
Peso			5.28%																		
Media pesata			0.514905973																		

Table 28- Evaluation table Delichon urbicum

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	mooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC	Egretta LC
Intensità	Basso Medio Alto Molto alt	1 2 4 8	0	3	0	0	0	3	3	3	3	-3	0	0	-3	0	0	3	0	0	0
Estensione	Locale Comunal Regional Nazional ternazion	1 2 4 8 12	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
Momento	Lungo Medio mmediat	1 2 4	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
Persistenza	NP emporan Insistente ermanen	1 2 4 8	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
Reversibilità	reve term edio term ngo term ermanen	1 2 4 8	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
Cumulabilità	Semplice Cumulativ	1 4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Effetto	Indiretto Diretto	1 4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP CP	1 4	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
Periodicità	Non Prev Regolare Continuo	1 2 4	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
Recuperabilità	mmediat edio term Mitigabile ecuperab	1 2 4 8	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	0	2	0	0	0	2	2	2	2	-2	0	0	-2	0	0	2	0	0	0
xi			0	15	0	0	0	36	44	43	15	-23	0	0	-20	0	0	15	0	0	0
Deviazione standard			0	0.721687836	0	0	0	1.354006401	2.838231061	3.967751952	0.721687836	1.187317237	0	0	1.027402334	0	0	0.721687836	0	0	0
Inv dev standard^2				1.92				0.545454545	0.124137931	0.063520071	1.92	0.709359606			0.947368421			1.92			
xi/sigmai				28.8				19.63636364	5.462068966	2.731363035	28.8	-16.31527094			-18.9473684			28.8			
			Egretta LC																		
Media ponderata			9.689411169																		
Norma max-min			0.996874383																		
Norma pesata			0.052672215																		
Peso			5.28%																		
Media pesata			0.511962952																		

Table 29- Evaluation table Egretta Garzetta

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	mooring Reef	mooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC	gulosus LC
Intensità			0	6	0	0	0	12	12	6	3	-6	0	0	-6	0	0	3	0	0	0
	Basso	1																			
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ernazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	emporan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	umulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Pre	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolar	2																			
	Continu	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabil	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	2	0	0	0	2	2	2	2	-2	0	0	-2	0	0	2	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	18	0	0	0	45	54	43	15	-26	0	0	-23	0	0	15	0	0	0
Deviazione standard			0	1.431637795	0	0	0	2.712078889	3.423303706	4.12210329	0.642824347	1.553455226	0	0	1.504813214	0	0	0.642824347	0	0	0
Inv dev standard^2				0.487903226				0.135955056	0.085331453	0.05885214	2.42	0.414383562			0.441605839			2.42			
xi/sigmai				8.782258065				6.117977528	4.607898449	2.530642023	36.3	-10.7739726			-10.1569343			36.3			
			gulosus LC																		
Media ponderata			11.40277112																		
Norma max-min			0.996321687																		
Norma pesata			0.05269311																		
Peso			5.29%																		
Media pesata			0.60																		

Table 30- Evaluation table Gulosus aristotelis

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutic	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring nois	Mooring Seab	oving - Seab
			himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus LC	himantopus L	himantopus LC	himantopus L	himantopus LC	himantopus LC
Intensità			0	6	0	0	0	12	12	6	3	-6	0	0	-6	0	0	3	0	0	0
	Basso	1																			
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ternazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	emporan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Prev	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	2	0	0	0	2	2	2	2	-2	0	0	-2	0	0	2	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	18	0	0	0	45	54	43	15	-26	0	0	-23	0	0	15	0	0	0
Deviazione standard			0	1.431637795	0	0	0	2.712078889	3.423303706	4.12210329	0.642824347	1.553455226	0	0	1.504813214	0	0	0.642824347	0	0	0
Inv dev standard^2				0.487903226				0.135955056	0.085331453	0.05885214	2.42	0.414383562			0.441605839			2.42			
xi/sigmai				8.782258065				6.117977528	4.607898449	2.530642023	36.3	-10.7739726			-10.1569343			36.3			
			himantopus LC																		
Media ponderata			11.40277112																		
Norma max-min			0.094253012																		
Norma pesata			0.000322104																		
Peso			0.34%																		
Media pesata			0.04																		

Table 31- Evaluation Table Himantopus Himantopus

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC	Hirundu LC
Intensità	Basso	1	0	3	0	0	0	3	3	3	3	-3	0	0	-3	0	0	3	0	0	0
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ernazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	empoRan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1						
	umulativ	4														0	0	1	0	0	0
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1						1	1	1	1	-4	0	0	-1						
	CP	4	0	1	0	0	0									0	0	1	0	0	0
Periodicità	Non Pre	1						4	1	1	1	-4	0	0	-1						
	Regolar	2	0	1	0	0	0									0	0	1	0	0	0
	Continu	4																			
Recuperabilità	mmediat	1					0	2	8	2	1	-2	0	0	-2						
	edio term	2	0	1	0	0										0	0	1	0	0	0
	Mitigabil	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	2	0	0	0	2	2	2	2	-2	0	0	-2	0	0	2	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	15	0	0	0	36	45	40	15	-23	0	0	-20	0	0	15	0	0	0
Deviazione standard			0	0.721687836	0	0	0	1.354006401	2.742413779	4.027681991	0.721687836	1.187317237	0	0	1.027402334	0	0	0.721687836	0	0	0
Inv dev standard^2				1.92				0.545454545	0.132963989	0.061643836	1.92	0.709359606			0.947368421			1.92			
xi/sigmai				28.8				19.63636364	5.983379501	2.465753425	28.8	-16.31527094			-18.9473684			28.8			
			Hirundu LC																		
Media ponderata			9.712503736																		
Norma max-min			0.996866934																		
Norma pesata			0.052712985																		
Peso			5.29%																		
Media pesata			0.51																		

Table 32- Evaluation table Hirundu rustica

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	ooring Reef	ooring Fish	+mooring N	oring Spill	ble routing	essel nois	ssel polluti	ooring nois	Mooring Seab	oving - Seab
			ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus nt	ichthyaetus n	ichthyaetus nt	ichthyaetus n	ichthyaetus nt	ichthyaetus nt
Intensità	Basso Medio Alto Molto alt	1 2 4 8	0	6	0	0	0	12	12	6	3	-6	0	0	-6	0	0	3	0	0	0
Estensione	Locale Comunal Regional Nazional ernazion	1 2 4 8 12	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
Momento	Lungo Medio mmediat	1 2 4	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
Persistenza	NP emporan Insistent ermanen	1 2 4 8	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
Cumulabilità	Semplice umulativ	1 4	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
Effetto	Indiretto Diretto	1 4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP CP	1 4	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
Periodicità	Non Pre Regolar Continu	1 2 4	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
Recuperabilità	mmediat edio term Mitigabil ecuperab	1 2 4 8	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	0	2	0	0	0	2	2	2	2	-2	0	0	-2	0	0	2	0	0	0
xi			0	18	0	0	0	45	54	43	15	-26	0	0	-23	0	0	15	0	0	0
Deviazione standard			0	1.431637795	0	0	0	2.712078889	3.423303706	4.12210329	0.642824347	1.553455226	0	0	1.504813214	0	0	0.642824347	0	0	0
Inv dev standard^2				0.487903226				0.135955056	0.085331453	0.05885214	2.42	0.414383562			0.441605839			2.42			
xi/sigmai				8.782258065				6.117977528	4.607898449	2.530642023	36.3	-10.7739726			-10.1569343			36.3			
			ichthyaetus nt																		
Media ponderata			11.40277112																		
Norma max-min			0.996321687																		
Norma pesata			0.055757393																		
Peso			5.60%																		
Media pesata			0.64																		

Table 33-Evaluation table Ichthyaetus audouinii

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutic	Mooring Nois	Mooring Sea	Cable routing	Turbine noise	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			motacilla flava VU	motacilla flava VU	motacilla flava VU	otacilla flava V	motacilla flava VU	otacilla flava V	otacilla flava V	otacilla flava V	otacilla flava V	otacilla flava V	otacilla flava V	otacilla flava V	otacilla flava V	otacilla flava V	otacilla flava	otacilla flava V	otacilla flava	motacilla flava VU	otacilla flava V
Intensità			0	6	0	0	0	6	6	3	3	-3	0	0	-3	0	0	3	0	0	0
	Basso	1																			
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ernazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	empoa	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Pre	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabil	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	4	0	0	0	8	8	8	2	-4	0	0	-2	0	0	4	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	20	0	0	0	45	54	46	15	-25	0	0	-20	0	0	17	0	0	0
Deviazione standard			0	1.585054161	0	0	0	1.729663417	2.712078889	4.217241274	0.642824347	1.212878551	0	0	0.935966376	0	0	0.987525499	0	0	0
Inv dev standard^2				0.398026316				0.334254144	0.135955056	0.056226766	2.42	0.679775281			1.141509434			1.025423729			
xi/sigmai			7.960526316				15.04143646	7.341573034	2.586431227	36.3	-16.99438202			-22.83018868			17.4322034				
			motacilla flava VU																		
Media ponderata			7.565225029																		
Norma max-min			0.997559605																		
Norma pesata			0.042672772																		
Peso			4.28%																		
Media pesata			0.32																		

