D6.2 Report on Environmental Impact Assessment and Mitigation Strategies

University Bremen/MARUM

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Abstract

This report presents the Deliverable 6.2 – Report on Environmental Impact Assessment and Mitigation Strategies. The first and essential step for an evaluation of potential effects on the environment was the collection of available information on the existing environments at the three sites: (i) off Gran Canaria (Spain), (ii) off Crete (Greece), and (iii) off Liuqiu Island (Taiwan). In the second step we developed an appropriate methodology for the environmental impact assessment (EIA) of floating multi-use offshore platforms that may serve as a guideline for future EIAs. The third step involved the identification and summary of potential impacts of the three selected TROPOS scenarios, Leisure Island (Gran Canaria), and Green & Blue Scenario (Crete and Liuqiu Island), on the particular environments. In the fourth step we evaluated the significance of each identified effect to estimate overall magnitude of consequences. The fifth and final step was the development of appropriate negative impact mitigation measures. In total, a multitude of potential impacts were identified for each scenario, most of them of only minor or moderate significance. The Green & Blue Scenario off Crete is not expected to have major detrimental effects on the environment, because the existing environment is not of high sensitivity. However, the waters are phosphorous limited and the deposits and remains from the fish aquaculture may result in a boost of local primary production due to phosphorous input. For the Leisure Island scenario off Gran Canaria, noise from vessel traffic and operation of leisure facilities, as well as artificial lighting from bars and restaurants have been identified as the most critical effects. The Green & Blue scenario in Taiwan involves aquaculture, OTEC and some leisure facilities, i.e. noise and artificial lighting are impacts to consider here, too. Additionally, solid and liquid wastes from leisure facilities and the fish aquaculture may in combination significantly affect water quality and the living community. Some of the identified negative effect can be efficiently mitigated, e.g. appropriate waste and waste water treatment and management will avoid or at least significantly reduce negative impacts of wastes on the environment. Other negative effects, such as noise generated by mooring installation, vessel traffic and leisure facilities or artificial lighting can be reduced, but not completely removed. Effects of these stressors on the environment will need comprehensive monitoring and appropriate management. An EIA of a 4th TROPOS concept, the so-called *Sustainable Service Hub*, will be included in a future deliverable; nevertheless, a first short introduction of the concept and a preliminary summary on environmental aspects are already provided, here.

TABLE OF CONTENTS

Chapter *Description* *Page*

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES INDEX

FIGURES INDEX

Description *Page*

1 INTRODUCTION

1.1 OBJECTIVES

When planning and designing any kind of offshore installation, the potential effects on the environment need to be considered. As the TROPOS scenarios, so far, are still in design, and there are no existing multi-use offshore installations outside of the Oil & Gas sector that can be used as an example, the approach used to assess the environmental impact of the TROPOS scenarios is based on state-of-the-art knowledge from single-use or onshore installations and experience gained within this project. However, the methodology developed here will provide the guideline for future real EIAs when the platforms are going to be built.
This deliverable, D6.2, involves 2 tasks: Task 6.2 on Environmental Impact Assessment, and Task 6.3 on Negative Impact Mitigation Strategies. In this deliverable, we are providing a detailed overview on potential impacts of single elements, and a synthesis of the impacts of the scenarios as a whole. The evaluation and assessment are done based on (i) information available from previous deliverables (Chapter 4), (ii) a comprehensive collection of background data (Chapter 5), (iii) an extensive literature survey (see D.6.1), and (iv) experience and expert knowledge. To evaluate which impacts can be considered of minor and which ones of major significance, several variables are taken into account. For impacts of major significance, appropriate mitigation strategies are developed according to state-of-the-art knowledge. Based on the outcomes of this impact assessment, a suitable monitoring program will be developed in the scope of D6.3.

The ultimate aim of this Environmental Impact Assessment study, is the reduction or mitigation of negative impacts, in particular the avoidance of cumulative negative impacts, and the enhancement of synergies, to make the TROPOS scenarios an ecologically valuable and feasible contribution to future offshore installations.

In this deliverable we are considering 3 different TROPOS scenarios (for details, see Chapter 4): Leisure Island off Gran Canaria, Green & Blue Concept off Crete, and Green & Blue Concept off Liuqiu Island, Taiwan. Recently, a 4th scenario was chosen to be considered in more detail in the scope of TROPOS, the so-called *Sustainable Service Hub Concept*, which is supposed to be located on the Dogger Bank, in the North Sea. As this scenario was just recently selected for further consideration, it is not analysed in detail, here. However, a preliminary summary on environmental aspects of the *Sustainable Service Hub* Concept on the Dogger Bank is given in the Annex, Chapter 11.3. A more detailed assessment on environmental aspects of this concept will be included in D6.5.

1.2 ENVIRONMENTAL IMPACT ASSESSMENT

According to the UN Environment Programme (UNEP), the term "*Environmental Impact Assessment (EIA)*" is defined as a procedure that identifies, describes, evaluates and develops means of mitigating potential impacts of a proposed activity on the environment. In Europe, an EIA is mandatory according to the EIA Directive (2011/92/EU) for projects likely to have significant effects on the environment. The EIA is a process that aims at identifying negative impacts of a new project in an early design stage, so that changes in plans or redesign of the structure can be made if necessary, according to the outcome of the assessment.

Despite some inconsistencies in implementation of the EIA Directive between individual EU member states (Telfer et al. 2009), the general structure of the EIA process within **Europe** is identical. The EIA is composed of different phases, starting with the screening as a first step:

- *Screening* – the process of determining whether or not an EIA is required for a particular project; if yes, the following steps are required.
- *Scoping* – the process of determining the scope, framework and content of the environmental impact analyses and the environmental impact report.
- *Prediction and Mitigation* – the process of predicting, identifying and assessing potential impacts (positive and negative impacts) of a project, and development of negative impact mitigation strategies. The results of the evaluation are to be submitted in *draft Environmental Impact Statement (EIS)* to a competent authority, and will be reviewed by the competent authority and the public.
- *Final EIS, management and monitoring* – the final EIS is the main output of the EIA and includes a management plan and a monitoring program.

The main steps of the EIA process and parallel studies are shown in Figure 1-1. The process of virtual scoping for the TROPOS scenarios was completed based on an extensive literature survey and submitted to the European Commission (EC) in deliverable D6.1.

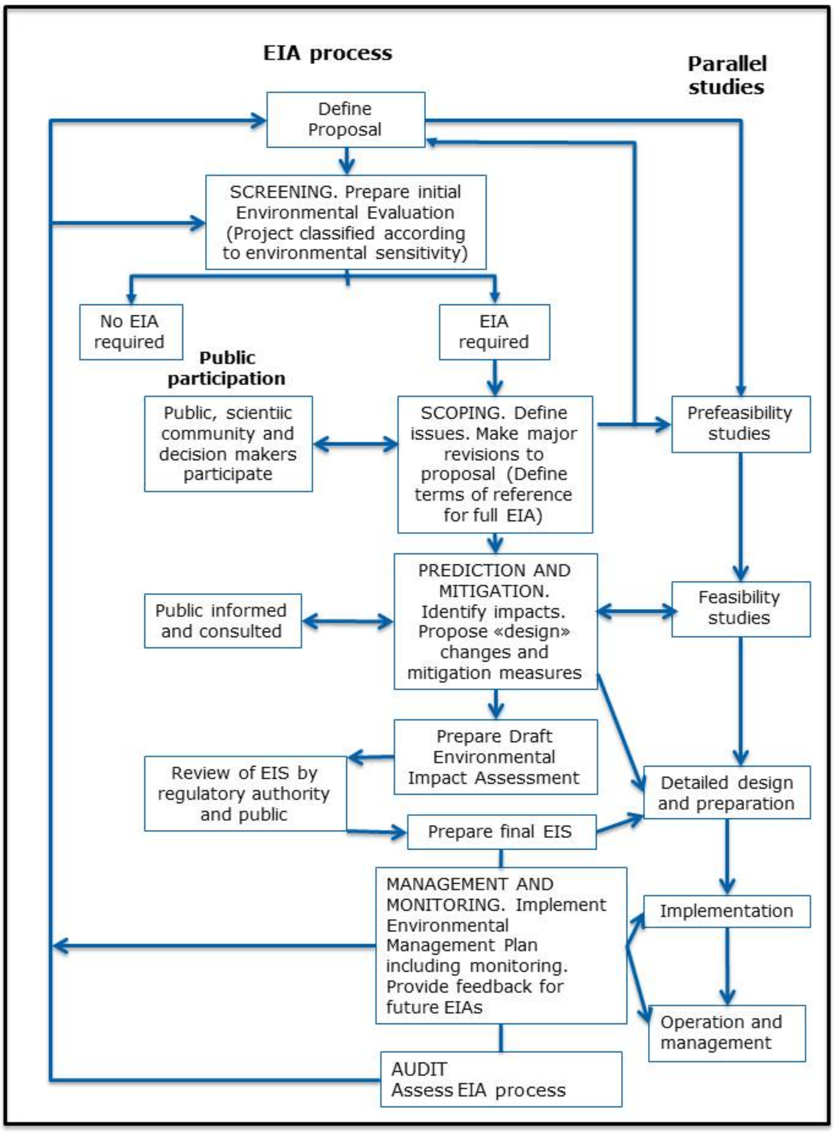


Figure 1-1: Flow diagram of the EIA process and parallel studies (source: FAO)

The involvement of the public is an important part of project planning and EIA. However, social acceptance and impacts are not discussed in this deliverable, as these topics are covered in detail in D6.4, *A framework for describing the social impact with concrete examples that apply for the Canary Island*. The monitoring program developed based on the outcomes of D6.2, is part of the deliverable D6.3.

In **Taiwan**, the process is similar to the one in Europe. Here, the environmental impact assessment (EIA) involves the processes of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to making major decisions and commitments. The purpose of the assessment is to ensure that decision-makers consider environmental impacts before deciding whether to proceed with new projects (Environmental Protection Administration, Taiwan, 1997). The process of EIA in Taiwan includes the following steps (Environmental Protection Administration, Taiwan, 1997):

1. Site Allocation:

- To insure the proposed development site is not located in environmentally sensitive areas (e.g. water supply protection zone, wildlife refuge, national parks, geological sensitive areas etc.), specific land use (e.g. military control, air traffic control zone etc.).
- To avoid the proposed plan if it may violate prohibitions and restrictions by laws and regulations in Taiwan.
- To arrange appropriate adjustment plans (alternative sites).

2. Environmental Survey:

- Data collection – physical, natural, social, economic environment.
- Potential impact assessment during and after construction.
- Comprehensive assessment.

3. Prediction and Assessment – Forecast and prediction.

4. Mitigation Strategies:

- Strategies for "avoidance, mitigation, and compensation".
- Both construction and operation stages.
- Monitoring strategies.

5. Alternative Plan – Alternative plans in terms of site location, materials, construction methodologies and others.

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The policy and legal framework involves different levels: national legislation, European policy, and international commitments and conventions. European policy is a broad field. The Treaty on European Union (Treaty on Maastricht) has been in force since 1993; it is European Union law, a collection of treaties and legislation, such as regulations and directives. These European regulations and directives directly or indirectly affect the laws of EU member states. While EU 'regulations' have direct force of law in EU member states, 'directives' are binding as to the results to be achieved, but give some flexibility over the means used to achieve those results. According to Article 10 of the European Community Law,

"Member States shall take all appropriate measures, whether general or particular, to ensure fulfillment of the obligations arising out of this Treaty or resulting from action taken by the institutions of the Community. They shall facilitate the achievement of the Community's tasks. They shall abstain from any measure which could jeopardise the attainment of the objectives of this Treaty".

This means, that by becoming a member of the European Community, the state is obliged to incorporate European regulations and directives into national law. This is also valid concerning laws for environmental protection; it has to be ensured that the European standards are adopted and followed on the national level.

On the international level, there are several commitments and conventions dealing with environmental issues, mainly focusing on protection and sustainability. By signing an international commitment, a state undertakes to follow terms and conditions. There are also international agreements concerning particular regions or areas, such as the Mediterranean. A summary of European and international legislation and regulations is given in Table 2-3.

2.1 NATIONAL LEGISLATION

2.1.1 SPAIN (CANARY ISLANDS)

The Canary Islands is one of Spain's autonomous communities. Environmental and species protection on the Canary Islands are regulated based on different laws and regulations.

Species Protection involves two major categories: (i) protection of endangered species, and (ii) protection of exploited species. The general and basic legal framework is represented by **Law 4/1989** on nature conservation for the whole Spanish state, including guidelines for a legal regime on protected areas. Endangered species of the Canary Islands are listed in a catalog, following *Decreto 151/2001*. The catalogue includes a total of 104 marine species, 17 plants, 42 invertebrates and 45 vertebrates. In accordance with the state legislation, species are grouped in four different categories: "endangered", "sensitive", "vulnerable", and "of special interest". For the protection of species different conservation measures and recovery and handling plans, which can be specified in individualised plans and strategies, have been established. *Decreto 151/2001* also specified additions and deletions of species names in the catalogue, as well as breaches and approvals. Whether or not a species is included in the list may be subject to discussions, but there is no doubt that this catalogue represents an important contribution to species protection on the archipelago.

The Statute of Autonomy of the Canary Islands (Constitutional law 10/1982 4/1996) states that the autonomous region of the Canaries owns sovereign rights for fishing in inland waters, shellfish and aquaculture. The statute also assigns the legislative handling and the execution of issues related to the fishing sector to the Autonomous region of the Canary Islands. In 1986 the state published the *ROYAL DECREE 2200/1986* of regulation of arts and forms of fishing in the waters of the Canary Islands. The Royal Decree

2200/1986 applies to the Spanish territorial waters around the Canary Islands as well as to the Exclusive Economic Zone (EEZ).

The minimum catch sizes of fish in waters around the Canary Islands are regulated in the *Decree n ° 155 of 1986*. This decree aims to avoid capture of too young and immature individuals and to protect breeding and nursery ground for a sustainable stock management. Sports fishing licenses are regulated by *Decree n ° 121/1998*.

The declaration of protected areas is regulated in the Canary Island by several different norms. There is a consolidated version of the "Ley de Espacios Naturales de Canarias" (Law of Nature Reserves) and the "Ley de Ordenación del Territorio" (Law on Spatial Planning), approved in *legislative Decree 1/2000* (May 8), defining an are to be protected as ""those of the terrestrial or marine territory that contain elements or natural systems of special interest or value".

The Fisheries Law of the Canary Islands, **Law 17/2003** of April 10, dedicates its chapter III to the "Measurements of protection and regeneration of the fishery resources", establishing a set of areas protected from fishing. The law declared three different protection schemes for marine reserves for fishing interests, marine restoration zones, and marine repopulation zones.

Currently, there are three large-scale protected areas which have been created by Decree of the Government of Canaries and Ministerial Order of the State Department of Marine Fishing (Table 2-1).

Table 2-1: Marine protected areas of the Canary Islands

Reserva Marina	Latitud	Longitud	Tamaño (ha)	Gestión
Isla de la Graciosa e Islotes al Norte de Lanzarote	29º27'N 29º12'N	13º34'W 13º17'W	70.700	Administración del Estado Comunidad Autónoma Canaria
LA RESTINGA - MAR DE LAS CALMAS Isla de El Hierro	27º 38,38' N 27º 36,30' N 27º 40,35' N 27º 38,85' N	17º 58,59' W 17º 58,90' W 18º 02,24' W 18º 00,20' W	750	Administración del Estado Comunidad Autónoma Canaria
Isla de La Palma	28º 34,2 N 28º 28,2 N.	Perpendiculares a tierra	3.791	Administración del Estado

In each of the reservations at least two areas are established: (i) an area of integral reservation, in which no type of activity, except for scientific studies, is allowed; and (ii) an area of restricted uses, where activities such as sports diving or fishing with hook are allowed.

The *Royal Decree 1997/1995* integrates the European Habitat Directive into national law (see below) and aims at protecting and conserving natural habitats and wild flora and fauna.

The **Law 12/1994** of Nature Reservations of the Canary Islands now merged with the Law of Spatial Planning and in accordance with article 18 of the consolidated version, establishes that an Insular Plan of Spatial Planning must include criteria for defense, progress and organisation of the coastal areas and marine nature reservations, including a list of activities that could be developed in the area itself and its surrounding. Such a plan should also include the specific measures that should be taken by the competent Administration.

2.1.2 GREECE (CRETE)

In the following chapter, some of the major laws and regulations related to the environment and environmental protection are summarised.

In Greece, **Law 1650/86** was the main legal provision for the protection of the environment. The law, together with the *Joint Ministerial Decision (JMD) 69269/5387/1990*, regulates the categorisation of projects, procedure of environmental terms approval, the content of EIAs and public information. Parts of this law were amended and replaced in 2011 by **Law 4014/2011** on the environmental licensing of projects and activities. The approval procedures are specified within the *Ministerial Decision (MD) 167563/2013*. The *JMD 11014/703/Φ104/2003* defines the environmental permitting procedure, including EIA procedure, competent authorities, and content of EIA studies, and *JMD 37111/2021/2003* regulates the involvement and information of public (TAP 2013).

Law 3937/2011 deals with the protection of biodiversity and NATURA 2000 network areas, and **Law 3983/2011** sets the framework of the protection and management of the marine environment.

The legislative framework for spatial planning in Greece is defined by **Law 2742/1999** 'Spatial Planning, Sustainable development and other provisions'. **Law 3199/2003** and *Presidential Decree 51/2007* on water protection and the sustainable management of water resources correspond to the European Water Framework Directive. The *Sanitary Provision E1B/221/65* sets procedures for wastewater disposal. The new framework **Law 4042/2012** on waste management (together with *JMD 50910/2727/2003* and *JMD 114218/1997)* follows the EU Waste Framework Directive and the Directive 99/2008/EC. Handling of oil or other pollution incidents involving harmful substances is regulated by *Ministerial Decree 11/2002* (the National Plan of Emergency).

Law 3851/2010 provides the framework for "Accelerating the development of Renewable Energy Sources to deal with climate change and other regulations addressing issues under the authority of the Ministry of Environment, Energy and Climate Change".

The Greek government agencies with responsibilities related to environmental protection include:

- The Ministry for the Environment, Physical Planning and Public Works.
- The National Center for Environment and Sustainable Development.
- National Environmental Information Network.

2.1.3 TAIWAN (LIUQIU ISLAND)

Considering the legal aspects, the different functions (Transport, Energy, Aquaculture, Leisure) of the TROPOS project may be relevant to various administrations in Taiwan. Several laws and corresponding authorities are listed below.

- Environmental Protection Administration

  Environmental Impact Assessment Act, The Environmental Education Act, Noise Control Act, Waste Disposal Act, Toxic Chemical Substances Control Act, Air Pollution Control Act, Marine Pollution Control Act, Water Pollution Control Act, Drinking Water Management Act.
- Council of Agriculture, Executive Yuan

  Fishing Port Act, Fisheries Act, Cultural Heritage Preservation Act, Wildlife Conservation Act, Veterinary

Drugs Control Act.

- Construction and Planning Agency Ministry of the Interior

  The Law of Ships, Act for the Development of Tourism, Yacht Harbor Law (Draft), Building Act, National Park Law, Coastal Law (Draft), Landscape Law (Draft).

- Coast Guard Administration, Executive Yuan

  The Coast Guard Act.

According to the above laws and authorities, the relationship with function (Leisure, Energy, Aquaculture and Transportation) and laws are identified in Table 2-2.

Table 2-2: Legislations in Taiwan related to TEAL platforms

	Authority	Leisure	Energy	Aquaculture	Transportation
Environmental Impact Assessment Act	Environmental Protection Administration	●	●	●	●
The Environmental Education Act		●	●	●	
Noise Control Act		●	●		●
Waste Disposal Act		●			●
Toxic Chemical Substances Control Act					●
Air Pollution Control Act		●			●
Marine Pollution Control Act		●	●	●	●
Water Pollution Control Act		●	●		●
Drinking Water Management Act		●			
Fishing Port Act	Council of Agriculture, Executive Yuan			●	●
Fisheries Act		●		●	●
Cultural Heritage Preservation Act		●			
Wildlife Conservation Act		●	●	●	●
Veterinary Drugs Control Act				●	
The Law of Ships	Ministry of Transportation and Communications	●		●	●
Act for the Development of Tourism		●			
Yacht Harbor Law (Draft)		●			●
Building Act	Construction and Planning Agency Ministry of the Interior	●	●	●	●
National Park Law		●	●	●	●
Coastal Law (Draft)		●	●	●	●
Landscape Law (Draft)		●	●	●	●
The Coast Guard Act	Coast Guard Administration, Executive Yuan	●	●	●	●

2.2 EUROPEAN POLICY

In the following chapter, some of the most important European environmental directives are summarised (also, see Table 2-4). These directives have to be integrated into national law by each member state of the EU.

2.2.1 ENVIRONMENTAL IMPACT ASSESSMENT DIRECTIVE

The original *Environmental Impact Directive 85/337/EEC*, in short *EIA Directive*, has been in force since 1985 and has been amended three times, in 1997 (Directive 97/11/EC), in 2003 (Directive 2003/35/EC), and in 2009 (Directive 2009/31/EC). The initial Directive of 1985 and its three amendments have been codified by Directive 2011/92/EU in December 2011. This codified directive, again, has been replaced in 2014 by Directive 2014/52/EU (for details see ec.europa.eu).

The EIA Directive established procedures to assess environmental impacts, and it applies to different public and private projects which are defined in the Annexes I and II of the directive. Projects listed in Annex I are considered to have significant environmental effects and require an impact assessment (mandatory EIA) prior to them being granted consent by local and/or national authorities. Projects listed in Annex I are mostly large-scale projects, such as motorways, power stations, chemical works, oil refineries, etc. For projects listed in Annex II of the directive (e.g. related to energy industry, food and textile industry, development of tourism and leisure facilities, etc.), the national authorities have to decide whether an EIA is needed. This is done by the "screening procedure", which determines the effects of projects on the basis of thresholds/criteria or a case by case examination. However, the national authorities must take into account the criteria laid down in Annex III of the Directive (e.g. characteristics of the project, location, etc.).

According to the EC, the EIA procedure can be, in short, summarised as follows (EC 2014): *"…the developer may request the competent authority to say what should be covered by the EIA information to be provided by the developer (scoping stage); the developer must provide information on the environmental impact (EIA report – Annex IV); the environmental authorities and the public (and affected Member States) must be informed and consulted; the competent authority decides, taken into consideration the results of consultations. The public is informed of the decision afterwards and can challenge the decision before the courts."* In Figure 1-1 (above) the EIA procedure and parallel studies are illustrated.

2.2.2 STRATEGIC ENVIRONMENTAL ASSESSMENT DIRECTIVE

The Strategic Environmental Impact Assessment Directive 2001/42/EC, in short SEA Directive, has been in force since 2001. While the EIA Directive applies to public and private projects (see above), the SEA Directive applies to a wide range of public plans and programmes (e.g. land use, transport, energy, waste, etc.). The plans and programmes must be prepared or adopted by an authority (at national, regional or local level) and must be required by legislative, regulatory or administrative provisions. According to Article 3 of the Directive, an SEA is mandatory for plans/programmes,

(a) which are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use and which set the framework for future development consent of projects listed in Annexes I and II to Directive 85/337/EEC, or
(b) which, in view of the likely effect on sites, have been determined to require an assessment pursuant to Article 6 or 7 of Directive 92/43/EEC.

According to the EC, the SEA procedure can be, in short, summarised as follows (EC 2014):

"…an environmental report is prepared in which the likely significant effects on the environment and the reasonable alternatives of the proposed plan or programme are identified. The public and the environmental authorities are informed and consulted on the draft plan or programme and the environmental report prepared. As regards plans and programmes which are likely to have significant effects on the environment in another Member State, the Member State in whose territory the plan or programme is being prepared must consult the other Member State(s). The environmental report and the results of the consultations are taken into account before adoption. Once the plan or programme is adopted, the environmental authorities and the public are informed and relevant information is made available to them. In order to identify unforeseen adverse effects at an early stage, significant environmental effects of the plan or programme are to be monitored."

SEA and EIA procedures are similar, but there are some differences, e.g. the SEA requires consultation of environmental authorities during screening, and scoping is obligatory (for more details see their website (EC 2014).

2.2.3 HABITATS DIRECTIVE

The *Council Directive 92/43/EEC* on the conservation of natural habitats and of wild fauna and flora, known as *Habitats Directive*, was adopted in 1992. Together with the Birds Directive (see below), the Habitat Directive is a key element of the European nature conservation policy. The directive intends to protect biodiversity by demanding maintenance and restoration of habitats and species from the members of the EU. The directive protects more than 1,000 animals and plant species and more than 200 habitat types (e.g. special types of forests, meadows, wetlands, etc.), which are of European importance. The protected natural habitats and wild species are all listed in the Annexes of the Habitats Directive (EC 2014).

One key element of European nature and biodiversity policy, which was established under the directive, is the *Natura 2000 network*. This EU-wide network aims to protect Europe's most valuable and threatened species and habitats. The Natura 2000 network includes Special Areas of Conservation (SAC) defined by member states under the Habitat Directive, and Special Protection Areas (SPAs) defined under the Birds Directive (see below). However, it is not a strict system which excludes all human activities in all areas, because the focus of the network is sustainable long-term management, both in terms of ecology and economy. Accordingly, SACs and SPAs within the Natura 2000 network involve nature reserves as well as land in private ownership.

2.2.4 WILD BIRD DIRECTIVE

The *EU Directive 2009/147/EC* on the conservation of wild birds, in short Wild Bird Directive or Bird Directive, is the codified version of Directive 79/409/EEC as amended, and has been in force since 1979. Many wild birds are migratory and distribution areas of species are extending across the borders of European member states. Effective conservation of wild birds therefore requires an international cooperation (EC 2014). The Wild Birds Directive aims to protect all European wild birds and the habitats of species listed in the Annex of the Directive. Particular emphasis is on the protection and restoration of habitats, and the SPAs defined in the framework of this directive are part of the Natura 2000 network (see above). This Directive provides a comprehensive framework for the conservation and management of wild birds in Europe, and human interactions with them.

The Wild Bird Directive is the EU's oldest, and, together with the Habitats Directive, most important piece of nature conservation legislation in Europe.

2.2.5 WATER FRAMEWORK DIRECTIVE

The *Directive 2000/60/EC* of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, in short the *Water Framework Directive*, was finally adopted in 2000. The purpose of this directive is to establish a framework for the protection of inland surface waters (rivers, lakes), transitional waters (estuaries), coastal waters and groundwater to improve the water quality throughout Europe (EC 2014).

Though the major focus of this directive is on inland waters, it also considers coastal waters. Accordingly, this directive has to be taken into account, at least for TROPOS scenarios that are located closer to the coast (e.g. Leisure Island, Gran Canaria).

2.2.6 MARINE STRATEGY FRAMEWORK DIRECTIVE

Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy, known as *Marine Strategy Framework Directive*, has been in force since 2008. The aim of the directive is the more efficient protection of the marine environment across Europe. The Marine Directive aims to achieve so-called "Good Environmental Status" (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend.

According to Article 3 of the directive, the term *good environmental status* is defined as *"…the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable…".* More specifically, GES is achieved when:

1. Biodiversity is maintained
2. Non-indigenous species do not adversely alter the ecosystem
3. The population of commercial fish species is healthy
4. Elements of food webs ensure long-term abundance and reproduction
5. Eutrophication is minimised
6. The sea floor integrity ensures functioning of the ecosystem
7. Permanent alteration of hydrographical conditions does not adversely affect the ecosystem
8. Concentrations of contaminants give no effects
9. Contaminants in seafood are below safe levels
10. Marine litter does not cause harm
11. Introduction of energy (including underwater noise) does not adversely affect the ecosystem

The directive thus integrates the concepts of environmental protection and sustainable use. Based on geographical and environmental criteria, the following European regions were determined in the directive: the Baltic Sea, the north-east Atlantic Ocean, the Mediterranean Sea and the Black Sea. These European marine regions are located within the geographical boundaries of the existing *Regional Sea Conventions* (see 2.3.3 below)**,** and are further divided into sub-regions (for more details see the directive, Article 4). Each EU member state is required to develop a Marine Strategy for its marine waters (EC 2014).

2.2.7 RENEWABLE ENERGY DIRECTIVE

In 2007, the heads of state and government of the 27 EU countries adopted a binding target of 20% final energy consumption from renewable energy by 2020. The Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources is into force since 2009, and amends and repeals Directives 2001/77/EC and 2003/30/EC. According to Article 1 of the directive, it

"*… establishes a common framework for the promotion of energy from renewable sources. It sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport. It lays down rules relating to statistical transfers between Member States, joint projects between Member States and with third countries, guarantees of origin, administrative procedures, information and training, and access to the electricity grid for energy from renewable sources. It establishes sustainability criteria for biofuels and bioliquids*".

2.2.8 DIRECTIVE ON ANIMAL HEALTH REQUIREMENTS

The *Council Directive 2006/88/EC on animal health requirements for aquaculture animals, and on the prevention and control of certain diseases* is the basic legal provision for aquaculture and aquaculture products. It lays down control and preventive measures for avoiding outbreaks of certain diseases (exotic and non-exotic), and defines the animal health requirements to be applied on the market (and the imports) of aquaculture animals and products. The directive it to be applied to fish, molluscs and crustaceans at all their life stages reared in a farm or mollusc farming area, including any aquatic animal from the wild intended for a farm or mollusc farming area (EC 2014).

2.2.9 WASTE FRAMEWORK DIRECTIVE

Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives has been in force since 2008 and sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery.

2.2.1 SEVESO 3 AND IPCC DIRECTIVES

Directive 2012/18/EU of 4 July 2012 known as the *Seveso 3 Directive* on the control of major-accident hazards involving dangerous substances will enter into force on 1 June 2015, amending and repealing Directive 96/82/EC known as *Seveso 2*. The *Seveso* Directive requires the creation of a safety report and a hazard assessment.

Directive 2008/1/EC from 15 January 2008, also know as the *IPPC Directive*, aims at regulating integrated pollution prevention and control. This directive requires industrial and agricultural activities with a high pollution potential to have a permit, which can only be issued if certain environmental conditions are met. This means that companies themselves bear responsibility for preventing and reducing any pollution they may cause (EC 2014).

2.3 INTERNATIONAL COMMITMENTS & CONVENTIONS

The international commitments and conventions concerning environmental issues mainly deal with air and water pollution, waste management, ecosystem management, and protection and preservation of biodiversity, natural resources, wildlife and endangered species. However, the UN Law of the Sea is one of the most important international conventions; addressing law and order concerning sovereign rights and territories, as well as issues related to environmental protection (see Table 2-4).