Table 34- Evaluation table Motacilla flava

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU	nycticorax VU
Intensità	Basso Medio Alto Molto alt	1 2 4 8	0	6	0	0	0	6	6	3	3	-3	0	0	-3	0	0	3	0	0	0
Estensione	Locale Comunal Regional Nazional ternazion	1 2 4 8 12	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
Momento	Lungo Medio mmediat	1 2 4	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
Persistenza	NP emporan Insistente ermanen	1 2 4 8	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
Cumulabilità	Semplice Cumulativ	1 4	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
Effetto	Indiretto Diretto	1 4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP CP	1 4	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
Periodicità	Non Prev Regolare Continuo	1 2 4	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
Recuperabilità	mmediat edio term Mitigabile ecuperab	1 2 4 8	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	0	4	0	0	0	8	8	8	2	-4	0	0	-2	0	0	4	0	0	0
xi			0	20	0	0	0	45	54	46	15	-25	0	0	-20	0	0	17	0	0	0
Deviazione standard			0	1.585054161	0	0	0	1.729663417	2.712078889	4.217241274	0.642824347	1.212878551	0	0	0.935966376	0	0	0.987525499	0	0	0
Inv dev standard^2				0.398026316				0.334254144	0.135955056	0.056226766	2.42	0.679775281			1.141509434			1.025423729			
xi/sigmai				7.960526316				15.04143646	7.341573034	2.586431227	36.3	-16.99438202			-22.8301887			17.43220339			
			nycticorax VU																		
Media ponderata			7.565225029																		
Norma max-min			0.997559605																		
Norma pesata			0.048437257																		
Peso			4.86%																		
Media pesata			36.73%																		

Table 35- Evaluation table Nycticorax nycticorax

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	mooring Reef	mooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring nois	Mooring Seab	oving - Seab
			oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT	oenanthe NT
Intensità	Basso	1	0	6	0	0	0	6	6	3	3	-3	0	0	-3	0	0	3	0	0	0
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ernazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	emporan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Prev	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	2	0	0	0	2	2	2	2	-2	0	0	-2	0	0	2	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	18	0	0	0	39	48	40	15	-23	0	0	-20	0	0	15	0	0	0
Deviazione standard			0	1.431637795	0	0	0	1.304790918	2.637930569	4.073701182	0.642824347	1.083306844	0	0	0.935966376	0	0	0.642824347	0	0	0
Inv dev standard^2				0.487903226				0.587378641	0.143705463	0.060258964	2.42	0.852112676			1.141509434			2.42			
xi/sigmai				8.782258065				22.90776699	6.897862233	2.410358566	36.3	-19.59859155			-22.8301887			36.3			
			oenanthe NT																		
Media ponderata			8.772417113																		
Norma max-min			0.997170188																		
Norma pesata			0.052768157																		
Peso			5.29%																		
Media pesata			46.42%																		

Table 36- Evaluation table Oenanthe Oenanthe

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	mooring Reef	mooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	Mooring Seab	oving - Seab
			passer hispanioles VU	asser hispanioles	sser hispanioles	ser hispanioles	passer hispanioles V	ser hispanioles	ser hispaniole	ser hispanioles	ser hispanioles	ser hispanioles	ser hispanioles	ser hispanioles	ser hispaniole	ser hispaniole	ser hispaniole	ser hispanioles	ser hispaniole	sser hispanioles	ser hispanioles
Intensità	Basso	1	0	3	0	0	0	3	3	3	3	-3	0	0	-3	0	0	3	0	0	0
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ternazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	emporan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Prev	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabil	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	4	0	0	0	4	8	4	4	-2	0	0	-2	0	0	4	0	0	0
	o vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	17	0	0	0	38	51	42	17	-23	0	0	-20	0	0	17	0	0	0
Deviazione standard			0	0.987525499	0	0	0	0.987525499	2.739367122	4.041111049	0.987525499	1.083306844	0	0	0.935966376	0	0	0.987525499	0	0	0
Inv dev standard^2				1.025423729				1.025423729	0.133259912	0.061234818	1.025423729	0.852112676			1.141509434			1.025423729			
xi/sigmai				17.43220339				38.96610169	6.796255507	2.571862348	17.43220339	-19.59859155			-22.8301887			17.43220339			
			passer hispanioles VU																		
Media ponderata			9.253384959																		
Norma max-min			0.997015037																		
Norma pesata			0.052769604																		
Peso			5.29%																		

Table 37- Evaluation table Passer hispanioles

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird ste	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	Mooring S	Mooring Seab	oving - Seab
			riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU	riparia VU
Intensità	Basso	1	0	6	0	0	0	6	6	3	3	-3	0	0	-3	0	0	3	0	0	0
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ternazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	empo:an	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Prev	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabil	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	4	0	0	0	8	8	8	2	-4	0	0	-2	0	0	4	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	20	0	0	0	45	54	46	15	-25	0	0	-20	0	0	17	0	0	0
Deviazione standard			0	1.585054161	0	0	0	1.729663417	2.712078889	4.217241274	0.642824347	1.212878551	0	0	0.935966376	0	0	0.987525499	0	0	0
Inv dev standard^2				0.398026316				0.334254144	0.135955056	0.056226766	2.42	0.679775281			1.141509434			1.025423729			
xi/sigmai				7.960526316				15.04143646	7.341573034	2.586431227	36.3	-16.99438202			-22.8301887			17.43220339			
			riparia VU																		
Media ponderata			7.565225029																		
Norma max-min			0.997559605																		
Norma pesata			0.042754056																		
Peso			**4.29%**																		

Table 38- Evaluation table Riparia riparia

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring nois	Mooring Seab	oving - Seab
			saxicola rubicula VU	saxicola rubicula VU	axicola rubicula V	xicola rubicula	saxicola rubicula VU	xicola rubicula	xicola rubicula	xicola rubicula	axicola rubicula	axicola rubicula	xicola rubicula	xicola rubicula	xicola rubicula	xicola rubicula	icola rubicula	xicola rubicula	icola rubicula	axicola rubicula V	xicola rubicula V
Intensità			0	3	0	0	0	3	3	3	3	-3	0	0	-3	0	0	3	0	0	0
	Basso	1																			
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	0	2	0	0	0	4	2	16	2	-2	0	0	-4	0	0	2	0	0	0
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ernazion	12																			
Momento	Lungo	1	0	1	0	0	0	4	4	2	1	-2	0	0	-1	0	0	1	0	0	0
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	emporan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	0	1	0	0	0	4	8	4	1	-1	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	0	1	0	0	0	4	4	1	1	-1	0	0	-1	0	0	1	0	0	0
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	0	1	0	0	0	4	4	4	1	-1	0	0	-1	0	0	1	0	0	0
Propagazione	SP	1	0	1	0	0	0	1	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	CP	4																			
Periodicità	Non Prev	1	0	1	0	0	0	4	1	1	1	-4	0	0	-1	0	0	1	0	0	0
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	0	1	0	0	0	2	8	2	1	-2	0	0	-2	0	0	1	0	0	0
	edio term	2																			
	Mitigabil	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	0	4	0	0	0	4	8	4	4	-2	0	0	-2	0	0	4	0	0	0
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	17	0	0	0	38	51	42	17	-23	0	0	-20	0	0	17	0	0	0
Deviazione standard			0	0.987525499	0	0	0	0.987525499	2.739367122	4.041111049	0.987525499	1.083306844	0	0	0.935966376	0	0	0.987525499	0	0	0
Inv dev standard^2				1.025423729				1.025423729	0.133259912	0.061234818	1.025423729	0.852112676			1.141509434			1.025423729			
xi/sigmai				17.43220339				38.96610169	6.796255507	2.571862348	17.43220339	-19.59859155			-22.8301887			17.43220339			
			saxicola rubicula VU																		
Media ponderata			9.253384959																		
Norma max-min			0.997015037																		
Norma pesata			0.042730717																		
Peso			**4.29%**																		