2.3.1 UNITED NATIONS CONVENTION OF THE LAW OF THE SEA

The *United Nations Convention on the Law of the Sea (UNCLO*S) was adopted in 1982, and finally entered into force in 1994. UNCLOS lays down a comprehensive regime of law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources (UN 2014).

Among others, the convention defines the maritime zones: territorial waters (12 nautical miles zone), continuous zone, exclusive economic zone (EEZ; 200 nautical miles zone) and national and international right and duties in these maritime zones. Territory waters extend up to 12 nautical miles from the coast and are sovereign territory of the state; foreign vessels are allowed "innocent passage" through those waters. The EEZ is an area beyond and adjacent to the territorial sea, which shall not extend beyond 200 nautical miles from the coast/baseline. The EEZ is subject to the specific legal regime established in Part V of the convention. Article 56 states the following:

1. In the EEZ, the coastal state has:

(a) sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds;

(b) jurisdiction as provided for in the relevant provisions of this convention with regard to:

(i) the establishment and use of artificial islands, installations and structures;

(ii) marine scientific research;

(iii) the protection and preservation of the marine environment;

(c) other rights and duties provided for in this Convention.

2. In exercising its rights and performing its duties under this convention in the exclusive economic zone, the coastal state shall have due regard to the rights and duties of other states and shall act in a manner compatible with the provisions of this convention.

3. The rights set out in this article with respect to the seabed and subsoil shall be exercised in accordance with Part VI.

All other States have freedom of navigation and overflight in the EEZ, as well as freedom to lay submarine cables and pipelines.

Article 60 of the Conventions considers "Artificial islands, installations and structures in the EEZ". Here it states, that in the exclusive economic zone, the coastal state shall have the exclusive right to construct and to authorise and regulate the construction, operation and use of:

(a) Artificial islands;

(b) Installations and structures for the purposes provided for in article 56 and other economic purposes;

(c) Installations and structures which may interfere with the exercise of the rights of the coastal state in the zone.

The coastal state shall have exclusive jurisdiction over such artificial islands, installations and structures, including jurisdiction with regard to customs, fiscal, health, safety and immigration laws and regulations. Due notice must be given of the construction of such artificial islands, installations or structures. The presence of such artificial islands, installations and structures must be clearly and permanently marked and indicated to avoid collisions. Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, also concerning fisheries and protection of the marine environment. If necessary, safety zones around such artificial islands, installations and structures may be established to ensure the safety both of navigation and of the artificial islands, installations and structures. These safety zones shall not exceed a distance of 500 m around them, and shall be marked as well. Ships must respect these safety zones and shall comply with generally accepted international standards regarding navigation in the vicinity of artificial islands, installations, structures and safety zones.

However, "*artificial islands, installations and structures and the safety zones around them may not be established where interference may be caused to the use of recognized sea lanes essential to international navigation*", and they "*…do not possess the status of islands. They have no territorial sea of their own, and their presence does not affect the delimitation of the territorial sea, the exclusive economic zone or the continental shelf*" (UNCLOS 1994).

Part XII of the convention deals with the protection and preservation of the environment and includes measures to prevent, reduce and control pollution (Article 194) including pollution from vessels (Article 211), the duty not to transfer damage or hazards or transform one type of pollution into another (Article 195), and the use of technologies or introduction of alien or new species (Article 196). Global and regional cooperation (Section 2), monitoring and environmental assessment (Section 4), international rules and national legislation to prevent, reduce and control pollution of the marine environment (Section 5), as well as their enforcement (Section 6) are also addressed.

2.3.2 REGIONAL SEA CONVENTIONS

The *Regional Sea Conventions* are cooperation structures, which aims to protect the marine environment. These conventions involve the cooperation of EU member states with non-EU neighbouring countries sharing marine waters.

Four Regional Sea Conventions exist in Europe, with the European Community being party to the first three of the conventions:

1. The OSPAR Convention (OSPAR)
2. The Helsinki Convention (HELCOM)
3. The Barcelona Convention (UNEP-MAP)
4. The Bucharest Convention

2.3.2.1 The OSPAR Convention

OSPAR refers to the *Convention for the Protection of the Marine Environment in the North-East Atlantic* of 1992. This convention is the current legal instrument guiding international cooperation on the protection of the marine environment of the north-east Atlantic. It combines and updates the 1972 Oslo Convention on disposing of waste at sea and the 1974 Paris Convention on land-based sources of marine pollution. Work under the convention is managed by the OSPAR Commission, made up of representatives of the governments of 15 contracting parties and the EC, representing the EU. The contracting parties are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom, together with the EU. The OSPAR Convention includes a series of Annexes, dealing with different topics (OSPAR 2014):

- Annex I: Prevention and elimination of pollution from land-based sources;
- Annex II: Prevention and elimination of pollution by dumping or incineration;
- Annex III: Prevention and elimination of pollution from offshore sources; and
- Annex IV: Assessment of the quality of the marine environment.

2.3.2.2 The Helsinki Convention

HELCOM refers to the *Convention on the Protection of the Marine Environment in the Baltic Sea Area* of 1992, and aims to protect the marine environment of the Baltic Sea from all sources of pollution, and to restore and safeguard its ecological balance through intergovernmental cooperation. The contracting parties of HELCOM are Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden, and the EU. HELCOM is an environmental policy maker for the Baltic Sea area, an environmental focal point, a body for developing and supervising, and also for coordinating. The major priorities of the convention are on eutrophication assessment, hazardous substances, land and maritime transport sector, environmental impacts of fishery management and practices, protection and conservation of marine and coastal biodiversity, and implementation of the joint comprehensive environmental action programme and HELCOM recommendations (for more details see HELCOM 2014).

2.3.2.3 The Barcelona Convention

In 1975, 16 Mediterranean countries and the European Community adopted the *Mediterranean Action Plan* (MAP), the first-ever Regional Seas Programme under UNEP's umbrella. In 1976 these Parties adopted the *Convention for the Protection of the Mediterranean Sea Against Pollution* (Barcelona Convention). The Barcelona Convention has given rise to seven Protocols addressing specific aspects of Mediterranean environmental conservation (UNEP 2014):

- Dumping Protocol (from ships and aircraft)
- Prevention and Emergency Protocol (pollution from ships and emergency situations)
- Land-based Sources and Activities Protocol
- Specially Protected Areas and Biological Diversity Protocol
- Offshore Protocol (pollution from exploration and exploitation)
- Hazardous Wastes Protocol
- Protocol on Integrated Coastal Zone Management (ICZM)

In 1995, the Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean (MAP Phase II) was adopted to replace the Mediterranean Action Plan of 1975, and the Barcelona Convention of 1976 was amended and renamed into *Convention for the Protection of Marine Environment and the Coastal Region of the Mediterranean* of 1995. The Convention today has 22 contracting parties: Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, the European Community, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria, Tunisia and Turkey. The contracting parties are obliged to protect the Mediterranean marine and coastal environment while supporting regional and national plans to achieve sustainable development. The Convention's main objectives are:

- To assess and control marine pollution.
- To ensure sustainable management of natural marine and coastal resources.
- To integrate the environment in social and economic development.
- To protect the marine environment and coastal zones through prevention and reduction of pollution, and as far as possible, elimination of pollution, whether land or sea-based.
- To protect the natural and cultural heritage.
- To strengthen solidarity among Mediterranean coastal states.
- To contribute to improvement of the quality of life.

2.3.3 CONVENTION ON BIOLOGICAL DIVERSITY

The *Convention on Biological Diversity (CBD)* is an international agreement established by the United Nations (UN). The Convention was signed by 150 government leaders at the 1992 Rio Earth Summit, and entered into force in December 1993. It aims to prevent the further loss of biodiversity whilst using its components sustainably and sharing benefits equitably. The convention has 3 main objectives:

1. The conservation of biological diversity.
2. The sustainable use of the components of biological diversity.
3. The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.

The convention is responsible for the development of strategies and action plans for biodiversity at a European, community and national level. The convention requires the integration of this strategy in the planning and activities of all sectors whose activities are likely to have consequences (positive or negative) for biodiversity.

Subject to the rights of other states, and unless otherwise expressly provided for in this convention, the provisions of the convention apply to each contracting party (Article 4):

"a) When relating to elements of biological diversity of the zones situated within the limits of national jurisdiction;

b) When relating to processes and activities that are carried out under its jurisdiction or control, either within the area under its national jurisdiction or beyond the limits of national jurisdiction, regardless of the place where these processes and activities produce their effects."

Article 14 on Impact assessment and minimising adverse impacts states particularly that *"each contracting party shall introduce appropriate procedures requiring environmental impact assessment of its proposed projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimizing such effects and, where appropriate, allow for public participation in such procedures"*.

Certain areas subject to international agreements are subject to specific regulatory constraints. This is particularly the case for the Marine Protected Areas introduced by the International Union for Conservation of Nature (IUCN) via the World Conservation Strategy, in 1980.

Today, the convention has 194 parties, one of these is the EU (CBD 2014).

2.3.4 BONN CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS (CMS)

Adopted on 23 June 1979 and having entered into force on 1 November 1983, the Bonn Convention on the Conservation of Migratory Species of Wild Animals (CMS) aims to ensure global conservation of terrestrial, marine and avian migratory species throughout their range.

This is a framework agreement setting the general objectives for the 112 signatory States (on 1 August 2009). These objectives aim to promote research on migratory species and implement immediate protective measures for endangered species.

2.3.5 UNESCO CONVENTION ON THE PROTECTION OF THE UNDERWATER CULTURAL HERITAGE

The United Nations 1982 Convention on the Law of Sea which establishes sovereignty at sea, does not protect underwater cultural heritage, it only regulates maritime areas. The 2001 adoption of the *Convention on the protection of the underwater cultural heritage*[1], by the UNESCO general conference rectified this legal void. This convention is the main international treaty on underwater cultural heritage. It strengthens the legal protection, cooperation, awareness and reaction capacity faced with the destruction of submerged archaeological sites (wrecks and remains) by commercial treasure hunters and by certain industrial activities.

The convention does not regulate the ownership of wrecks and does not affect the jurisdiction or sovereignty of states under the law of the sea. Its annex establishes rules concerning activities at underwater sites, widely recognised by archaeologists.

The 2001 convention establishes these important principles:

- The obligation to preserve underwater cultural heritage for the benefit of humanity.
- The preservation in situ of underwater cultural heritage shall be considered as the first option and should be prioritised.
- As with cultural heritage on land, the underwater cultural heritage shall not be commercially exploited or speculated with. This does not preclude archaeological research or tourist access.
- Training in underwater archaeology and sharing of information should be encouraged. A principle of assistance and cooperation between signatory states is also declared.
- The convention does not regulate ownership of cultural heritage.

The convention entered into force on 2 January 2009 and is applicable both within territorial waters (Article 7) and EEZ (Article 10). France, which ratified the convention on 7th February 2013, is the 42nd state to ratify it.

2.3.6 UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The *United Nations Framework Convention (UNFCCC)* entered in force in 1994, and was, as was the CBD, adopted during the 1992 Rio Earth Summit. The ultimate aim of the convention is to stabilise greenhouse gas concentrations "*at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system*". It states that "*such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner*" (UNFCCC 2014). The convention was

[1] "Underwater cultural heritage" means all traces of human existence having a cultural, historical or archaeological character which have been partially or totally under water, periodically or continuously, for at least 100 years.

ratified by 195 countries as well as by the EU.

The directive provides a framework, but does define binding emission limits for particular countries; it is considered to be legally non-binding. Binding limits were set in the framework of the UNFCCC in the *Kyoto Protocol*, which commits its parties by setting internationally binding emission reduction targets. The Kyoto Protocol was adopted in Kyoto, Japan, in December 1997 and entered into force in February 2005 (UNFCCC 2014).

2.3.7 IMO RULES AND REGULATIONS

The *International Maritime Organization (IMO)* is the UN specialised agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. The IMO Convention entered into force in 1958, and today IMO has about 170 member states. The purposes of the organisation, as summarised by Article 1(a) of the convention, are "to provide machinery for cooperation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships" (IMO 2014). IMO has, over many years, adopted a wide range of measures to prevent and control pollution caused by ships and to mitigate the effects of any damage to the environment, human health, property and resources that may occur as a result of maritime operations and accidents. In order to address the increasing focus on environmental issues and to clearly demonstrate the importance of such issues for the organisation, in 1973 IMO established its Marine Environmental Protection Committee (MEPC) to consider any matter concerned with marine pollution from ships (IMO 2014).

In the framework of IMO several conventions were adopted; three of those are of interest in the scope of TROPOS, one dealing with pollution, and two dealing with maritime safety:

1. The International Convention for the Prevention of Pollution from Ships (MARPOL).
2. The Convention on the International Regulations for Preventing Collisions at Sea (COLREGs).
3. The International Convention for the Safety of Life at Sea (SOLAS).

These three IMO conventions are described more detailed below.

2.3.7.1 *International Convention for the Prevention of Pollution from Ships*

In 1973, IMO adopted the International Convention for the Prevention of Pollution from Ships, now known universally as MARPOL, which has been amended by protocols adopted in 1978 and 1997 and kept updated through other relevant amendments. MARPOL is the most important international regulation for preventing pollution of the marine environment by oil from ships due to accidental or operational reasons. MARPOL does not only cover pollution by oil, but also by chemicals, goods in packaged form, sewage, litter and air pollution. Greece, Spain and China are member states of the MARPOL Convention. The measures to prevent pollution are listed in the annexes:

Annex I: Regulations for the Prevention of Pollution by Oil (entered into force on 2 October 1983).

Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (entered into force on 2 October 1983).

Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force on 1 July 1992).

Annex IV: Prevention of Pollution by Sewage from Ships (entered into force on 27 September 2003).

Annex V: Prevention of Pollution by Garbage from Ships (entered into force on 31 December 1988).

Annex VI: Prevention of Air Pollution from Ships (entered into force on 19 May 2005).

A revised version of MARPOL Annex V has been developed by the IMO and entered into force in 2013. A simplified overview of the discharge provisions the annex is shown in Table 2-3.

Table 2-3: Simplified overview of the discharge provisions of the revised MARPOL Annex V (resolution MEPC.201(62))

Type of garbage	Ships outside special areas	Ships within special areas	Offshore platforms (more than 12 nm from land) and all ships within 500 m of such platforms
Food waste comminuted or ground	**Discharge permitted** ≥3 nm from the nearest land, en route and as far as practicable	**Discharge permitted** ≥12 nm from the nearest land, en route and as far as practicable	**Discharge permitted**
Food waste not comminuted or ground	**Discharge permitted** ≥12 nm from the nearest land, en route and as far as practicable	**Discharge prohibited**	**Discharge prohibited**
Cargo residues[1] not contained in wash water	**Discharge permitted** ≥12 nm from the nearest land, en route and as far as practicable	**Discharge prohibited**	**Discharge prohibited**
Cargo residues[1] contained in wash water		**Discharge permitted** ≥12 nm from the nearest land, en route, as far as practicable and subject to two additional conditions[2]	**Discharge prohibited**
Cleaning agents and additives[1] contained in cargo hold wash water	**Discharge permitted**	**Discharge permitted** ≥12 nm from the nearest land, en route, as far as practicable and subject to two additional conditions[2]	**Discharge prohibited**
Cleaning agents and additives[1] in deck and external surfaces wash water		**Discharge permitted**	**Discharge prohibited**
Carcasses of animals carried on board as cargo and which died during the voyage	**Discharge permitted** as far from the nearest land as possible and en route	**Discharge prohibited**	**Discharge prohibited**
All other garbage including plastics, synthetic ropes, fishing gear, plastic garbage bags, incinerator ashes, clinkers, cooking oil, floating dunnage, lining and packing materials, paper, rags, glass, metal, bottles, crockery and similar refuse	**Discharge prohibited**	**Discharge prohibited**	**Discharge prohibited**
Mixed garbage	When garbage is mixed with or contaminated by other substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply		

1 These substances must not be harmful to the marine environment.

2 According to regulation 6.1.2 of MARPOL Annex V the discharge shall only be allowed if: (a) both the port of departure and the next port of destination are within the special area and the ship will not transit outside the special area between these ports (regulation 6.1.2.2); and (b) if no adequate reception facilities are available at those ports (regulation 6.1.2.3).

According to this amendment, almost all discharges of waste into the sea are prohibited now. The new regulations apply to all ships as well as to fixed and floating offshore installations (see Resolution MEPC.201(62)).

2.3.7.2 Convention on the International Regulations for Preventing Collisions at Sea

The *Convention on the International Regulations for Preventing Collisions at Sea* (*COLREGs*) was adopted in 1972 and entered into force in 1977. It was designed to update and replace the Collision Regulations of 1960. COLREGs is the main convention regulating international maritime traffic. The convention includes several measures concerning light and sound signals, navigation rules & behavior, safe speed, and traffic separation schemes. Greece, Spain and China are member states of the COLREGs Convention.

2.3.7.3 International Convention for the Safety of Life at Sea

The *International Convention for the Safety of Life at Sea (SOLAS)* was adopted in 1974 and entered into force in 1980. Since then, the convention has been updated and amended numerous times. SOLAS has 159 contracting states, including Greece, Spain and China. The main objective of the SOLAS Convention is:

"… *to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done. Control provisions also allow Contracting Governments to inspect ships of other Contracting States if there are clear grounds for believing that the ship and its equipment do not substantially comply with the requirements of the Convention - this procedure is known as port State control*" (IMO 2014). The convention also includes measures related to carriage of cargoes and dangerous goods and identifies certain services for safety of navigation.

2.3.8 AGREEMENT ON THE CONSERVATION OF CETACEANS IN THE BLACK SEA, MEDITERRANEAN SEA, AND CONTIGUOUS ATLANTIC AREA (ACCOBAMS)

ACCOBAMS (signed on 24th November 1996 and entered into force on 1st June 2001) is a legal tool for conservation based on international scientific and political cooperation of 23 countries with the aim of reducing threats to cetaceans (whales, dolphins, porpoises) in the Mediterranean and the Black Sea waters and part of the Atlantic area contiguous to the Straits of Gibraltar and since 2010, including the exclusive economic zones of Spain and Portugal.

It was created under the auspices of the Bonn Convention on the Conservation of Migratory Species of Wild Animals (CMS) which aims to ensure global conservation of terrestrial, marine and avian migratory species throughout their range.

In the Mediterranean, there are several sub-regional agreements that protect either species or marine areas:

- Agreement relating to the creation of a sanctuary for marine mammals in the Mediterranean, the *PELAGOS Agreement* (signed on 25 November 1999 by France, Italy and the Principality of Monaco and entered into force on 21 February 2002). This agreement aims to establish coordinated and harmonised actions among the three countries for the protection of cetaceans and their habitats against all causes of disturbance: pollution, noise, capture and accidental injuries, disruption, etc.

- The *RAMOGE Agreement* relates to the protection of the Mediterranean coastal waters as part of the Barcelona Convention and the Mediterranean Action Plan. It was ratified by France, Monaco and Italy and came into force in the first half of 1981. This agreement is an instrument of scientific, technical, legal and administrative cooperation where the governments of these three countries are acting to prevent and fight against incidents leading to pollution and to preserve biodiversity of marine areas in the Provence-Alpes-Côte d'Azur, the Principality of Monaco and the Riviera regions. The area covered extends from the mouth of the Grand Rhône to the west, at the mouth of the Magra River to the east. In 1993, with the implementation of the Plan RAMOGEPOL, RAMOGE saw its influence extended to the high seas.

Table 2-4: Summary of the main regulatory framework in the EU

	Legislation	Objectives
International Level	United Nations Convention on the Law of the Sea (UNCLOS)	Protection of the marine environment, Including in the EEZ
	Regional Sea Conventions (OSPAR, HELCOM, Barcelona Conventions)	Prevention and elimination of all kinds of pollution from regional seas
	Convention on Biological Diversity	Conservation of biodiversity sustainable use of species and natural habitats
	Bonn Convention (CMS)	Protection of migratory species
	UNESCO Convention on the Protection of Underwater Cultural Heritage	Protection of underwater cultural heritage
	UN Framework Convention on Climate Change (UNFCCC)	Stabilisation of greenhouse gas concentrations
	International Convention for the Prevention of Pollution from Ships (MARPOL)	Prevention and control of pollution from ships
	The Convention on the International Regulations for Preventing Collisions at Sea (COLREGs)	Regulation of international marine traffic
	The International Convention for the Safety of Life at Sea (SOLAS)	Safety at sea, security of ships, safety on board
	Agreement on the Conservation of Cetaceans of the Mediterranean and the Black Sea and contiguous Atlantic Area (ACCOBAMS)	Reduction of threats to cetaceans

	Legislation	Objectives
European Level	Environmental Impact Assessment Directive (Directive 85/337/EEC, Directive 2014/52/EU)	Evaluation of environmental impact of a project
	Strategic Environmental Impact Assessment Directive Directive 2001/42/EC	Evaluation of environmental impact of a plan or programme
	Habitat Directive (Directive 92/43/EEC)	Conservation of natural habitats and wild flora and fauna
	Wild Birds Directive (Directive 2009/147/EC)	Conservation of wild birds
	Water Framework Directive (Directive 2000/60/EC)	Protection of inland and coastal waters
	Marine Strategy Framework Directive (Directive 2008/56/EC)	Reducing the impact of activities on the marine environment to achieve "good environmental status"
	Renewable Energy Directive (Directive 2009/28/EC)	Promotion of energy from renewable resources
	Directive on Animal Health Requirements (Directive 2006/88/EC)	Prevention of diseases in aquaculture species
	Waste Framework Directive (Directive 2008/98/EC)	Regulation of waste management, recycling, recovery
	Directive 2008/1/EC called SEVESO III	Prevention of industrial risks
	Directive 2008/1/EC (called IPPC)	Prevention and reduction of pollution risks

2.4 TEAL ELEMENTS

The TROPOS concept TEAL integrates elements from four different sectors: Transport (T), Energy (E), Aquaculture (A), and Leisure (L). In the following tables, the main European and international legislative framework to be considered by each sector is summarised.

Table 2-5: Legislative framework and key issues to be considered for elements related to the Transport (T) sector

<table>
<tr><td></td><td>Transport (Port and transport infrastructure)</td></tr>
<tr><td colspan="2">The component "Transport" involves maritime ports and shipping traffic.</td></tr>
<tr><td>Specific regulatory framework</td><td>Key issues to be addressed in the EIS</td></tr>
<tr><td><u>International Conventions</u>:

- UNCLOS Convention, SOLAS, COLREG Convention, MARPOL 1973/78, Basel (1992), London (1972), supplemented by the Protocol of 1996 (TBT, arsenic and mercury), Barcelona (Protocols "Telluric" and "immersions ")

<u>European Directives</u>

Regulation (EC) No 725/2004 of the European Parliament and of the Council of 31 March (Security of Ships and Port Facilities (ISPS Code))

Risks: Law No. 2003-699 of 30 July 2003 on the prevention of natural and technological risks and repairing damage,

- Pollution IPPC Directive 2008/1/EC and Directive Seveso III, Act No. 96-1236 of 30 December 1996 on Air and the Rational Use of Energy, Order No. 2005-185 of 25 February 2005 (carbon monoxide, hydrocarbons and other pollutants), Directive REACH entered into force on 1 June 2007 (Registration, Evaluation, Authorisation and restriction of Chemicals)

- Waste: DC No. 2008/98/EC, but also specific directives 2000/59/EC 75/442/EEC, 75/439/EC, 86/101/EC, 2003/44/EC, 2000/59/EC, 91/157/EEC, 91/689/EEC, 94/62/EC for the receipt, disposal and recovery of waste.</td><td>- Maritime safety/traffic.

- Water quality (accidental pollution, discharge of wastewater from the port and vessels (grey water, black water, etc.).

- Impacts on marine habitats/wildlife and flora by pollutants.

- Waste Management.

- Landscape.

- Compliance with sanitation rules.

- Socio-economic impacts.</td></tr>
</table>

Table 2-6: Legislative framework and key issues to be considered for elements related to the Energy (E) sector

Marine Renewable Energies

The development of renewable energy is the subject of many discussions and negotiations at national and international levels in the fight against climate change. Member states of the EU were given targets for developing renewable sectors.

Specific regulatory framework	Key issues to be addressed in the EIS
- Renewable Energy Directive (Directive 2009/28/EC) on the promotion of electricity produced from renewable energy sources in the electricity market.	- Compliance with regulations (protected areas, directives, Natura 2000 impact). - Marine Safety and Security (radar and others). - Conservation of biodiversity and heritage (marine birds, marine mammals, etc.). - Potential conflicts of use (constraints, fishing, maritime traffic, landscape, etc.). - Noise Disturbance. - Water Quality. - Risks associated with emissions from electromagnetic fields.

Table 2-7: Legislative framework and key issues to be considered for elements related to the Aquaculture (A) sector

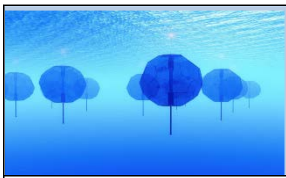
<table>
<tr><td></td><td>Marine Aquaculture</td></tr>
<tr><td colspan="2">Regulations related to aquaculture are the same as for any development at sea with the condition of obtaining a licence to operate as a marine farmer. Regulations on the sanitary quality of water are particularly important.
In terms of prevention and risk reduction, preferred actions are related to positioning of aquaculture activities in relation to other activities, measures of optimised farm management to reduce impact.</td></tr>
<tr><td>Specific regulatory framework</td><td>Key issues to be addressed in the EIS</td></tr>
<tr><td>- Habitat Directive (Directive 92/43/EEC)
- Water Framework Directive (Directive 2000/60/EC)
- Directive on Animal Health Requirements (Directive 2006/88/EC).
- Code of Practice ICES 2003 relating to the Introduction and Transfer of Marine Organisms.
+ national legislation</td><td>- Quality of water and sediment,- Impact on habitats, flora and fauna (benthos, mammals, meadows, protected areas, etc.)- Physical Impacts on land and at sea (traffic and land occupation), - Impacts of management practices in the operational phase (nutrition, surveillance, sanitation, genetic pollution and other).
- Security: impacts on health and safety of people and property.
- Visual and landscape impacts and other disturbances.
- Socio-economic impacts.</td></tr>
</table>

Table 2-8: Legislative framework and key issues to be considered for elements related to the Leisure (L) sector

Tourisms & Leisure

The development of infrastructure and tourism on the offshore platform shall comply with the current regulations concerning the management of waste and discharges, pollution prevention, maritime safety as previously mentioned and safety of goods and people . The legal context of issues associated with sanitation and public health are added to these regulations (Code of Public Health).

Specific regulatory framework	Key issues to be addressed in the EIS
- Directive No. 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC. - Directive 94/25/EC of 16 June 1994 requiring pleasure boats to be equipped with storage facilities for sewage & waste. - International Health Regulations (Decree 89-38 of – 24 January 1989, Article 14) and departmental (circular of –9 August 1978, Article 95).	- Quality of water (waste at sea, treatment and discharges, etc.). - Drinking water (supply, desalination, etc.). - Waste management (solid waste and other). - Safety of goods and people. - Marine Traffic. - Impacts on marine habitats/flora and fauna.

In conclusion, several elements should be taken into account in an assessment study for a multi-use offshore platform:

- The content of impact studies is increasingly accurate and demarcated by regulation and there are many methodological guides which explain the impacts and measures put in place to reduce or offset impacts.
- Common procedures for different activities are clearly identified while respecting certain conditions of each activity.
- It is necessary to optimise synergies between proposed activities (services, compatibility, distance, etc.), to prevent incompatibilities of planned activities on the platform which could affect other activities dependent on the quality of the environment (leisure, aquaculture) and to anticipate potential health risks.
- Depending on the location and the number of proposed activities on the platforms, the impact assessments must integrate economies of scale in terms of volume regarding impact studies, measurements taken, monitoring mechanisms to reduce costs and ensure the coordination of presentations of regulatory submissions.
- The assessment should pay particular attention to studies of the cumulative effects of various activities envisaged for the platform.
- Several regulatory domains are evolving in the context of offshore platforms (renewable energy, offshore platforms, transportation, EEZ, directives on impact assessments, etc.).

3 CONSULTATION

Public consultation and stakeholder engagement are integral parts of project planning, specification, and impact assessment, to estimate needs and demands as well as concerns and potential socio-economic impacts of the planned project. In the framework of the TROPOS project, the consultation issue is going to be addressed more detailed in D6.4, *A framework for describing the social impacts with concrete examples that apply for the Canary Island*. However, TROPOS platform construction stage, public consultation and stakeholder engagement are essential parts of the actual EIAs that are going to be carried out.

4 PROJECT DESCRIPTION

4.1 PROJECT OVERVIEW

The three scenarios that were selected to exemplify an impact assessment of modular multi-use offshore platforms differ in composition of modules, satellites, components and services. As nature and strength of environmental impacts are determined by the composition of components and services, this chapter provides a short overview of the three scenarios. Unless otherwise stated, all the information is taken from deliverable D3.5.

4.1.1 LEISURE ISLAND, GRAN CANARIA (SPAIN)

For Gran Canaria the Leisure Island concept was chosen. This scenario involves a multitude of leisure facilities for tourists and local residents, including the full range of hotel services. The energy demand of the platform is met by a photovoltaic plant (*Table 4-1*).

Table 4-1: Components and services of the Leisure Island scenario off Gran Canaria (source: D3.5)

MODULES	COMPONENTS/SERVICES	
Visitors Center	Reception Deck	Store Room
	Show Room	Rest Rooms
	Shop Room	Corridors
	Mammals & Birds Observatory & Astronomical	Passenger Terminal
	Ichthyofauna Observatory	
Food & Beverage	Restaurant	Kitchen
	Chill Out Bar	Store Room
	Underwater Restaurant & Bar	Office Room
	Night Club	Rubbish Room
	Thematic Café	Restrooms
	Sports Bar	Kinder Garden
	Corridors	
Accommodation	Customer Lodging	Hospital
	Reception Desk	Office Room
	Staff/Crew Lodging	Store Room
	Gym	Maintenance Room
	Repairing & Adaptation Area	Corridors
	Meeting Room	Rest Rooms
	Marina	Store Room
	Office & Reception	Repair and Adaptation Area

Nautical Activities Marina	Teaching Room	Corridors
	Diving	Recycling Zone
	Rest Rooms & Changing Rooms	Hyperbaric Chamber
Safety and Environmental Monitoring (CU)	Surveillance Room	Repair Area for buoys and other equipment
	Monitoring Room	Restrooms
	Laboratories	
Renewable Energy	Photovoltaic (PV) Plant	Energy Storage

The Visitors Center, Food & Beverages, Accommodation, Monitoring, Energy Storage, and parts of the Marina are integrated into the Central Unit in this scenario. The Leisure scenario is very different to the other scenarios because it involves the presence of many people on the platform during day and night, and increased ships traffic due to frequent daily shuttle transfer between Gran Canaria Islands and the platform, and private yachts entering the Marina. Up to 1,200 visitors per day are expected to come by shuttle (8-10 shuttles per day), additional guests will come by private boats docking at the Marina (approximately, 12-36 boats per day). The staff required for the operation of the leisure modules were estimated to 100- 120 employees, the majority of which will not stay overnight, but will come and leave with extra-shuttles. Accommodation is provided on the platform for 56 visitors (28 double rooms) and 9 staff members (single cabins). Depending on the season, between 22 and 34 guests are expected to stay overnight on the platform. The main business hours on Leisure Island will be between 10:00 and 23:00. The Underwater Bar will close at 24:00. The facilities located above the sea surface, Restaurant and the Chill Out Bar will have extended opening hours, from 7:00 to 23:00. The Night Club (Deck 5) will only be opened for special events.