Table 39- Evaluation table Saxicola rubicola

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	mooring Reef	nooring Fish	+mooring N	oring Spill	le routing E	essel nois	essel polluti	ooring nois	Mooring Seab	oving - Seab
			sternula albifrons EN	ternula albifrons EN	ernula albifrons E	rnula albifrons	sternula albifrons EN	ernula albifrons	rnula albifrons	rnula albifrons	ernula albifrons	ernula albifrons	rnula albifrons	rnula albifrons	rnula albifrons	rnula albifrons	nula albifrons	rnula albifrons	nula albifrons	ernula albifrons E	rnula albifrons E
Intensità			**0**	**6**	**0**	**0**	**0**	**12**	**12**	**6**	**3**	**-6**	**0**	**0**	**-6**	**0**	**0**	**3**	**0**	**0**	**0**
	Basso	1																			
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	**0**	**2**	**0**	**0**	**0**	**4**	**2**	**16**	**2**	**-2**	**0**	**0**	**-4**	**0**	**0**	**2**	**0**	**0**	**0**
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ernazion	12																			
Momento	Lungo	1	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**2**	**1**	**-2**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	**0**	**1**	**0**	**0**	**0**	**4**	**8**	**4**	**1**	**-1**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
	emporan	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	**0**	**1**	**0**	**0**	**0**	**4**	**8**	**4**	**1**	**-1**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**1**	**1**	**-1**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
	Cumulativ	4																			
Effetto	Indiretto	1																			
	Diretto	4	**0**	**1**	**0**	**0**	**0**	**4**	**4**	**4**	**1**	**-1**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
Propagazione	SP	1	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**-4**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
	CP	4																			
Periodicità	Non Prev	1	**0**	**1**	**0**	**0**	**0**	**4**	**1**	**1**	**1**	**-4**	**0**	**0**	**-1**	**0**	**0**	**1**	**0**	**0**	**0**
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	**0**	**1**	**0**	**0**	**0**	**2**	**8**	**2**	**1**	**-2**	**0**	**0**	**-2**	**0**	**0**	**1**	**0**	**0**	**0**
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	**0**	**8**	**0**	**0**	**0**	**8**	**8**	**8**	**8**	**-2**	**0**	**0**	**-2**	**0**	**0**	**2**	**0**	**0**	**0**
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			0	24	0	0	0	51	60	49	21	-26	0	0	-23	0	0	15	0	0	0
Deviazione standard			0	2.328408814	0	0	0	2.83717937	3.394209946	4.228983036	2.020555525	1.553455226	0	0	1.504813214	0	0	0.642824347	0	0	0
Inv dev standard^2				0.18445122				0.124229979	0.086800574	0.055914972	0.244939271	0.414383562			0.441605839			2.42			
xi/sigmai				4.426829268				6.335728953	5.208034433	2.739833641	5.143724696	-10.7739726			-10.1569343			36.3			
			sternula albifrons EN																		
Media ponderata			9.874126604																		
Norma max-min			0.996814798																		
Norma pesata			0.040856528																		
Peso			**4.10%**																		

Table 40- Evaluation table Sternula albifrons

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutio	Mooring Nois	Mooring Sea	Cable routing	Turbine nois	bine bird st	bird displa	ring metallic	nooring Reef	nooring Fish	+mooring N	oring Spillo	le routing	essel nois	ssel polluti	ooring noi	ooring Polluti	oving - Seabe
			ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH	ABFT FH
Intensità	Basso	1	12	6	12	6	6	6	0	0	6	-24	18	18	-6	6	6	6	6	6	6
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	8	2	2	2	2	4	0	0	2	-2	2	2	-4	2	4	2	2	2	2
	Comunal	2																			
	Regional	4																			
	Nazionale	8																			
	ternazion	12																			
Momento	Lungo	1	4	2	4	1	4	2	0	0	2	-2	4	4	-1	4	4	2	4	1	1
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	2	2	4	2	1	2	0	0	4	-2	2	4	-2	2	2	2	2	1	1
	emporan	2																			
	Insistente	4																			
	ermanen	8																			
Reversibilità	eve term	1	2	4	4	4	2	4	0	0	4	-2	8	4	-2	2	1	2	2	2	2
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	4	4	4	1	1	4	0	0	4	-1	1	4	-1	4	4	4	4	1	1
	Cumulativ	4																			
Effetto	Indiretto	1	4	1	4	1	1	4	0	0	1	-1	4	1	-1	4	4	1	4	1	1
	Diretto	4																			
Propagazione	SP	1	1	4	1	1	1	1	0	0	1	-4	1	1	-4	1	1	4	1	1	1
	CP	4																			
Periodicità	Non Prev	1	2	1	4	1	1	4	0	0	1	-4	1	4	-1	4	2	1	1	1	1
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	2	2	1	2	2	2	0	0	2	-2	2	2	-2	2	1	2	2	2	2
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	2	2	2	2	2	1	1	1	2	-4	2	2	2	2	2	2	2	2	2
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			**41**	**28**	**40**	**21**	**21**	**33**	**0**	**0**	**27**	**-44**	**43**	**44**	**-24**	**31**	**29**	**26**	**28**	**18**	**18**
Deviazione standard			1.920937271	1.113552873	1.264911064	0.9	0.9	1.2489996	0.3	0.3	1.187434209	1.113552873	2.051828453	1.2489996	1.624807681	1.1	1.28452326	0.979795897	1.11355287	0.489897949	0.489897949
Inv dev standard^2			0.27100271	0.806451613	0.625	1.234567901	1.234567901	0.641025641			0.709219858	0.806451613	0.237529691	0.641025641	0.378787879	0.826446281	0.60606061	1.041666667	0.80645161	4.166666667	4.166666667
xi/sigmai			11.11111111	22.58064516	25	25.92592593	25.92592593	21.15384615			19.14893617	-35.48387097	10.21377672	28.20512821	-9.09090909	25.61983471	17.5757576	27.08333333	22.5806452	75	75
			ABFT FH																		
Media ponderata			20.18533246																		
Norma max-min			0.993488602																		
Norma pesata			0.029302731																		
Peso			2.95%																		
Media pesata			0.595362014																		

Table 41- Evaluation table ABFT FH

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollutic	Mooring Nois	Mooring Sea	Cable routing	Turbine noise	bine bird ste	bird displa	ring metallic	mooring Reef	mooring Fish	+mooring N	oring Spill	ble routing	Vessel noise	ssel polluti	ooring noi	ooring Polluti	oving - Seabe
			ABFT SH	ABFT SH	ABFT SH	ABFT SH	ABFT SH	ABFT SH	ABFT SH	ABTF SH	ABTF SH	ABTF SH	ABTF SH	ABFT SH	ABTF SH	ABTF Sh	ABFT SH	ABTF SH	ABTF SH	ABFT SH	ABFT SH
Intensità	Basso Medio Alto Molto alt	1 2 4 8	12	6	12	6	6	6	0	0	6	-24	18	18	-6	6	6	6	6	6	6
Estensione	Locale Comunal Regional Nazional ernazion	1 2 4 8 12	8	2	2	2	2	4	0	0	2	-2	2	2	-4	2	4	2	2	2	2
Momento	Lungo Medio mmediat	1 2 4	4	2	4	1	4	2	0	0	2	-2	4	4	-1	4	4	2	4	1	1
Persistenza	NP empoRan Insistente ermanen	1 2 4 8	2	2	4	2	1	2	0	0	4	-2	2	4	-2	2	2	2	2	1	1
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	2	4	4	4	2	4	0	0	4	-2	8	4	-2	2	1	2	2	2	2
Cumulabilità	Semplice Cumulativ	1 4	4	4	4	1	1	4	0	0	4	-1	1	4	-1	4	4	4	4	1	1
Effetto	Indiretto Diretto	1 4	4	1	4	1	1	4	0	0	1	-1	4	1	-1	4	4	1	4	1	1
Propagazione	SP CP	1 4	1	4	1	1	1	1	0	0	1	-4	1	1	-4	1	1	4	1	1	1
Periodicità	Non Prev Regolare Continuc	1 2 4	2	1	4	1	1	4	0	0	1	-4	1	4	-1	4	2	1	1	1	1
Recuperabilità	mmediat edio term Mitigabile ecuperab	1 2 4 8	2	2	1	2	2	2	0	0	2	-2	2	2	-2	2	1	2	2	2	1
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	2	2	2	2	2	1	1	1	2	-4	2	2	2	2	2	2	2	2	2
xi			41	28	40	21	21	33	0	0	27	-44	43	44	-24	31	29	26	28	18	17
Deviazione standard			1.920937271	1.113552873	1.264911064	0.9	0.9	1.2489996	0.3	0.3	1.187434209	1.113552873	2.051828453	1.2489996	1.624807681	1.1	1.28452326	0.979795897	1.11355287	0.489897949	0.458257569
Inv dev standard^2			0.27100271	0.806451613	0.625	1.234567901	1.234567901	0.641025641			0.709219858	0.806451613	0.237529691	0.641025641	0.378787879	0.826446281	0.60606061	1.041666667	0.80645161	4.166666667	4.761904762
xi/sigmai			11.1111111	22.58064516	25	25.92592593	25.92592593	21.15384615			19.14893617	-35.48387097	10.21377672	28.20512821	-9.09090909	25.61983471	17.5757576	27.08333333	22.5806452	75	80.95238095
			ABFT SH																		
Media ponderata			19.87905558																		
Norma max-min			0.993587401																		
Norma pesata			0.036552194																		
Peso			3.68%																		
Media pesata			0.731312719																		