Leisure Island is designed to be self-sustaining in terms of energy. In particular, the energy demand for electricity, air conditioning and hot water will be met by solar energy (PV plant), diesel generators serve as backup. Energy demand was estimated to be approximately1 kWh/(person*day) for the Food & Beverages sector, around 9 kWh/(room*day) for the Accommodation sector, and approximately 0.6 mWh/(berth*year) for the Marina. Freshwater will be generated on board the platform in Desalination Units. Freshwater consumption was estimated to be around 25 l/(person*day) for the Food & Beverages sector, approximately 110 l/(person*day) for the Accommodation sector, and around 10 m^3/(berth*year) for the Marina. Drinking water will not be generated on board.

To minimise vessel traffic as much as possible, the transport of waste, goods, maintenance services, equipment, etc. will be joined with the regular shuttle transfers (see D5.5).

4.1.2 GREEN & BLUE CONCEPT, CRETE (GREECE)

The Green & Blue platform concept off Crete combines offshore fish and algae aquaculture with wind energy production (*Table 4-2*).

Table 4-2: Components and services of the Green & Blue platform scenario off Crete (source: D3.5)

MODULES	COMPONENTS/SERVICES	
Fish Aquaculture and Satellite Unit Fish Farm	Fish Aquaculture parts of the 30 Satellite Units	Fish Aquaculture Module (on CU, operation and control)
Algae Aquaculture and Satellite Unit Algae Farm	Algae Aquaculture parts of the 30 Satellite Units	Algae Aquaculture Module (on CU, operation and control)
	Biorefinery, accommodation, storage (on CU)	
Processing Plant (CU)	Storage	Processing, packaging, freezing
Quick Reaction Maintenance Base and Satellite Unit Energy Farm	Staging area	Wind Farm 60 Turbines + some PV panels
Substation		

Fish Aquaculture is a central component of the Green & Blue Scenario. For Crete, an annual production of 5,500 tonne finfish biomass is planned, with Greater Amberjack (*Seriola dumerili*), Meagre (*Argyrosomus regius*), and European Seabass (*Dicentrarchus labrax*) as culture candidates. The Fish Farm includes 30 cages. The fish fry will be introduced into the floating cages, fed with artificial feeds and reared for about 2 years until market size is reached. Estimated energy consumption of the Fish Aquaculture unit is estimated 123 kWh/day for daily operations (feeding, monitoring, lighting), plus about 1195 kWh/ (period*cage) for periodic operations such as net cleaning and maintenance. Harvesting will additionally consume ~ 4 kWh/t biomass. The 30 Algae Aquaculture Satellite Units will be located downstream of the fish cages, allowing for recycling of nutrients from fish excrement by the algae. Both, Fish and Algae Aquaculture Satellite Units are controlled and monitored online from board the Central Unit (CU). To avoid redundant traffic between CU and Satellites, and platform and shore, there will be synergies between Fish and Algae units concerning transport, maintenance, etc. Personnel requirements for operation of the Fish and Algae Aquaculture, Processing and Satellite Units are expected to differ depending on season (summer and winter, rearing/feeding and harvesting, etc.).

The fish processing will require a lot of fresh water, ice, packaging material and energy for processing, freezing and cold storage of the final product. Fresh water will be generated on board the CU by a desalination unit. Additional energy will be consumed for the operation of labs, workshops, biorefinery, etc.

In this Blue & Green Scenario, energy requirements are met by 60 2-3.3 mW wind turbines (on 30 satellite units), which are connected to the substation by cables. The wind turbines are expected to require regular service, for interventions as well as for routine maintenance.

4.1.3 GREEN & BLUE CONCEPT, LIUQIU ISLAND (TAIWAN)

The Green & Blue platform concept off Liuqiu Island combines offshore fish and algae aquaculture with Ocean Thermal Energy Conversion (OTEC) for energy supply (*Table 4-3*).

Table 4-3: Components and services of the Green & Blue platform scenario off Liuqiu Island (source: D3.5)

MODULES	COMPONENTS/SERVICES	
Fish Aquaculture	Fish Aquaculture parts of the 30 Satellite Units	Fish Aquaculture Module (on CU, operation and control)
Algae Aquaculture	Algae Aquaculture parts of the 30 Satellite Units	Algae Aquaculture Module (on CU, operation and control)
	Biorefinery, accommodation, storage (on CU)	
Processing Plant (CU)	Storage	Processing, packaging, freezing
Renewable Energy	OTEC Plant on a satellite	
Accommodation	3 types of accommodation	
Food & Beverage	Restaurant	Kitchen
	Sky Observation Lounge	Ocean View Café
	Garden	Grill & Bar
	Store	

In the Green & Blue Concept off Liuqiu Island, the candidate species for Fish Aquaculture are Greater Amberjack (*Seriola dumerili*), Cobia (*Rachycentron canadum*), and Giant Grouper (*Epinephelus lanceolatus*). As in Crete, Fish as well as Algae Aquaculture Farms involve 30 Satellite Units. The fish fry will be introduced into the floating cages, fed with artificial feeds and reared for about 2 years until market size is reached. Estimated energy consumption of the Fish Aquaculture unit is the same as for the Crete scenario (*see 4.1.2*; 123 kWh/day for daily operations, 1195 kWh/ (period*cage) for periodic operations, 4 kWh/t biomass for harvesting). The 30 Algae Aquaculture Satellite Units will be located downstream of the fish cages, allowing for recycling of nutrients from fish excrement by the algae. Both, Fish and Algae Aquaculture Satellite units are controlled and monitored online from board the Central Unit. The biorefinery is combined with the fish aquaculture waste water for sustainable production. To avoid redundant traffic between CU and Satellites, and platform and shore, there will be synergies between Fish and Algae units concerning transport, maintenance, etc. Personnel requirements for operation of the Fish and Algae Aquaculture, Processing and Satellite Units are expected to differ depending on season as in Crete (*see 4.1.2.* above). The fish processing will require fresh water, ice, packaging material and energy for processing, freezing and cold storage. Fresh water will be generated on board the CU by a desalination unit. Additional energy will be consumed for the operation of labs, workshops, biorefinery, etc.

Energy for operation of the Green & Blue Scenario in Taiwan will be provided by an OTEC plant, operated as a closed cycle system. The 8 MW OTEC plant uses the ocean's naturally available vertical temperature gradient to produce electrical energy. The nutrient rich deep water pumped up by the OTEC may be used to enhance algae growth. The Green & Blue Concept off Liuqiu Island will also include some (limited) leisure facilities, such as cafés, bars, restaurants and observatories, and will provide accommodation for visitors.

4.2 DETAILS OF SELECTED TROPOS CASE STUDY ELEMENTS

This chapter aims at providing a short overview on design and composition of the central unit, modules and satellites in the three scenarios. The information provided here is taken from previous deliverables from WP3 and WP4.

4.2.1 CENTRAL CORE OF THE TROPOS PLATFORM

The central unit (CU) is designed as a floating SWATH (*Small Waterplane Area Twin Hull*) element. The general conceptual design of the CU is similar for all scenarios with all including 13 decks (Decks 0-12) (*see Table 4-4 & Figure 4-1*).

Table 4-4: Dimensions of the central unit (source: D3.2, D4.1)

Length	Beam	Dead works (to the deck 11)	Dead works (to the deck 12)	Underbody	Number of decks
80 m	56 m	18.4 m	24 m	17.2	12

The final **design** (*Figure 4-1*) was recently tested and optimised using experimental tests and model simulations (see D4.1) in order to guarantee best seakeeping behaviour of the CU.

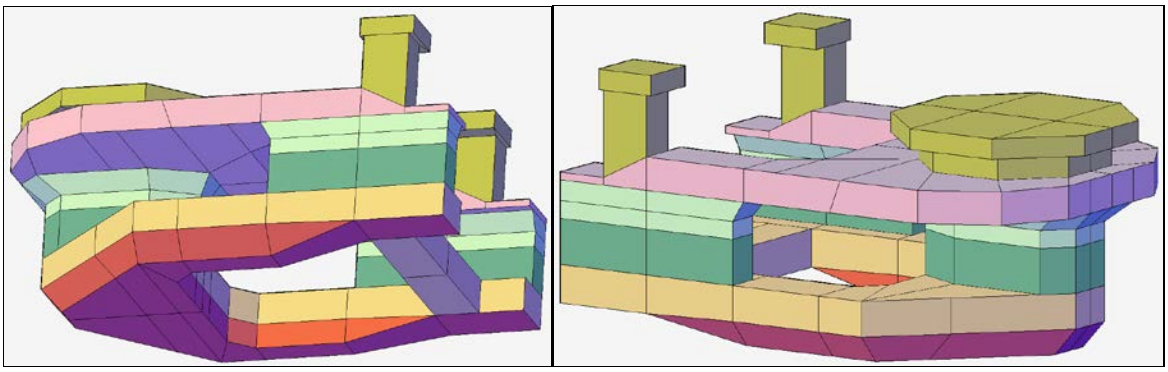


Figure 4-1: 3D view of the central unit (Source: D3.2, D4.1)

Unless otherwise stated, all the information in this chapter is taken from deliverable D3.2; the information summarised here focusses on details and characteristics that may be relevant concerning impacts on the environment (for more technical details see D3.2).

The CU builds the core of the TROPOS platform, to which the different modules can be attached. To maintain the position of the floating platform, the CU will be moored to the seafloor. There are different types of **moorings** (for details see D3.2, Annex I), and the ultimate choice and detailed design of the mooring type depend, amongst other, on the platform structure, sediment, bathymetric and oceanographic characteristics of the platform location. At the present time, a catenary mooring composed of 6 catenary lines was chosen and tested for the TROPOS CU (without modules attached) (see D.4.1). Catenary mooring is the most common configuration in water depths up to 1000 meters. This systems use different lines for positioning the platform. It consists of a combination of chain and wire rope. Catenary refers to the free hanging configuration of the lines. However, the final mooring design will be specified in September 2014 in deliverable D4.2.

Though the general design of the CU is the same for all scenarios; it differs in detailed space and services **layout** depending on concept and location. A summary of the CU layout for all three scenarios is given in *Table 4-5*. The underwater hull of the CU is subdivided into decks 0 to deck 3 (*Figure 4-2*). Equipment and facilities in decks 0 to 2 are similar in all 3 scenarios, and include the basic equipment and facilities, such as engine rooms and associated equipment and services, firefighting stations, wastewater tanks and treatment facilities, waste treatment plant, freshwater tanks and production system, air condition, and the desalination unit for freshwater generation.

The area in the bow between decks 0 and 1 is equipped with a double bottom; in the double bottom, there is the seacock which supplies the water required for e.g. seawater cooling, ballast tank system, firefighting system, and desalination. The area on the double bottom is reserved for **fuel** tanks (and ballast tanks), and for fuel and oil treatment and purification. The fuel is moved from the storage tanks to the sedimentation tanks by transfer pumps. A filter is connected ahead to protect the suction pump from any impurities which are in suspension. The pumps should be able to drain a whole tank and move the fuel to another tank in 12 hours. Both, storage and sedimentation tanks, will have a heating system to keep the fuel at temperature. Separators are formed by two centrifuges in series, one for purification and one for clarification. The sludge extracted from the fuel by the separators is stored in sludge tanks. Overflow/spill tanks pick spills of the trays of different pumps involved in the process and the overflow of the sedimentation tanks and other fuel tanks. Clean fuel will be recirculated and reused, dirty fuel will be stored in the sludge tanks. Each of the engines on the CU will have its own separate lubricating **oil**. Used (dirty) oil will be purified and reused.

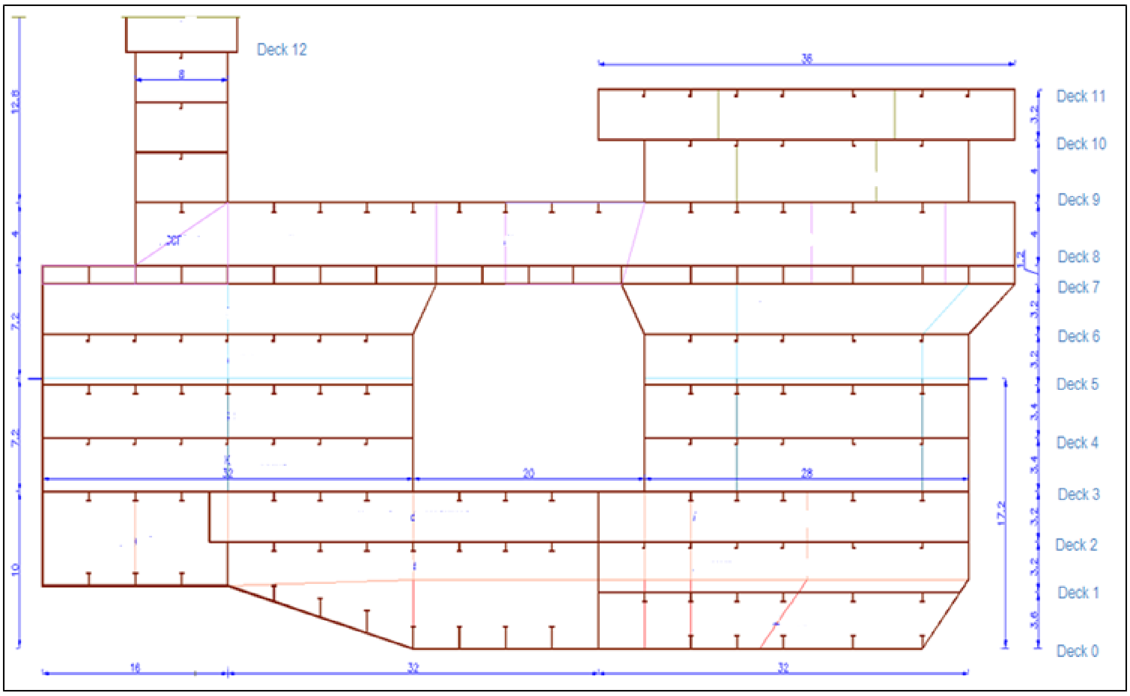


Figure 4-2: *Central unit deck layout (side view, values in m) (Source: D3.2, D3.5)*

The **cooling water system** consists of two subsystems, the system cooling salt water and the freshwater system cooling. Freshwater system cooling is an internal cooling system which is enclosed in a closed circuit with a high temperature and a low temperature circuit. The high temperature circuit is used to cool the water in the jackets of the cylinders, while the low temperature system is responsible for the charge air cooler, the lube oil cooler and the cooler fuel injectors.