Table 42- Evaluation table ABFT SH

			Construction					Operation										Decommissioning				
			Vessel Noise	Vessel Pollution	Mooring Noise	ooring Seabed integ	Cable routing	Turbine noise	urbine bird stri	ne bird displace	ooring metallic p	mooring Reef	mooring Fish	+mooring N	ooring Spillov	le routing	Vessel noise	essel polluti	Mooring noise	g Seabed i	oving - Seab
			Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fissa	Tonnara fiss	Tonnara fissa
Intensità	Basso	1	12	12	3	3	3	3	0	0	6	-12	3	3	6	3	6	6	3	3	3
	Medio	2																			
	Alto	4																			
	Molto alt	8																			
Estensione	Locale	1	2	2	2	2	2	2	0	0	2	-2	2	2	2	2	2	2	2	2	2
	Comunal	2																			
	Regional	4																			
	Nazional	8																			
	ternazion	12																			
Momento	Lungo	1	4	2	2	1	1	1	0	0	2	-2	2	2	2	1	4	2	2	1	1
	Medio	2																			
	mmediat	4																			
Persistenza	NP	1	2	4	4	4	4	1	0	0	4	-4	2	4	4	2	2	4	4	4	4
	empora	2																			
	Insistent	4																			
	ermanen	8																			
Reversibilità	eve term	1	2	4	2	4	4	1	0	0	2	-2	2	2	4	2	2	4	2	4	4
	edio term	2																			
	ngo term	4																			
	ermanen	8																			
Cumulabilità	Semplice	1	4	4	4	1	1	4	0	0	4	-1	1	4	1	1	4	4	4	1	1
	Cumulativ	4																			
Effetto	Indiretto	1	1	1	1	1	1	1	0	0	1	-4	1	1	4	1	1	1	1	1	1
	Diretto	4																			
Propagazione	SP	1	1	1	1	1	1	1	0	0	1	-1	1	1	1	0	1	1	1	1	1
	CP	4																			
Periodicità	Non Pre	1	2	1	4	1	1	4	0	0	1	-1	1	4	1	4	2	1	4	1	1
	Regolare	2																			
	Continuo	4																			
Recuperabilità	mmediat	1	2	2	2	2	2	1	0	0	2	-2	2	2	2	0	2	2	2	2	2
	edio term	2																			
	Mitigabile	4																			
	ecuperab	8																			
Vulnerabilità	Neutro	1	1	1	1	1	1	1	0	0	1	-1	1	1	1	1	1	1	1	1	1
	co vulner	2																			
	Vulnerabil	4																			
	to vulner	8																			
xi			**33**	**34**	**26**	**21**	**21**	**20**	**0**	**0**	**26**	**-32**	**18**	**26**	**28**	**17**	**27**	**28**	**26**	**21**	**21**
Deviazione standard			3.015113446	3.058655244	1.149919149	1.164204407	1.164204407	1.19226155	0	0	1.553455226	3.058655244	0.642824347	1.149919149	1.616035349	1.157083824	1.499311137	1.616035349	1.149919149	1.16420441	1.164204407
Inv dev standard^2			0.11	0.106890459	0.75625	0.737804878	0.737804878	0.703488372			0.414383562	0.106890459	2.42	0.75625	0.382911392	0.74691358	0.444852941	0.382911392	0.75625	0.73780488	0.737804878
xi/sigmai			3.63	3.634275618	19.6625	15.49390244	15.49390244	14.06976744			10.7739726	-3.4204947	43.56	19.6625	10.72151899	12.69753086	12.01102941	10.72151899	19.6625	15.4939024	15.49390244

			Tonnara fissa
Media ponderata			21.68290962
Norma max-min			0.503497243
Norma pesata			0.005132046
Peso			1.02%
Media pesata			0.221009538

Table 43- Evaluation table permanent tuna trap

			Construction					Operation									Decommissioning				
			Vessel Noise	Vessel Pollution	Mooring Noise	ooring Seabed integ	Cable routing	Turbine noise	urbine bird strik	ne bird displace	ooring metallic p	mooring Reef	mooring Fish	+mooring N	ooring Spillov	le routing	Vessel noise	essel pollutio	Mooring noise	g Seabed i	oving - Seabe
			Tonnara Stagion	Tonnara Stagionale	Tonnara Stagionale	Tonnara Stagionale	Tonnara Stagionale	Tonnara Stagionale	Tonnara Stagional	Tonnara Stagionale	Tonnara Stagionale	Tonnara Stagiona	Tonnara Stagio	Tonnara Stagio	Tonnara Stagion	Tonnara Stag	Tonnara Stagio	Tonnara Stagio	Tonnara Stagiona	Tonnara Sta	Tonnara Stagion
Intensità	Basso Medio Alto Molto alt	1 2 4 8	12	12	3	3	3	3	0	0	6	-12	3	3	6	3	6	6	3	3	3
Estensione	Locale Comunal Regional Nazionale ernazion	1 2 4 8 12	2	2	2	2	2	2	0	0	2	-2	2	2	2	2	2	2	2	2	2
Momento	Lungo Medio mmediat	1 2 4	4	2	2	1	1	1	0	0	2	-2	2	2	2	1	4	2	2	1	1
Persistenza	NP emporan Insistente ermanen	1 2 4 8	2	4	4	4	4	1	0	0	4	-4	2	4	4	2	2	4	4	4	4
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	2	4	2	4	4	1	0	0	2	-2	2	2	4	2	2	4	2	4	4
Cumulabilità	Semplice Cumulativ	1 4	4	4	4	1	1	4	0	0	4	-1	1	4	1	1	4	4	4	1	1
Effetto	Indiretto Diretto	1 4	1	1	1	1	1	1	0	0	1	-4	1	1	4	1	1	1	1	1	1
Propagazione	SP CP	1 4	1	1	1	1	1	1	0	0	1	-1	1	1	1	0	1	1	1	1	1
Periodicità	Non Prev Regolare Continuo	1 2 4	2	1	4	1	1	4	0	0	1	-1	1	4	1	4	2	1	4	1	1
Recuperabilità	mmediat edio term Mitigabile ecuperab	1 2 4 8	2	2	2	2	2	1	0	0	2	-2	2	2	2	0	2	2	2	2	2
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	1	1	1	1	1	1	0	0	1	-1	1	1	1	1	1	1	1	1	1
xi			**33**	**34**	**26**	**21**	**21**	**20**	**0**	**0**	**26**	**-32**	**18**	**26**	**28**	**17**	**27**	**28**	**26**	**21**	**21**
Deviazione standard			3.015113446	3.058655244	1.149919149	1.164204407	1.164204407	1.19226155	0	0	1.553455226	3.058655244	0.642824347	1.149919149	1.616035349	1.157083824	1.499311137	1.616035349	1.149919149	1.16420441	1.164204407
Inv dev standard^2			0.11	0.106890459	0.75625	0.737804878	0.737804878	0.703488372			0.414383562	0.106890459	2.42	0.75625	0.382911392	0.74691358	0.444852941	0.382911392	0.75625	0.73780488	0.737804878
xi/sigmai			3.63	3.634275618	19.6625	15.49390244	15.49390244	14.06976744			10.7739726	-3.4204947	43.56	19.6625	10.72151899	12.69753086	12.01102941	10.72151899	19.6625	15.4939024	15.49390244
			Tonnara Stagionale																		
Media ponderata			21.68290962																		
Norma max-min			0.503497243																		
Norma pesata			0.00033556																		
Peso			0.07%																		
Media pesata			0.014450764																		