Exhaust gases from the main engines are removed by the **exhaust system;** these high-temperature gases may be utilised to some extent for the sanitary water heating.

The CU will have series of **ballast tanks** for adjusting intermediate load conditions to improve stability and performance at sea. Ballast tanks are on decks 0 and 1, and can be filled and drained independent from each other.

Bilge tanks will allow for the evacuation of accumulated water on board the CU. The bilge water pumped from the engine may be contaminated with fuel and oil, therefore the water pumped down will pass through a bilge separator before being discharged to the sea.

Wastewater and waste treatment are also part of the CU. Due to the high number of visitors overall production will be highest on Leisure Island, though the waste and wastewater from the yachts docking in the Marina will remain on board the boats and will not enter the platform waste and wastewater treatment. For the Leisure Island scenario, grey water production is expected to be 30 l/(person*day), which corresponds to approximately 5580 l/day for the entire Island. Black water production is expected to be 20 l/(person*day), which corresponds to around 3720 l/day for the entire Island. For the Green & Blue scenarios the wastewater production will be much smaller. The grey water system is a system that works by gravity, i.e. no pumps are needed. The black water system is a vacuum system. The wastewater produced on the platform is stored in tanks on the CU, and will be treated following best practice on board in a septic plant. The storage capacity of the tanks will allow for 5 days of autonomy. In case of risk of overflow the grey water can be directly discharged so that the storage for black water is increased. In the two Blue & Green scenarios, waste water will be filtered and purified before being discharged. In the area of the Leisure Island location off Gran Canaria it is forbidden to discharge any solid or liquid waste into the sea. Therefore, all sewage and waste produced on the platform will be transported to treatment facilities on the Canary Islands directly or pre-treated on board following best practice.

Total production of solid **waste** for the entire Leisure Island scenario is estimated 5 kg/(person *day), for the other scenarios it will be much smaller. Solid waste will the treated on board the CU following best practice, including compacting, high quality incinerator and subsequent transport to shore.

Freshwater for daily operations of the platforms is generated on the CU in **desalination units**, by evaporation of salt water at a temperature of about 40 ^{o} C at low pressure. The freshwater is stored in large tanks.

The exact type of air condition is not yet specified. In the Green & Blue concept for Crete the voltage transformers of the wind energy plant are going to be located on deck 1 of the CU. They will be described more detailed together with the wind energy units below in chapter 4.2.3.

The upper decks of the CU (decks 3 to 11) are more scenario-specific in their space and facility layout (*Table 4-5*). In Leisure Island, the various leisure facilities, bars, restaurants and cabins are located on these upper decks. In the Green & Blue concepts these decks are mainly occupied by the aquaculture (algae & fish) operation and control units, workshops and tool storages for service and maintenance of the aquaculture Satellite Units, fish processing plants, freezing and storage capacities and accommodation facilities for employees. In Taiwan, these decks also include cabins for visitors, gastronomy and some leisure facilities. On the top deck of the CU's, deck 12, control bridge, monitoring and surveillance rooms are located. The Aquaculture and Leisure modules, though integrated in the CU, are described more detailed below in chapter 4.2.2.

Table 4-5: Layout of central units (source: D3.5)

Deck	Leisure Island	Green & Blue Concept, Crete	Green & Blue Concept, Taiwan
0	Ballast Tanks, Diesel Oil Tanks, Fire Fighting Station, Storage Room, Grey Water Tank, Black Water Tank, Grey & Black Water Treatment Room, Waste Treatment	Ballast Tanks, Diesel Oil Tanks, Fire Fighting Station, Storage Room, Grey Water Tank, Black Water Tank, Grey & Black Water Treatment Room, Waste Treatment Plant	Ballast Tanks, Diesel Oil Tanks, Fire Fighting Station, Storage Room, Grey Water Tank, Black Water Tank, Grey & Black Water Treatment Room, Waste Treatment Plant
1	Ballast Tanks, Engine Room, Waste Water Treatment, Fresh Water Tank, Fresh Water Production Plant, Desalination Unit, Storage Rooms, WC	Ballast Tanks, Engine Room, Waste Water Treatment, Fresh Water Tank, Fresh Water Production Plant, Desalination Unit, Storage Rooms, WC, Medium Voltage Transformer, High Voltage Transformer	Ballast Tanks, Engine Room, Waste Water Treatment, Fresh Water Tank, Fresh Water Production Plant, Desalination Unit, Storage Rooms, WC
2	Engine Room, Laundry, Air Condition, Storage Room, Control Room, Clean & Dirty Clothes Room, Electronic & Mechanical Workshop, CO_2 Firefighting System	Engine Room, Laundry, Air Condition, Storage Room, Control Room, Clean & Dirty Clothes Room, Electronic & Mechanical Workshop, CO_2 Firefighting System	Engine Room, Laundry, Air Condition, Storage Room, Control Room, Clean & Dirty Clothes Room, Electronic & Mechanical Workshop, CO_2 Firefighting System, WC
3	Ichthyofauna Observatory	High Voltage Gas Insulated Switch Gear, Desalination Unit, WC	Algae Biorefinery, Laboratories/Stores, WCs
4	Laboratories, Underwater Restaurant & Bar	Fish Aquaculture Operation & Control Unit: Feeding System Fish Processing Plant: Gutting, Cleaning, Batching, Boxing, Labeling, Individual Quick Frozen, Palletising. WCs	Fish Aquaculture Operation & Control Unit: Automatic Feeding System Fish Processing Plant: Heading, Gutting, Filleting, Skinning, Portion Cutter, Sort, Piece Separator, Check Weight & Separator, Loading and Thermoforming, Batcher, Modified Atmosphere Packaging, Labeling, Boxing, By-Product Pretreatment Offices, Storages, Staff Cabins, WCs
5	Diving Area, Divers' Changing Room, Remotely Operated Vehicle Storage, Buoy Repair, Night Club	Fish Aquaculture Operation & Control Unit: Automatic Feeding System Fish Processing Plant: Heading, Gutting, Filleting, Skinning, Portion Cutter, Sort, Piece Separator, Check Weight & Separator, Loading & Thermoforming, Batcher, Modified Atmosphere Packaging, Labeling, Boxing, By-Product Pretreatment Storage Area, WCs	Fish Processing Plant: Reception & Storage Tank, Drainage Tank, Flow Scale, Check Weight, Batcher, Box Processing, Storage Area Staff Cabins, Offices, Stores, Meeting rooms, WCs
6	Passenger Terminal, Reception Deck, Hyperbaric Chamber, Staff & Crew Accommodation, Repair & Adaption Area, Gym, Store Room	Fish Processing Plant: Reception & Storage Tank, Drainage Tank, Flow Scale, Check Weight, Batcher, Box Processing, Storage	Fish Aquaculture Operation & Control Unit: Reception, Loading, Hatch, Net Cleaning & Storage Space, Workshop, Fish Aquaculture Harvesting Equipment, Fish Aquaculture Storage

		Equipment Spare Parts Storage, WCs	Staff Cabins, Hospital, Large Load Elevator, Tourist Dock, Hall
7	-	-	Large Load Elevator
8	Reception & Office, Screening Room, Show Room, Restaurant, Kitchen, Shop Room, Multi-Use Room, Meeting Room, Teaching Room, Party Room, Hospital, Emergency Group, Store Rooms, Food Storage, Rubbish Room, Office, WC	Fish Storage, Freeze Storage for Fish & Algae, Cold Storage, Biorefinery, Net Cleaning & Storage, Fish Aquaculture Harvesting Equipment, Fish Aquaculture Spare Part Storage, Biological Fish & Algae and Electrical Laboratory, Workshop & Diving Workshop, Diving Suit Store, Diving Suit Drying Area, Maintenance & Repair Area, Emergency Group, Large Load Elevator, WCs	Cold Storage for Algae, Freeze Storage for Fish, Storage for Fish, Staff Cabins, Visitors Cabins, Offices, Conference Room, Gym, Large Load Elevator, WCs
9	Rescue Equipment, Spa, Batteries	Rescue Equipment, Dining Room, Kitchen, Meeting Rooms, Offices, Hospital, Common & Leisure Room, Food Storage, Large Load Elevator, WCs	Rescue Equipment, Kitchen, Staff Cabins, Restaurant, Operation Deck, Crane, Sky Observation Lounge, Ocean View Café, Garden, Large Load Elevator, WC
10	Maintenance Room, Cabins, Store Room	Algae & Fish Aquaculture: Fish Accommodation, Algae Accommodation, Processing Plant Crew Accommodation, Gym, Offices, Meeting Room, WCs	Visitor Cabins, Store Rooms
11	Mammals & Birds Observatory, Chill Out Bar, Thematic Café, Kinder Garden, Kitchen, WC	WC	Observation, Spa, Sky Garden, Grill & Bar, Kitchen, Store, Locker Room, WC
12	Control Bridge, Monitoring Room, Surveillance Room, WC	Control Bridge, Monitoring Room, Surveillance Room, WC	Control Bridge, Monitoring Room, Surveillance Room, WC

4.2.2 MODULES OF THE TROPOS PLATFORM

4.2.2.1 Leisure 1 - Leisure Island, Gran Canaria

The Leisure Island has been defined as a floating platform moored in shallow waters, in a chosen sustainable and ecologic location, in order to provide areas and activities attractive to tourists. The selected activities are especially focused on the exploitation of environmental resources in the area, such as marine mammal & birds observatory, providing a different activity compared to existing leisure activities that can be carried out onshore. This is a business model trying to attract tourists looking for more than just "sun & beach", prioritising the best offer from a ranking list, considering engineering restrictions.
The estimated daily average for Leisure Island is 950 visitors per day, representing 346,750 visitors a year.
Leisure Module in fact includes four modules:

- Module 1: Visitors Center.
- Module 2. Food & Beverage.
- Module 3: Accommodation.
- Module 4: Marina & Nautical activities.

Visitor Center. A space for research and educational activities focused on the exploitation of environmental resources of the area, providing activities not only for tourists but also for children and students: marine mammal observatory, sea birds observatory, astronomic observation, interactive services, 3D movies, etc.
Module 1 service has the following functions (Table 4-6):

- Reception desk: Information point. Tickets &Vouchers.
- Showroom: Sea world Visual information.
- Screening room: 3D marine life movies.
- Shop Room: Merchandising.
- Store Room: Service employers area.
- Observatory of Mammals and Birds & Astronomical: Open air place observatory.
- Ichthyofauna Observatory: Underwater observatory.
- Passengers Terminal: Ferry service area.

Table 4-6: Description of Leisure Module 1, Visitor Center (source: D4.2)

LEISURE ACTIVITIES	COMPONENTS		
Module 1	**SERVICES**	**Square Meters**	**Deck**
Visitors Center (Science & Attraction Center)	Reception Desk	25	8
	Showroom	435	9
	Screening room	100	9
	Shop Room	45	9
	Store Room	20	9
	Observatory of Mammals and Birds & Astronomical	400	11
	Ichthyofauna Observatory	350	3
	Passengers Terminal	70	6

Total Weight: **Total Power Demand:**	**8,012.20 kg** **56,329 kW**

Main energy consumption will be by electric facilities in the office, showroom and screening room. Additionally, energy is consumed in restrooms and the shop room. Specifications of illumination in this module are shown in Table 4-7.

Table 4-7: Illumination power for module 1 (source: D4.2); A: Area in m², E: Energy in lux (SI unit of luminous flux), P: Power in watts and kilowatts

Module 1: Science & Attraction Center (Visitors Centre)				
Spaces	**A (m²)**	**E (lx)**	**P (W)**	**P (kW)**
Reception Desk	25	150	450	0.45
Showroom	435	200	10,440	10.44
Screening room	100	300	3,600	3.6
Shop room	45	200	1,080	1.08
Store room	20	100	240	0.24
Observatory	350	300	12,600	12.6
Ichthyofauna	400	200	9,600	9.6
Restrooms	20	100	180	0.24
Corridors	17	150	306	0.31
TOTAL (kW)				**38.50**

Food & Beverage. Complementing the main touristic activities, Module 2 will provide restaurants, bars, cafés and entertainment services, distributed at the platform on different decks according to their own characteristics (*Table 4-8*).

Table 4-8: Description of Leisure Module 2, Food & Beverage (source: D4.2)

LEISURE ACTIVITIES	COMPONENTS		
Module 2	**SERVICES**	**Square Meters**	**Deck**
Food & Beverage	Restaurant	600	8
	Kitchen	143	8
	Sport Bar	200	8

	Restrooms	130	8
	Office Room	50	8
	Recycling zone	100	8
	Night Club	400	5
	Restrooms	20	5
	Underwater Restaurant / Lounge	400	4
	Restrooms	20	4
	Thematic Grill Café	200	11
	Kinder Garden	100	11
	Restrooms	47.50	11
	Kitchen	50	11
	Chill Out Bar	175	11
Total Weight: **Total Power Demand:**	**12,623.24 Kg** **362,972 kW**		

The bars, restaurants, cafés and kitchens make most of the high energy demand of this module. Energy is also needed for storage facilities (cooling rooms, freezer), recycling zone and the restrooms. The main business hours on Leisure Island will be between 10:00 and 23:00. The Underwater Bar will close at 24:00. The facilities located above the sea surface, Restaurant and the Chill Out Bar, will have extended opening hours, from 7:00 to 23:00. The Night Club (Deck 5) will only be opened for special events if necessary. The use of artificial lighting in this module is summarised in Table 4-9.

Table 4-9: Illumination in module 2 (source: D4.2); *A: Area in m^2, E: Energy in lux (SI unit of luminous flux), P: Power in watts and kilo watts*

Module 2: Food and Beverage				
Spaces	**A (m^2)**	**E (lx)**	**P_{max} (W)**	**P (kW)**
Restaurant	600	300	21,600	21.6
Thematic Grill Café	200	300	7,200	7.2
Kitchen Deck 11	50	200	1,200	1.2
Kindergarten	100	100	1,200	1.2
Chill Out Bar	175	300	6,300	6.3
Night Club	400	400	19,200	19.2
Sport Bar	200	300	7,200	7.2
Kitchen Deck 8	143	200	3,432	2.43

Rubbish Room	10	100	120	0.12
Recycling Zone	100	100	1,200	1.2
Corridors Deck 8	77.8	150	1,560	1.56
UnderWater restaurant / Lounge	400	300	14,400	14.4
Storage food	130.2	100	1,562	1.56
Restrooms Deck 4	20	100	240	0.24
Restrooms Deck 5	20	100	240	0.24
Restrooms Deck 8	130	100	1,560	1.56
Restrooms Deck 11	47.50	100	570	0.57
Corridors Deck 11	49	150	882	0.88
Office Room	50	150	900	0.90
TOTAL (kW)				**90.41**

Accommodation is a module designed to provide accommodation to hotel clients, and staff & crew members. 29 luxury twin rooms will be offered for customers and 9 single rooms for crew & staff according to service planning.

Module 3 services are distributed at the platform in different decks according to their own characteristics (*Table 4-10*).

Table 4-10: Description of Leisure Module 3, Accommodation (source: D4.2)

LEISURE ACTIVITIES	COMPONENTS		
Module 3	**SERVICES**	**Square meters**	**Deck**
Accommodation	Customer Lodging	504	10
	Reception Desk	20	10
	Staff/Lodging	76	6
	Crew Lodging	32	6
	Store Room	15	10
	Meeting Room	84	8
	Maintenance Room	15	10
	Hospital	20	8
	Gym	30	6
	Dining & Living Room	70	6

Total Weight: **Total Power Demand:**	**6,033.05 Kg** **89,128 kW**

The main part of the energy is consumed by customer lodging, and dining & living room. Illumination specification and power demand are shown in Table 4-11.

Table 4-11: Illumination in Module 3 (source: D4.2); *A: Area in m², E: Energy in lux (SI unit of luminous flux), P: Power in watts and kilowatts*

Module 3: Accommodation				
Spaces	**A (m^2)**	**E (lx)**	**P_{max} (W)**	**P (kW)**
Customer Lodging	504	150	9,072	9.07
Reception Desk	20	150	360	0.36
Staff lodging	76	150	1,368	1.37
Crew Lodging	32	150	576	0.58
Store Room	15	100	180	0.18
Meeting Room	84	200	2,016	2.02
Maintenance Room	15	100	180	0.18
Restrooms	7.50	100	90	0.09
Hospital	20	200	480	0.48
Staff, Crew Dining & Living Room	70	200	1,680	1.68
Gym	30	150	540	0.54
Corridors Deck 10	65	150	1,170	1.17
TOTAL (kW)				**17.71**

For Nautical Activities & Marina, due to excellent natural conditions of the area for nautical activities, sailing and diving have been considered the safest options for all levels.

Module 4 service function is as follows:

- Office & Reception. Information desk and booking.
- Teaching Room. Introduction lessons to diving & sailing
- Store Room. Diving compressors.
- Repair and adaptation area. Sailing facilities.
- Drying area for diving suits.
- Restrooms & Changing area.
- Hyperbaric Chamber. Emergencies & wellness treatments.
- Marina. Design pending for approximately 40 berths.

Table 4-12: Description of Leisure Module 4, Nautical Activities & Marina (source: D4.2)

LEISURE ACTIVITIES	COMPONENTS	UPDATED	UPDATED
Module 4	**SERVICES**	**Square Meters**	**DECK**
Marina & Nautical Activities	Office & Reception	10	6
	Teaching Room	24	8
	Store Room (Compressors)	30	6
	Repair and adaptation area	30	5
	Drying area for diving suits	10	6
	Restrooms & Changing rooms	30	6
	Hyperbaric Chamber	15	6
	Berths (Marina)	Pending	Pending
Total Weight:	**3,275.65 kg**		
Total Power Demand:	**14,666 kW**		

In this module, the compressors have the highest energy demand. Additional energy is required for electrical facilities in the office and restrooms. Illumination specification and power demand in module 4 are shown in Table 4-13.

Table 4-13: Illumination in Module 4 (source: D4.2); *A: Area in m^2, E: Energy in lux (SI unit of luminous flux), P: Power in watts and kilowatts*

Module 4: Marine & Nautical Activities				
Spaces	**A (m²)**	**E (lx)**	**P_{max} (W)**	**P (kW)**
Office/Reception	25	150	450	0.45
Teaching Room	24	200	576	0.58
Hyperbaric Chamber	15	100	180	0.18
Drying area	6	150	108	0.11
Store rooms	30	100	360	0.36
Repair area	30	250	900	0.90
Restrooms WC / Changing Room	30	100	360	0.36
Corridors	53	150	954	0.95
TOTAL (kW)				**4.26**

4.2.2.1 Leisure 2 – Green & Blue Concept, Liuqiu Island

Since the site is one of the popular sites for island tourism and most of the hotels and accommodations are local owned bed & breakfasts, the Leisure facilities on the TROPOS Green & Blue concept may provide an important contribution to local economy. Visitors can also realise the concept of sustainable energy and fishery through understanding the processes and functions of platform. It can also provide living space for international and national researchers and investors who study OTEC, aquaculture, floating structures etc. There already exists a variety of water activities in Liuqiu Island and the proposed site of platform is closer to the island. Therefore, the high-end hotel will be provided in the TROPOS platform, and other water activities will retain in Liuqiu Island.

Socio-economic and safety standards as well as space for the required activities are the main reasons to build the accommodation facilities. In the accommodation module, there are the hotel rooms, the related service facilities, the Food & Beverage services etc. included. The accommodation will be open all the time except during typhoon alarms. Restaurants, bar, spa and other facilities are mainly for visitors living in the platform. Restaurants will serve daily 7:00–10:00, 12:00–14:00, and 18:00–22:00. Bars and café provide drinks and light food, and open daily 10:00–24:00.

The major accommodation is located on the outside ring of deck 8 and deck 10. The shape of the Central Unit platform leads to three sizes/types of accommodation: small, medium and large sized suites. The accommodation for crew and staff is located separately on deck 6 and deck 8. There are three types of accommodation, and can fit 70 tourists at one time. Tourists can be transferred to the platform through shuttle boats. The shuttle boats can connect the platform to Donggang port (in Pintong) in 30-40 minutes, and to Baisha Port or Dafa port (in Liuqiu island) in 15-20 minutes.

The grey water system is a system that works by gravity with a minimum of piping and without any pump. It is estimated that 30 liters per person per day of grey water are produced and 5 days of autonomy for the storage tanks is required for 70 visitors and 35 staff, 105 in total. The black water system is a vacuum system, for driving these to the septic plant, which will be treated. In the case of black water service, it has been dimensioned with a production 20 liters and person per day.

4.2.2.3 Aquaculture (incl Processing Plant)

Green & Blue Concept, Crete. This module is the actual aquaculture production unit. In this module, the Satellite Units are operated and controlled, reducing the shipping to the satellites.

The main activities taking place in the Aquaculture module are fish processing plant, algae processing plant and biorefinery, operational centre of online-monitoring of satellite and storage. Other operational facilities are included to provide the support to the main activities: waste treatment, desalination unit, accommodation of staff and visitor, labs, warehouse for nets storage and cleaning, deck for repairs, etc.

The fish processing plant process the aquaculture into three different production lines with the following ratios: 25% fresh fish in ice, 55% transformed (Individually Quick Freezing / Modified Atmosphere Product) and 20% by-products. The generation of by-products reduce the generation of waste. During this process the consumption of goods (boxes, pallets, modified atmosphere packaging (MAP) mixed gases, thermo forming materials, etc.), energy, ice and fresh water along with the use of harmful substances, are the main environmental aspects of the processing plant.

The algae processing plant and biorefinery in this plant dried microalgae proceeding from Algae Farm Satellites is packaged, or used in the biorefinery for oil and pigment extraction. The biorefinery is combined with the fish aquaculture wastewater for sustainable production.

Microalgae are also used in this plant to purify wastewater through a bioremediation process.

The Aquaculture module also includes installations for desalination and ice making. Fresh water and ice are required in some of the processed mentioned. The desalination unit will provide the central unit with the required quantities of fresh water with the subsequent consumption of energy and discharge of water.

Cold storages are fundamental for the development of the activities performed in the aquaculture module. The storage space is enough to keep the incoming fish and algae before processing, and the generated products. The cold storage chambers will not be operated simultaneously (all at the same time), but according to the schedule (Table 2-23, D3.5); this will reduce the consumption of energy by 50%.

All wastewater and solid waste produced on the platform will be stored and treated on board of the Central Unit. Wastewater will be stored in tanks and will be treated and purified following best practice in a septic plant or through a bioremediation process before being discharged. Solid waste will be either burned in a high quality incinerator or, in the case of plastic, glass, cans, etc., compacted and transported to shore.

Green & Blue Concept, Liuqiu Island. Liuqiu island is located close to the main fish market, so the "Individually Quick Frozen (IQF)" part of the processing unit is not required, here. The processing in this scenario includes two different approaches for 30 groups of products: (i) fresh fish on ice and (ii) processed fish (fillets or steaks) packed in MAP (modified atmosphere packaging). All solid disposals from processing will be remanufactured to the bait for aquaculture, so waste does not cause problem in the system.

4.2.2.4 PV Modules (including Energy Storage)

The photovoltaic (PV) modules have different covered areas depending on whether they are installed on the Leisure Island platform or on the satellites units of the Green & Blue platform. However, both installations follow the same installation pattern. The main difference between them is the PV panels' distribution and area covered depending on infrastructure available on the platforms for this. A brief description of each plant focusing on key points that may cause any environmental impact is shown as follows.

Leisure Island: PV plants are panels consisting of a number of semiconducting PV cells, and inverters to convert the direct current (DC) electricity into alternating current (AC) electricity. In regard to the PV plant for the Leisure Island, the system is composed with a total rated power of 1.5 MW configured in twelve arrays (24 strings of 16 panels each) with one inverter for array. Each array will be connected to a single DC switch board before the connection with the inverter. There will be one singe AC array to connect the AC output coming from the twelve inverters with the Central Unit transformer.

Panels will lay flat on the deck's surface and fixed to a support lattice structure. The reason for this configuration is mainly the fact that the use of motors to adjust direction of panels according to sun position is not going to be effective due to platform degrees of freedom and it also requires an increase of costs in terms of capital expenditures (CAPEX) and especially operational expenditure (OPEX). Apart from this system, there are two other options which are setting the panels at the optimum inclination according to latitude or laying them flat. Second choice was selected due to higher efficiency taking into account the fact that setting panels with a certain inclination requires to separate them out to avoid shadowing between each other, thus laying panels flat will reduce their efficiency but will allow to install many more of them covering the same area. Fixed structure consists of angled profiles in lattice shape which will increase stability with less amount of steel. Panels are going to be screwed onto the structure and the structure will be painted to avoid corrosion.

Taking into account the dimensions of each panel (1954 x 982 x 40 mm) and the number of panels (4608 panels), the area covered with PV panels is 8,841.96 m^2. This area will reflect a 5% of the radiation that reaches the plant in terms of losses. When heat, transmission, absorption and electrical losses are added, the final loss is approximately 87% in total. Reflection will vary according to the position of the sun and its movement.

Panels will reach an operation temperature range of 15–60ºC. Heat losses are the most important problem regarding PV systems. Due to not having a tracking system to follow the sun, PV plant will not make any noise or vibration except for the usual whir low sound of the inverters.
PV cells are composed of crystalline silicon which creates silicon dioxide to develop the cell; the latter chemical can be dangerous. However, cells' surfaces are purified and enclosed within a container with aluminum frames and glass walls, which prevent any contamination risk.
Cleaning PV panels will be carried out every 3 months and always at night time to avoid interrupting energy generation. Process will use high pressure water without harmful chemicals; cold water will not be used when the module glass temperature is hot and hot water will be used to clean cold modules to avoid potential fracturing. Storage will take place at the center of the platform.
On the Satellite Unit for the **Green & Blue platform**, PV plant is installed on top of the floater, surrounded by the floater columns. Panels will be installed flat on the deck; as a consequence, a distance between each row to avoid shadowing is not required, as explained above. It is assumed that a distance of 0.1 m between each row and of 1 m between the two arrays will be sufficient to install a gangway. The rows are installed parallel to the floater's brace between column A and C.
Consequently, the maximum length of each row is determined by the available space between the floater triangle-leg braces. The total number of rows that can fit onto the floater is determined by the space between the A-to-C brace and the tip of the triangle at column B. As a result, the maximum number panels that can be installed on the floater is 1,400 with a total capacity of 434 kW. Each array will have 13 strings of variable number of panels. This number will decrease when closer to the tip (column B).

Inverters and UPS support batteries will be located within the floater columns in different levels and completely sealed.

Surfaces of the panels will be cleaned with demineralised water exclusively, i.e. no detergents will be used.

4.2.3 SATELLITES OF THE TROPOS PLATFORM

4.2.3.1 Algae Aquaculture Units

Green & Blue Concept, Crete. The Algae Unit structure has a frame that is a modified version of the Subflex fish cage system composed of PE, Dyneema, steel track and steel. The dimensions of the Algae Farm Satellite structure are 50 x 200 m with an inserted phytoplankton unit of 400 m³. Two thrusters, located at the end of the plant, help to manoeuvre the culture system. The Algae Farm Satellite Units are connected with the wind Satellite Unit to avoid anchoring cost, environmental impact and operative maintenance costs.

As the microalgae are in a closed system, the medium will be supplemented with some nutrients, as nitrogen (9 t/year), phosphorus and micronutrients (1.5 t/year). The prevention of the accidental release of the nutrients is needed to avoid negative effects on the environment.

CO_2 is applied additionally to enhance the production yield; this will be done by direct injection from a 50 t cryogenic CO_2 storage with an assistance of an air blower. As in the case of the nutrients, the release of CO_2 in the water and/or the air must be prevented.

The online control system allows monitoring and controlling the production process inside the photobioreactor, the online information provided by the sensors (temperature, pH, optical density, etc.) allows evaluating the need of supplementation and harvesting reducing the shipping.

The area of control and harvesting algae unit is installed inside column D. When the microalgae culture reaches the desired concentration the harvest starts. A two-step algae harvest is implemented with a first step consisting in a pre-concentration followed by a second step of centrifugation that consumes 0.3 and 0.5 kW/m^3 respectively. The dewatering process before the centrifugation reduces the energy demand. The algae biomass is dried by spray-dryer or solar-dryer positioned in column and on deck of column D.

Green & Blue Concept, Liuqiu Island. Seaweed biomass power generation and bio-ethanol are the two of the main objectives for seaweed industry in Taiwan. Algae can quickly absorb nutrients and grow. It can provide the ecological restoration function as well to inhibit the red tide generation. It can be cultivated together with fish and shrimps to make aquaculture on the platform sustainable. Algae also can absorb carbon dioxide. The suitable species in the proposed site are the red algae *Gracilaria tenuistipitata* and the sea lettuce *Ulva lactuca*.

The unit for the production of algae is connected with the fish aquaculture unit. An algae unit-structure of dimensions is 50 x 200 m with an inserted phytoplant unit of 400 m^3 plus the rope/chain system for macroalgae. This unit has an annual production capacity of 65 t (biomass dry weight). Each cage is predicted a production capacity of 100-150 t per 2 year cycle. For this design, a 30 unit scenario is considered and the annual production capacity of the facility will be 1,950 t/year.

4.2.3.2 Fish Aquaculture Units

Green & Blue Concept, Crete. Each satellite contains atypical offshore cage collar of 33/36 internal/external diameter that can be moored in between the base legs. The cage, composed by Dyneema nets, can have a volume of 650 m^3 (refer to D3.4, Chapter 6.2.2.5, for more information). Single mooring lines with a swivel function at the anchoring moor the Satellites. Both, the cages and the mooring line, could affect the natural populations.

The main processes implemented in the satellite are stocking of fry, monitoring, feeding, care of the cultured fish and harvest. The first step for the production of fish is the introduction of the fry in the cages. In this process, it is extremely important to prevent the escape of fry, to avoid the attraction by predators and the escape of domestic fish.

The feed is supplied through feeding storage silos and a feeding system able to operate autonomous for a week period with a daily energy consume of 75 kWh/day. The amount of feed supplied, which is actually going to be consumed by the cultured fish will depend on the Feed Conversion Ratio (FCR) that relies on species, fish age, temperature, feed quality and condition of the fish. The value of the FCR (estimated in 17), apart from the amount of feeds used, will determine the amount of feed released into the sea. An appropriate adaptation of the feed to the growth conditions will be performed in order to avoid negative effects as nitrification and the attraction of wild animals.