Table 44- Evaluation table seasonal tuna traps

			Construction					Operation									Decommissioning				
			Vessel noise	Vessel pollution	Mooring Noise	ing Seabed Int	outing -Seabed i	Turbine noise	rbine bird stri	bird displa	ooring metallic p	b+mooring Reef effe	+mooring Fish St	Sub+mooring Noise	b+mooring Spillover eff	Cable routing EMF	Vessel noise	Vessel pollution	Mooring noise	Seabed	ing - Se
			Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabed	Seabe
Intensità	Basso Medio Alto Molto alt	1 2 4 8	4	12	4	4	24	3	0	0	12	-24	0	3	-12	3	6	6	6	6	12
Estensione	Locale Comunal Regional Nazional ternazion	1 2 4 8 12	2	2	2	2	2	2	0	0	2	-2	0	2	-2	2	2	2	2	2	2
Momento	Lungo Medio mmediat	1 2 4	1	2	1	2	4	1	0	0	2	-2	0	2	-2	2	1	2	1	2	4
Persistenza	NP emporan Insistent ermanen	1 2 4 8	2	2	2	2	8	1	0	0	4	-4	0	2	-4	2	1	2	1	2	4
Reversibilità	eve term edio term ngo term ermanen	1 2 4 8	1	4	1	4	8	1	0	0	4	-2	0	2	-2	2	1	4	1	4	4
Cumulabilità	Semplice Cumulativ	1 4	4	4	4	4	1	1	0	0	4	-1	0	4	-1	4	4	4	4	4	1
Effetto	Indiretto Diretto	1 4	4	1	4	1	4	1	0	0	4	-1	0	1	-4	1	1	1	1	1	4
Propagazione	SP CP	1 4	1	1	1	1	1	1	0	0	1	-1	0	1	-1	1	1	1	1	1	1
Periodicità	Non Prev Regolare Continuo	1 2 4	2	1	2	1	1	2	0	0	1	-1	0	4	-1	4	2	1	2	1	1
Recuperabilità	mmediat edio term Mitigabil ecuperab	1 2 4 8	2	4	2	4	8	1	0	0	8	-2	0	2	-2	2	2	4	2	4	8
Vulnerabilità	Neutro co vulner Vulnerabil to vulner	1 2 4 8	1	4	1	8	8	1	0	0	4	-1	0	2	-2	2	1	4	1	4	4
xi			24	37	24	33	69	15	0	0	46	-41	0	25	-33	25	22	31	22	31	45
Deviazione standard			1.19226155	2.993105024	1.19226155	2	6.31147453	0.642824347	0	0	3.0989201	6.467975784	0	0.962091386	3.015113446	0.962091386	1.53741223	1.585054161	1.53741223	1.58505	3.17532
Inv dev standard^2			0.703488372	0.111623616	0.703488372	0.25	0.025103734	2.42			0.104130809	0.023903595		1.080357143	0.11	1.080357143	0.423076923	0.398026316	0.423076923	0.39803	0.09918
xi/sigmai			16.88372093	4.130073801	16.88372093	8.25	1.732157676	36.3			4.790017212	-0.980047412		27.00892857	-3.63	27.00892857	9.307692308	12.33881579	9.307692308	12.3388	4.4631
			Seabed																		
Media ponderata			22.28120725																		
Norma max-min			0.503593743																		
Norma pesata			0.00513303																		
Peso			1.02%																		
Media pesata			0.227107866																		

Table 45- Evaluation table seabed

			Construction							Operation								Decommissiong						
			Vessel noise sel polluoring Ncoring Ncing Pollg - Seab						OWT obstruction	bine none Bird ird dispoooring Poring Reish Strikring r							OWT obstruction	ssel noisel polluoring Ncoring Ncing Polling - Se						OWT obstruction
			Vessel Traffi	Vessel	Vessel	Vessel	Vessel	Vessel	Vessel Traffic	Vessel	Vessel	Vessel	Vessel	Vessel	Vessel	Vess	Vessel Traffic	Vessel	Vessel	Vessel	Vessel	Vessel	Vessel	Vessel Traffic
	Basso	1																						
Intensità	Medio	2	0	0	0	0	0	0	12	0	0	0	0	0	0	0	6	0	0	0	0	0	0	6
	Alto	4																						
	Molto alt	8																						
	Locale	1																						
	Comunal	2																						
Estensione	Regional	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4
	Nazional	8																						
	ernazion	12																						
	Lungo	1																						
Momento	Medio	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4
	mmediat	4																						
	NP	1																						
Persistenza	emporan	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1
	Insistent	4																						
	ermanen	8																						
	eve term	1																						
Reversibilità	edio term	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1
	ngo term	4																						
	ermanen	8																						
Cumulabilità	Semplice	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	Cumulativ	4																						
Effetto	Indiretto	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4
	Diretto	4																						
Propagazione	SP	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	CP	4																						
	Non Prev	1																						
Periodicità	Regolare	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4
	Continuo	4																						
	mmediat	1																						
Recuperabilità	edio term	2																						
	Mitigabile	4																						
	ecuperab	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	Neutro	1																						
Vulnerabilità	o vulner	2																						
	Vulnerabil	4																						
	to vulner	8	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4
xi			0	0	0	0	0	0	38	0	0	0	0	0	0	0	31	0	0	0	0	0	0	31
Deviazione standard									3.026057632								1.585054161							1.748671278
Inv dev standard^2									0.109205776								0.398026316							0.327027027
xi/sigmai									4.149819495								12.33881579							10.13783784
			Vessel traffic																					
Media ponderata			32.50708215																					
Norma max-min			0.505243078																					
Norma pesata			0.00247642																					
Peso			0.004901443																					
Media pesata			0.159331619																					

Table 46- Evaluation table vessel traffic

2. Synthesis Tables

GES 1														
	ABFT FH	ABFT SH	Blue shark	Fin whale	Striped dolphin	Falco eleonorae	Ardea alba NT	burhinus_VU	carduelis_NT	Chloris nt	Circus VU	urruca undata V	Delichon Nt	Egretta LC
W	0.104	0.166	0.166	0.112	0.001	0.083	0.007	0.007	0.009	0.009	0.010	0.009	0.008	0.008
max	10.376	16.600	16.552	11.223	8.334	0.101	0.721	0.734	0.906	0.886	1.037	0.912	0.752	0.799
min	-10.376	-16.600	-16.552	-11.223	-8.334	-0.101	-0.721	-0.734	-0.906	-0.886	-1.037	-0.912	-0.752	-0.799
media	20.185	19.879	22.557	22.339	22.840	13.491	8.918	8.918	9.713	9.713	14.330	9.253	9.713	9.713
media nor	0.601	0.599	0.613	0.612	0.614	0.567	0.545	0.545	0.549	0.549	0.572	0.546	0.549	0.549
media nor	0.062	0.100	0.101	0.069	0.051	0.001	0.004	0.004	0.005	0.005	0.006	0.005	0.004	0.004
	gulosus LC	himantopus LC	Hirundu LC	ichthyaetus nt	motacilla flava VU	nycticorax VU	oenanthe NT	ser hispanioles	riparia VU	axicola rubicula V	ernula albifrons EN			
W	0.004	0.008	0.008	0.005	0.007	0.006	0.009	0.007	0.010	0.010	0.005			
max	0.357	0.818	0.814	0.532	0.693	0.558	0.860	0.651	1.016	1.016	0.495		raptors	classe 1
min	-0.357	-0.818	-0.814	-0.532	-0.693	-0.558	-0.860	-0.651	-1.016	-1.016	-0.495		seabirds	classe 2
media	11.403	11.403	9.713	11.403	7.565	7.565	8.772	9.253	7.565	9.253	9.874		longmigratory	classe 3
media nor	0.557	0.557	0.549	0.557	0.538	0.538	0.544	0.546	0.538	0.546	0.549			
media nor	0.002	0.005	0.004	0.003	0.004	0.003	0.005	0.004	0.005	0.006	0.003			

Table 47- Synthesis table GES 1

GES 3		
	Tonnara fissa	Tonnara Stagionale
W	0.026	0.026
max	2.611	2.617
min	-2.611	-2.617
MEDIA	21.683	21.683
media norm	0.608	0.608
media norm w	0.016	0.016

Table 48-Synthesis table GES 3

GES 6	
	Seabed
W	0.158
max	15.773
min	-15.773
MEDIA	22.281
media norm	0.611
media norm w	0.096

Table 49- Synthesis table GES 6

GES 11	
	Vessel traffic
W	0.0125
max	1.2541
min	-1.2541
MEDIA	32.5071
MEDIA NORM	0.6625
media norm w	0.0083

Table 50- Synthesis table GES 11

Bibliography

Abramic, A., Cordero-Penin, V., & Haroun, R. (2022). Environmental impact assessment framework for offshore wind energy developments based on the marine Good Environmental Status. In *Environmental Impact Assessment Review* (Vol. 97). Elsevier Inc. https://doi.org/10.1016/j.eiar.2022.106862

Addis, P., Secci, M., Biancacci, C., Loddo, D., Cuccu, D., Palmas, F., & Sabatini, A. (2016). Reproductive status of Atlantic bluefin tuna, Thunnus thynnus, during migration off the coast of Sardinia (western Mediterranean). *Fisheries Research*, *181*, 137–147. https://doi.org/10.1016/j.fishres.2016.04.009

Andrea Copping. (2023). *Entanglement with Marine Renewable Energy Mooring Lines*. https://tethys.pnnl.gov/

ARPA Sardegna. (2022). *Annuario dei dati ambientali della Sardegna*. 115–118.

Assandri, G., Bazzi, G., Bermejo-Bermejo, A., Bounas, A., Calvario, E., Catoni, C., Catry, I., Catry, T., Champagnon, J., De Pascalis, F., de la Puente, J., del Moral, J. C., Duriez, O., Evangelidis, A., Gameiro, J., García-Silveira, D., Garcés-Toledano, F., Jiguet, F., Kordopatis, P., … Cecere, J. G. (2024). Assessing exposure to wind turbines of a migratory raptor through its annual life cycle across continents. *Biological Conservation*, *293*. https://doi.org/10.1016/j.biocon.2024.110592

Assessorato dell'agricoltura e riforma agro-pastorale. (2020). *Prot. N. 6747 del 30/04/2020 Determinazione N.207*.

Bracco, G. (2023). *B07. FLOATING OFFSHORE WIND Wind and Ocean Energy Plants*. https://eit.europa.eu/sites/default/files/KIC_IE_OffshoreWind_anticipated_innovations_impact.pdf

Cañadas, A., Pierantonio, N., Araújo, H., David, L., Di Meglio, N., Dorémus, G., Gonzalvo, J., Holcer, D., Laran, S., Lauriano, G., Perri, M., Ridoux, V., Vázquez, J. A., & Panigada, S. (2023). Distribution patterns of marine megafauna density in the Mediterranean Sea assessed through the ACCOBAMS Survey Initiative (ASI). *Frontiers in Marine Science*, *10*. https://doi.org/10.3389/fmars.2023.1270917

Cau, A., Follesa, M. C., Moccia, D., Bellodi, A., Mulas, A., Bo, M., Canese, S., Angiolillo, M., & Cannas, R. (2017). Leiopathes glaberrima millennial forest from SW Sardinia as nursery ground for the small spotted catshark Scyliorhinus canicula. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *27*(3), 731–735. https://doi.org/10.1002/aqc.2717

Christensen, E. D., Kristensen, S. E., & Deigaard, R. (2014). *IMPACT OF AN OFFSHORE WIND FARM ON WAVE CONDITIONS AND SHORELINE DEVELOPMENT*.

Climate, E. (2018). *EUROPEAN COMMISSION*.

Clò, S., De Sabata, E., & Clò, S. (2010). Public sighting scheme reveals the seasonal presence of Cetorhinus maximus around North Sardinia, Italy PUBLIC SIGHTING SCHEME REVEALS THE SEASONAL PRESENCE OF CETORHINUS MAXIMUS AROUND NORTH SARDINIA, ITALY UN PROGETTO DI AVVISTAMENTO PUBBLICO RIVELA LA PRESENZA DI CETORHINUS MAXIMUS NELLE ACQUE DELLA SARDEGNA SETTENTRIONALE. *Biol. Mar. Mediterr*, *17*(1), 246–247. https://doi.org/10.13140/RG.2.2.27556.96646

Commissione Europea. (1992). *DIRETTIVA 92/43/CEE DEL CONSIGLIO del 21 maggio 1992 relativa alla conservazione degli habitat naturali e seminaturali e della flora e della fauna selvatiche*.

Dean, M. (2020). Chapter Six - Multi-criteria analysis. In N. Mouter (Ed.), *Advances in Transport Policy and Planning* (Vol. 6, pp. 165–224). Academic Press. https://doi.org/https://doi.org/10.1016/bs.atpp.2020.07.001

Diakoulaki, D., Mavrotas, G., & Papayannakis, L. (1995). Determining objective weights in multiple criteria problems: The critic method. *Computers and Operations Research*, *22*(7), 763–770. https://doi.org/10.1016/0305-0548(94)00059-H

Dierschke, V., Furness, R. W., & Garthe, S. (2016). Seabirds and offshore wind farms in European waters: Avoidance and attraction. In *Biological Conservation* (Vol. 202, pp. 59–68). Elsevier Ltd. https://doi.org/10.1016/j.biocon.2016.08.016

Direzione generale Servizio Pesca e Acquacoltura. (2022). *Prot. N.5437 del 29/03/2022*. www.regione.sardegna.it

Dott. Ing. Luigi Severini. (2023). *Ministero dell'Ambiente e della Sicurezza Energetica PARCO EOLICO FLOTTANTE NEL MARE DI SARDEGNA SUD OCCIDENTALE Relazione tecnica STUDIO DI IMPATTO AMBIENTALE PARTE 1 di 2 Progetto Dott. Ing. Luigi Severini YR03 C0421YR03RELSIA00a*.

E. Giglio, A. V. C. M. C. C. R. N. G. M. (2023). *AGENDA DI TRANSIZIONE PER L'ENERGIA PULITA*.

Galparsoro, I., Menchaca, I., Garmendia, J. M., Borja, Á., Maldonado, A. D., Iglesias, G., & Bald, J. (2022). Reviewing the ecological impacts of offshore wind farms. *Npj Ocean Sustainability*, *1*(1). https://doi.org/10.1038/s44183-022-00003-5

Giglio, E., Petracca, E., Paduano, B., Moscoloni, C., Giorgi, G., & Sirigu, S. A. (2023). Estimating the Cost of Wave Energy Converters at an Early Design Stage: A Bottom-Up Approach. *Sustainability (Switzerland)*, *15*(8). https://doi.org/10.3390/su15086756

Gill, A. B., & Kimber, J. A. (2005). The potential for cooperative management of elasmobranchs and offshore renewable energy development in UK waters. In *Journal of the Marine Biological Association of the United Kingdom* (Vol. 85, Issue 5, pp. 1075–1081). https://doi.org/10.1017/S0025315405012117

Gschweng, M., Kalko, E. K. V., Querner, U., Fiedler, W., & Berthold, P. (2008). All across Africa: Highly individual migration routes of Eleonora's falcon. *Proceedings of the Royal Society B: Biological Sciences*, *275*(1653), 2887–2896. https://doi.org/10.1098/rspb.2008.0575

Hötker, H., Thomsen, K.-M., & Jeromin, H. (2005). *Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats Facts, gaps in knowledge, demands for further research, and onithological guidelines for the development of renewabe energy exploitation*.

International Energy Agency, I. (2023). *Energy Policy Review Italy 2023*. www.iea.org/t&c/

Josimović, B., Cvjetić, A., & Furundžić, D. (2021). Strategic Environmental Assessment and the precautionary principle in the spatial planning of wind farms – European experience in Serbia. In *Renewable and Sustainable Energy Reviews* (Vol. 136). Elsevier Ltd. https://doi.org/10.1016/j.rser.2020.110459

Kirchgeorg, T., Weinberg, I., Hörnig, M., Baier, R., Schmid, M. J., & Brockmeyer, B. (2018). Emissions from corrosion protection systems of offshore wind farms: Evaluation of the potential impact on the marine environment. In *Marine Pollution Bulletin* (Vol. 136, pp. 257–268). Elsevier Ltd. https://doi.org/10.1016/j.marpolbul.2018.08.058

Lebreton, L., Slat, B., Ferrari, F., Sainte-Rose, B., Aitken, J., Marthouse, R., Hajbane, S., Cunsolo, S., Schwarz, A., Levivier, A., Noble, K., Debeljak, P., Maral, H., Schoeneich-Argent, R., Brambini, R., & Reisser, J. (2018). Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. *Scientific Reports*, *8*(1). https://doi.org/10.1038/s41598-018-22939-w

Liu, L., Fu, Y., Ma, S., Huang, L., Wei, S., & Pang, L. (2019). Optimal scheduling strategy of O&M task for OWF. *IET Renewable Power Generation*, *13*(14), 2581. https://doi.org/10.1049/iet-rpg.2019.0196

Margheritini, L., Hansen, A. M., & Frigaard, P. (2012). A method for EIA scoping of wave energy converters-based on classification of the used technology. *Environmental Impact Assessment Review*, *32*(1), 33–44. https://doi.org/10.1016/j.eiar.2011.02.003

Marques, A. T., Batalha, H., Rodrigues, S., Costa, H., Pereira, M. J. R., Fonseca, C., Mascarenhas, M., & Bernardino, J. (2014). Understanding bird collisions at wind farms: An updated review on the causes and possible mitigation strategies. In *Biological Conservation* (Vol. 179, pp. 40–52). Elsevier Ltd. https://doi.org/10.1016/j.biocon.2014.08.017

Meinardi Cesare. (2023). *L06-2. FOUNDATION INSTALLATION Wind and Ocean Energy Plants*.

Ministero dell'Ambiente e della Sicurezza Energetica. (2024). *PIANO NAZIONALE INTEGRATO PER L'ENERGIA E IL CLIMA*.

M.Klinowska. (1985). Cetacean live stranding sties relate to geomagnetic topography. *Aquatic Mammals*, 27–32.

Moscoloni, C., Chicco, C., Giglio, E., Giorgi, G., & Mattiazzo, G. (2024). *A HYBRID ALTERNATIVES ANALYSIS OF AN OFFSHORE WIND INSTALLATION IN THE MEDITERRANEAN SEA: HOW PIVOTAL ARE THE TECHNOLOGICAL ASPECTS?*

Normandeau Exponent T. Tricas and A. Gill. (2011). *EFFECTS OF EMFS FROM UNDERSEA POWER CABLES ON ELASMOBRANCHS AND OTHER MARINE SPECIES Final Report Prepared under BOEMRE Contract M09P C00014*. http://www.gomr.boemre.gov/homepg/espis/espisfront.asp

Peñalvo-López, E., Andrada-Monrós, C., León-Martínez, V., & Valencia-Salazar, I. (2024). Assessing energy transition in Mediterranean islands. A review. *E-Prime - Advances in Electrical Engineering, Electronics and Energy*, *9*. https://doi.org/10.1016/j.prime.2024.100719

Rezaei, F., Contestabile, P., Vicinanza, D., & Azzellino, A. (2023). Towards understanding environmental and cumulative impacts of floating wind farms: Lessons learned from the fixed-bottom offshore wind farms. In *Ocean and Coastal Management* (Vol. 243). Elsevier Ltd. https://doi.org/10.1016/j.ocecoaman.2023.106772

Rosé N, M., Hedenstro¨m, A., & Hedenstro¨m, H. (2002). Soaring Flight in the Eleonora's Falcon (Falco eleonorae). In *Notes The Auk* (Vol. 119, Issue 3). https://academic.oup.com/auk/article/119/3/835/5561789

Siwabessy, P. J. W., Tran, M., Picard, K., Brooke, B. P., Huang, Z., Smit, N., Williams, D. K., Nicholas, W. A., Nichol, S. L., & Atkinson, I. (2018). Modelling the distribution of hard seabed using calibrated multibeam acoustic backscatter data in a tropical, macrotidal embayment: Darwin Harbour, Australia. *Marine Geophysical Research*, *39*(1–2), 249–269. https://doi.org/10.1007/s11001-017-9314-7

Storai, T., Zinzula, L., Repetto, S., Zuffa, M., Morgan, A., & Mandelman, J. (2011). Bycatch of large elasmobranchs in the traditional tuna traps (tonnare) of Sardinia from 1990 to 2009. *Fisheries Research*, *109*(1), 74–79. https://doi.org/10.1016/j.fishres.2011.01.018

Tahir, Z. ul R., Abdullah, M., Ahmad, S., Kanwal, A., Farhan, M., Saeed, U. Bin, Ali, T., & Amin, I. (2023). An approach to assess offshore wind power potential using bathymetry and near-hub-height reanalysis data. *Ocean Engineering*, *280*, 3. https://doi.org/10.1016/j.oceaneng.2023.114458

Taormina, B., Bald, J., Want, A., Thouzeau, G., Lejart, M., Desroy, N., & Carlier, A. (2018). A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. In *Renewable and Sustainable Energy Reviews* (Vol. 96, pp. 380–391). Elsevier Ltd. https://doi.org/10.1016/j.rser.2018.07.026

TERNA. (2021). *Scenario National Trend Italia*.

Vargiu, A., Novo, R., Moscoloni, C., Giglio, E., Giorgi, G., & Mattiazzo, G. (2022). An Energy Cost Assessment of Future Energy Scenarios: A Case Study on San Pietro Island. *Energies*, *15*(13). https://doi.org/10.3390/en15134535

Vej Niels Jernes. (2010). *WindPRO / Energy Power Curve Air Density Correction And Other Power Curve Options In WindPRO EMD International A/S*. www.emd.dkorwww.windpro.com

Walker, M. M., Diebel, C. E., & Kirschvink, J. L. (2003). *Detection and Use of the Earth's Magnetic Field by Aquatic Vertebrates*.

WWF- France. (2019). *SAFEGUARDING MARINE PROTECTED AREAS IN THE GROWING MEDITERRANEAN BLUE ECONOMY RECOMMENDATIONS FOR THE OFFSHORE WIND ENERGY SECTOR*. https://pharos4mpas.interreg-med.eu

Zarzavilla, M., Quintero, A., Abellán, M. A., Serrano, F. L., Austin, M. C., & Tejedor-Flores, N. (2022). Comparison of Environmental Impact Assessment Methods in the Assembly and Operation of Photovoltaic Power Plants: A Systematic Review in the Castilla—La Mancha Region. *Energies*, *15*(5). https://doi.org/10.3390/en15051926

Sitography

Accobams. (2001). *Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranea Sea and contiguous Atlantic area* . Retrieved from ACCOBAMS: https://accobams.org/

Ana Cañadas1*, N. P. (n.d.). Distribution patterns of marine megafauna density in the Mediterranean Sea assessed though the ACCOBAMS Survey Initiative (ASI). *Frontiers in Marine Science*.

Chitteth Ramachandran, R. D.-J. (2022). Floating wind turbines: marine operations challenges and opportunities. *Wind Energ. Sci.* , 903-924.

COP- Coopenhagen Offshore Partners . (2024, 08 2024). *Ichnusa Wind Power Project Launches Floating LiDAR Campaign, First for an Offshore Wind Project in Sardinia*. Retrieved from Cop: https://cop.dk/ichnusa-wind-power-project-launches-floating-lidar-campaign-first-for-an-offshore-wind-project-in-sardinia/

Dempsey, C. (2024, 08 07). *Types of GIS Data Explored: Vector and Raster*. Retrieved from Geography Realm: https://www.geographyrealm.com/geodatabases-explored-vector-and-raster-data/

earthlife. (2023, October 2023). *What Is A Elasmobranch*. Retrieved from earthlife: https://earthlife.net/what-is-a-elasmobranch/

eBird . (2024). *Explore*. Retrieved from eBird: https://ebird.org/hotspots?env.minX=6.63087899999999&env.minY=35.492917&env.maxX=18.520694&env.maxY=47.090962&yr=all&m=

EMODnet. (2024, 05). *EMODnet Digital Bathymetry (DTM 2022)*. Retrieved from EMODnet: https://sextant.ifremer.fr/record/ff3aff8a-cff1-44a3-a2c8-1910bf109f85/

EOD-eBird Observation Dataset. (2024, May 27). Retrieved from gbif: https://doi.org/10.15468/dl.437yrx

EOD-eBird Observation Dataset. (2024, May 26). *Gbif.* Retrieved from https://doi.org/10.15468/dl.zk89sr

European Commision. (2024, 08 12). *Descriptors under the Marine Strategy Framework Directive*. Retrieved from An official EU website: https://environment.ec.europa.eu/topics/marine-environment/descriptors-under-marine-strategy-framework-directive_en

European Commission . (2024, 08 11). *Descriptors under the Marine Strategy Framework Directive*. Retrieved from Energy, Climate change, Environment: https://environment.ec.europa.eu/topics/marine-environment/descriptors-under-marine-strategy-framework-directive_en

European Commission . (2024, 09 08). *Strategia a lungo termine per il 2050*. Retrieved from Energia, cambiamenti climatici, ambiente: https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_it

European Commission. (2024). *Clean energy vision to clean energy action*. Retrieved from Clean energy for EU islands: https://clean-energy-islands.ec.europa.eu/

European Commission. (2024). *EMODnet Map Viewer*. Retrieved from EMODNET: https://emodnet.ec.europa.eu/en/seabed-habitats

European Commission. (2024). *European Marine Observation and Data Network (EMODnet)*. Retrieved from Emodnet: https://emodnet.ec.europa.eu/geonetwork/emodnet/eng/catalog.search#/home

European Commission. (2024, 08 11). *Marine environment*. Retrieved from Energy, Climate change, Environment: https://environment.ec.europa.eu/topics/marine-environment_en

European Commission, Joint Research Centre. (2020, 11 23). *EMIS - Favourable feeding habitat of fin whale Monthly 1998-2018 (frequency of occurence, %)* . Retrieved from Joint Research Centre Data Catalogue: https://data.jrc.ec.europa.eu/dataset/343b4357-6550-4dcb-ba38-1f5b78f3ac9e

European Commission, Joint Research Centre. (2020, 11 23). *GMIS - Favourable feeding habitat of juvenile Atlantic bluefin tuna (ABFT) Monthly 2003-2017 (frequency of occurence, %)*. Retrieved from Joint Research Centre Data Catalogue: https://data.jrc.ec.europa.eu/dataset/8f566919-c88f-4c2d-84dc-7862800d5385

European Commission, Joint Research Centre. (2020, 11 23). *GMIS - Favourable feeding habitat of juvenile Atlantic bluefin tuna (ABFT) Monthly 2003-2017 (frequency of occurence, %)*. Retrieved from Joint Research Centre Data Catalogue: https://data.jrc.ec.europa.eu/dataset/8f566919-c88f-4c2d-84dc-7862800d5385

European Commission, Joint Research Centre. (2020, 11 23). *GMIS - Favourable spawning habitat of adult Atlantic bluefin tuna (ABFT) Monthly 1998-2017 (frequency of occurence, %)*. Retrieved from Joint Research Centre Data Catalogue: https://data.jrc.ec.europa.eu/dataset/a60cc972-2a78-461b-b8bd-9aae008e9c03

European Commission, Joint Research Centre. (2020, 11 23). *GMIS - Favourable spawning habitat of adult Atlantic bluefin tuna (ABFT) Monthly 1998-2017 (frequency of occurence, %)* . Retrieved from Joint Research Centre Data Catalogue: https://data.jrc.ec.europa.eu/dataset/a60cc972-2a78-461b-b8bd-9aae008e9c03

European Commission, Joint Research Centre. (2022, 04 04). *Joint Research Centre Data Catalogue*. Retrieved from Foraging habitat of blue shark (Prionace glauca) - Global Ocean MONTHLY - 2003-2018 (% of daily favorable occurrence, 1/24° by 1/24°): https://data.jrc.ec.europa.eu/dataset/6062ddae-2478-409a-89bf-8121902dc70e

European Environment Agency. (1992). *Site of Community importance* . Retrieved from European Environment Agency: https://www.eea.europa.eu/help/glossary/eea-glossary/site-of-community-importance

Garg, S. (2024, 08 07). *KDNuggets*. Retrieved from How to Deal with Categorical Data for Machine Learning: https://kdnuggets.com/2021/05/deal-with-categorical-data-machine-learning.html

Gbif. (1999). *GBIF*. Retrieved from GBIF: https://www.gbif.org/what-is-gbif

GBIF. (2024, 05 2024). *GBIF Occurence Download*. Retrieved from GBIF.org: https://doi.org/10.15468/dl.437yrx

GBIF. (2024, 06 04). *GBIF Occurrence Download*. Retrieved from GBIF: https://doi.org/10.15468/dl.sdrrs5

GBIF. (2024, 05 26). *GBIF Occurrence Download*. Retrieved from GBIF: https://doi.org/10.15468/dl.zk89sr

ISPRA. (2024, 07 20). *Atlante della migrazione degli uccelli in Italia*. Retrieved from isprambiente: https://www.isprambiente.gov.it/it/pubblicazioni/pubblicazioni-di-pregio/atlante-della-migrazione-degli-uccelli-in-italia

ISPRA. (2024). *Atlante della migrazione degli uccelli in Italia*. Retrieved from ISPRA: https://www.isprambiente.gov.it/it/pubblicazioni/pubblicazioni-di-pregio/atlante-della-migrazione-degli-uccelli-in-italia

ISPRA. (2024, 08). *Le specie non indigene nella valutazione degli impatti connessi al traffico marittino*. Retrieved from ISPRA: https://www.isprambiente.gov.it/it/progetti/cartella-progetti-in-corso/biodiversita-1/biodivalue/attivita-realizzate-da-ispra-1/4.2-le-specie-non-indigene-nella-valutazione-degli-impatti-connessi-al-traffico-marittimo

IUCN. (2024, 08 08). *IUCN Red list*. Retrieved from IUCN Red list: https://www.iucnredlist.org/

IUCN. (2024). *Liste rosse italiane*. Retrieved from IUCN Comitato Italiano: https://www.iucn.it/scheda.php?id=218610790

IUCN. (2024). *Liste Rosse italiane*. Retrieved from IUCN: https://www.iucn.it/liste-rosse-italiane.php?ricerca=Leiopathes+glaberrima&submit=Vai

IUCN. (2024). *Liste Rosse italiane*. Retrieved from IUCN: https://www.iucn.it/liste-rosse-italiane.php?ricerca=Posidonia&submit=Vai

IUCN. (2024). *Liste Rosse Italiane*. Retrieved from IUCN: https://www.iucn.it/classe-reptilia.php?ordine=TESTUDINES&famiglia=CHELONIIDAE

Janss, G. F. (2000). Avian mortality from power lines: a morphologic approach of a species-specific mortality. *Biological Conservation*, 353-359.

Karen L. Krijgsveld, K. A. (2009). Collision Risk of Birds with Modern Large Wind Turbines. *Ardea*, 357-366.

MATLAB. (2024). Retrieved from MATLAB: https://it.mathworks.com/products/matlab/programming-with-matlab.html#:~:text=MATLAB%20%C3%A8%20un%20linguaggio%20di,di%20applicazioni%20su%20larga%20scala.

Ministero dell'Ambiente e della Sicurezza Energetica. (2023, 05 22). *Strategia per il mare*. Retrieved from Ministero dell'Ambiente e della Sicurezza Energetica: https://www.mase.gov.it/pagina/strategia-il-mare

National Geographic . (2024). *Education*. Retrieved from National Geographic : https://education.nationalgeographic.org/resource/resource-library-food-chains-and-webs/

QGIS. (2024, 08 09). *General vector*. Retrieved from QGIS DOCUMENTATION: https://docs.qgis.org/3.16/it/docs/user_manual/processing_algs/qgis/vectorgeneral.html#join-attributes-by-location

QGIS. (2024, 08 08). *Analisi raster* . Retrieved from QGIS DOCUMENTATION: https://docs.qgis.org/3.16/it/docs/user_manual/processing_algs/qgis/rasteranalysis.html

QGIS. (2024, 08 07). *QGIS*. Retrieved from Working with the Attribute Table: https://docs.qgis.org/2.18/en/docs/user_manual/working_with_vector/attribute_table.html#:~:text=The%20attribute%20table%20displays%20information,selected%2C%20moved%20or%20even%20edited.

QGIS. (2024, 08 09). *Sovrapposizione dei vettori*. Retrieved from QGIS DOCUMENTATION: https://docs.qgis.org/3.16/it/docs/user_manual/processing_algs/qgis/vectoroverlay.html

Technical University of Denmark. (2024). Retrieved from Global Wind Atlas: https://globalwindatlas.info/en

Technical University of Denmark. (2024, 05). *GLOBAL SOLAR ATLAS|ENERGYDATA.INFO*. Retrieved from GLOBAL WIND ATLAS: https://globalwindatlas.info/en

Technical Univestity of Denmark . (2024, 05). *Software*. Retrieved from WAsP: https://www.wasp.dk/software/wasp

Vitiello, D. (2023, ottobre 2023). *Nidificazioni di tartaruga marina in Italia: 19esimo aggiornamento del 2023*. Retrieved from Tarpedia: https://tartapedia.it/nidificazioni-di-tartaruga-marina-in-italia-19esimo-aggiornamento-del-2023/

Wang, H. (2022). *Taut mooring* . Retrieved from SpringerLink: https://link.springer.com/referenceworkentry/10.1007/978-981-10-6946-8_146