The cage contains monitoring equipment (dissolved oxygen level sensor, temperature sensor and cameras) that are remotely controlled from the Operational and Feeding Center (OFC) located in the central platform. The monitoring equipment and the lighting will have a total energy demand of 2 kW expected to be available from the Satellite Unit.

Despite most of the monitoring activities can be performed from the Central Unit, some activities require *in situ* monitoring such as cages maintenance, sampling and treatment of the fish. The main risk of these processes is the escape of fish. The compounds and their dosage used to treat the fish will be adapted to the circumstances to prevent any unwanted effect over the natural population.

When sufficient feed and energy is available, market size fish are produced. According to the harvesting plan presented in Table 2-15 (refer to D3.4 for more information) each species will be harvested in their natural spawning periods to avoid overlapping that may overload the processing unit. The harvest is applied by a fish pump operated from a working barge deck and supplied with the energy from the Satellite Unit (4 kWh/t biomass). In order to minimise the expense of energy used in the harvest and to avoid other negative effects such as noise, a pre-concentration of the fish will be achieved by lifting the cages.

Green & Blue Concept, Liuqiu Island. The Satellite Units for this location are a combination of fish production and algae production. At the location of Taiwan, the plant will be provided with the three most common types of species in the area for the production. Major aquaculture species grow-out in Liuqiu Island, Taiwan, is Cobia (*Rachycentron canadum*), Greater amberjack (*Seriola dumerili*), Grouper (*Epinephelus lanceolatus*). Other minor species are *Lutjanus erythropterus*, *Pagrus major*, *Scatophagus argus*, *Kyphosus vaigiensis*, *Abudefduf vaigiensis* etc. Yellowfin tuna (*Thunnus albacares*) is also planned to be cultivated in Liuqiu Island. These species are to be grown in Satellite Units which are at some distance from the Central Unit.

The fish aquaculture unit has been estimated to have 30 Satellite Units. The shape of the aquaculture unit is a circular steel collar with a nominal diameter of 40 m consisting of 12 sealed tube segments. There is no extra energy need to support the entire procedure of cultivation. Feeding and harvesting processes will be adopted in an artificial manner. The estimated aquaculture production is approximately 2,000 t/year.

4.2.3.3 Wind Energy Units

The wind farm providing energy supply for the Green & Blue concept in Crete is based on 30 Satellite Units each accommodating two wind turbines (Figures 4-3 & 4-4). Construction of the satellites for wind turbines is assumed to be done at a shipyard nearby. The floating structure is manufactured in sections that are then welded together. All mechanical and electrical equipment is mounted at the shipyard including the wind turbines. All systems are tested and commissioned at the shipyard. Each completed floating structure (satellite) is then towed to the site and anchored at the moorings.

The satellites are unmanned and operated from the CU. Maintenance is carried out once a year (during a period of low wind) by a maintenance crew that have their base at the CU and visit the satellites during the daytime by boat.

Decommissioning of the satellites is done at a shipyard. The satellites are towed to the shipyard while the moorings are left on the seabed. All metal (steel and copper) and liquid materials (lubricants) are recycled. It is assumed that at the time of decommissioning the wind turbine blades can be also recycled. This means that virtually all materials can be recycled.

The basic assumptions for evaluation of the environmental impacts are as follows:

- 30 units with 2 each 3.3 MW Vestas floating turbines (60 turbines total produce about 198 MW) with 112 m rotor diameter, located about 45 km offshore.
- Each Satellite Unit is about 244 m across each platform; the entire footprint could range between 18 km^2 to 37.6 km^2 (see Figure 4-3 below).
- Maximum water depth is 970 m while the mean value is 450 m (for Crete).
- Dominant sand and gravel bottom.
- Lifetime of the project – 25 years.
- We assume that each satellite is anchored to the seabed by four anchors and that the electrical cable from each satellite follows one anchor line to the seabed. In the seabed the cable is buried in a trench. Each satellite is connected to the CU substation through an inter-array network and the substation is connected to a substation on land by a larger cable.
- We assume that no traffic is allowed in the wind farm area during construction and decommissioning phases. During the operation phase (25 years) leisure boats and small fishing boats are allowed but no trawling is permitted.

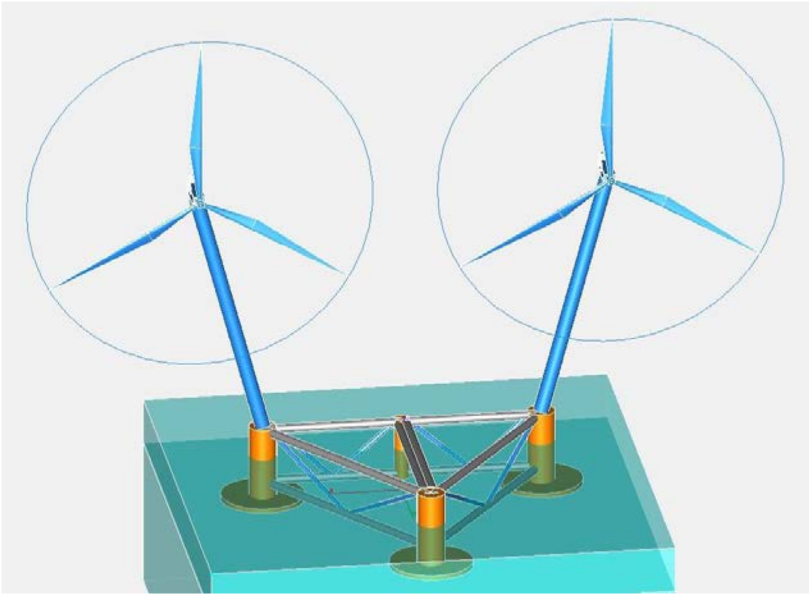


Figure 4-3: TROPOS Wind satellite (Source: D3.4, Page 35)

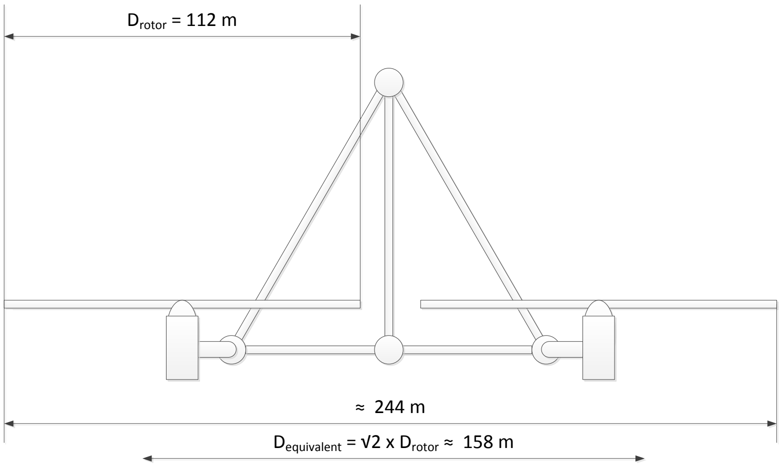


Figure 4-4: TROPOS Wind satellite seen from above (Source: D3.5 Page 57)

4.2.3.4 OTEC Plant

The Green & Blue concept in Taiwan is planned to include a floating Closed-Cycle OTEC plant. Due to its rather heavy structure and its autonomy, the OTEC plant is considered as a satellite. OTEC produces constant, base-load electricity in a turbo-generator that is driven by the evaporation/expansion of the working fluid ammonia in a closed circuit. The warm side is heated by surface ocean water at temperature around 25°C, and the cold side is cooled by cold deep water, from 6–800 m depth, at around 6°C in the deep canyon SW of Lingqui island.

The design according to work in WP3-4 is a 8 MWe gross, 5 MWe net plant, placed on a barge. The equipment will be distributed on two decks, see Figure 4-3. This size of a plant is regarded as technologically feasible today. As the whole, plant with barge will be quite heavy, around 17,000 t; it is suggested to have the OTEC plant as a stand-alone Satellite Unit. An electric cable will transport the electricity to the central unit or modules.

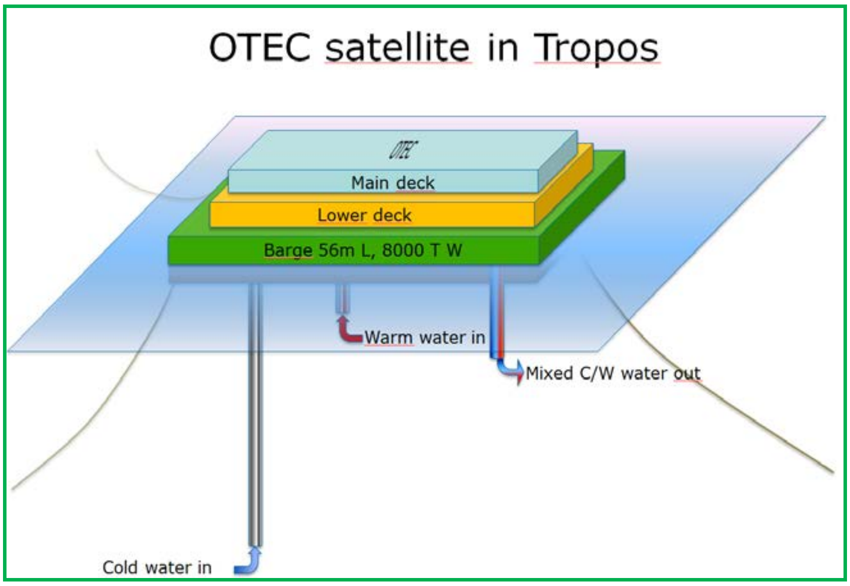


Figure 4-5: Sketch of the OTEC plant.

4.3 ANALYSIS OF ALTERNATIVES

The analysis of potential alternatives is an integral part of an EIA and during project development. In case of the TROPOS project, the alternatives include:

(i) Terminating the development

(ii) Developing onshore facilities instead of going offshore

(iii) Developing fixed instead of floating structures

(iv) Developing floating single-use instead of floating multi-use offshore platforms

The first option, terminating the development, is not feasible since it means stagnation. Onshore space becomes increasingly limited, and the aim is making use of offshore space. Accordingly, the second option is not an alternative to be considered either. Fixed offshore structures do exist in the world's oceans in the form of oil/gas platforms offshore or wind farms. Such fixed structures may be suitable for their particular purpose, but construction involves (among others) extensive ramming of the pile into the seabed, which means a significant negative impact on sediment dynamics, destruction of benthic flora and fauna, and significant disturbance of fish, turtles and marine mammals due to noise and vibrations generated during construction. The challenge is to choose floating structures, with much smaller impact on the seafloor, on sediment and current dynamics, and on the marine living communities, in particular marine mammals. The development of multi-use platforms instead of single-use platforms provide the opportunity for the reduction of the overall footprint due to e.g. joined logistics. However, the advantages and disadvantages of a multi-use platform compared to single-use installations will be discussed more detailed in D6.5 (to be delivered in month 36).

None of the options listed above is a valuable or reasonable alternative for the development of a floating multi-use offshore platform. The TROPOS platform locations and the scenarios, i.e. the combination of modules and satellites, are carefully chosen considering environmental, economic and technical aspects. The technical development of the compartments of the TROPOS scenarios follows best practice and techniques to deliver optimum design with lowest possible impact on the environment.

4.4 DESIGN CONSIDERATIONS

The design of the TROPOS platform (WP3) and the engineering specifications of the chosen designs (WP4) were/are developed under continuous exchange with WP6 (environmental issues). This was (and still is) done to ensure that negative impacts on the environment are avoided or at least kept at the lowest possible level.

To reduce pollution (emissions) and carbon footprint, the energy demand of the TROPOS scenarios are met (almost) completely by renewable energy, such as wind, solar and OTEC. The diesel machine mainly serves as a backup in a case of emergency or deficiency of the natural energy resource. To reduce pollution due to increased vessel traffic, logistics of CU, modules, and satellites are operated jointly. In case of Leisure Island (Gran Canaria), maintenance and supply are combined with the common daily tourist shuttle.

The cables connecting the wind turbines and the PV units with each other, as well as the cables between the CU and shore (Crete), are integrated, i.e. there will be just one cable between the Satellite Units, and one cable from the CU to the shore. These cables are well isolated to reduce electromagnetic fields.

The wastewater produced on board will be recycled/reused to reduce freshwater consumption. The lower part of the CU is equipped with a double hull to prevent oil spills. The design and engineering specifications of the platforms considers extreme weather conditions and unplanned events to be prepared for all kinds of emergencies. Safety and security of crew and visitors, and protection of the environment, are the top priority in the design of the TROPOS scenarios.

4.5 DEVELOPMENT LIFECYCLE

The construction of the CU, the modules and satellites will be done in a shipyard (construction yard), i.e. the offshore environment will not be affected by these construction activities. Only the mooring will be installed directly at the chosen platform site. As much as possible, all parts, mechanical and electrical equipment will mounted at the shipyard and tested there. The modules will be integrated into the Central Unit. When completed, the parts, i.e. central unit including modules, and the Satellite Units, will be towed offshore by service vessels to the selected platform site, and anchored to the moorings.

The Satellite Units are unmanned (except for OTEC) and will be monitored and operated from the Central Unit. Maintenance and regular inspection of the Satellite Units will be coordinated and performed from board of the central unit. Waste and wastewater produced during the operational phase of the platform will be treated following best practice and stored on board until it can be transferred to shore (see chapter 4.2.1 above).

For the decommissioning of the TROPOS platforms, the Central Unit including modules, and the Satellite Units, will be detached from the moorings, and towed to shore. The moorings will be left in/on the seabed. Disassembly of the platform parts will be done in a shipyard. Where possible, all materials (solid and liquid) and parts are going to be recycled. If recycling is not possible, disposal will be carried out following best practice to avoid or minimise any negative impact on the environment.

5 EXISTING ENVIRONMENT

For the extended descriptions of the existing environments in Gran Canaria Island, Crete and Liuqiu Island, and all references, see ANNEX Part B (extra document), chapters 1 to 3.

5.1 GRAN CANARIA

5.1.1 PHYSICAL ENVIRONMENT

The Canary Islands (Figure 5-1) consist of seven major volcanic islands located in the northeast Atlantic margin, a few hundreds kilometres from the northwest coast of Africa (Morocco). The islands roughly form a west-southwest to east-northeast trending archipelago confined between latitudes 27° 37' N and 29° 25' N, and longitudes 13° 20' W and 18° 10' W. Volcanism in this belt decreases in age from the northeast (approximately 70 million years) to the southwest (approximately 1 million years).

The 1,950 m high central volcano of Gran Canaria, which is approximately 15 million years old, shows signs that it is well into its destructive phase of evolution, with erosion and mass wasting outpacing growth through magmatic activity. In fact, although it is roughly round in its outline, it no longer presents a conical shape and is characterised by deeply incised canyons. Erosion has exposed intrusive complexes and dike swarms on the island.

Due to its geographical location and configuration, it is an important obstacle in the North Atlantic circulation, which, in turn, plays a key role in the global circulation and in the ocean-atmosphere interaction dynamics.

The Canary Islands` climate is determined by several factors: the trade winds, damp winds which combined with the orography of the islands produce climatic stability all year round, the cold current of the Canary Islands which keeps the water temperature lower than expected, their geographical latitude, close to the tropic of Cancer. All this together with their proximity to Africa, and their condition as islands give them a subtropical climate.

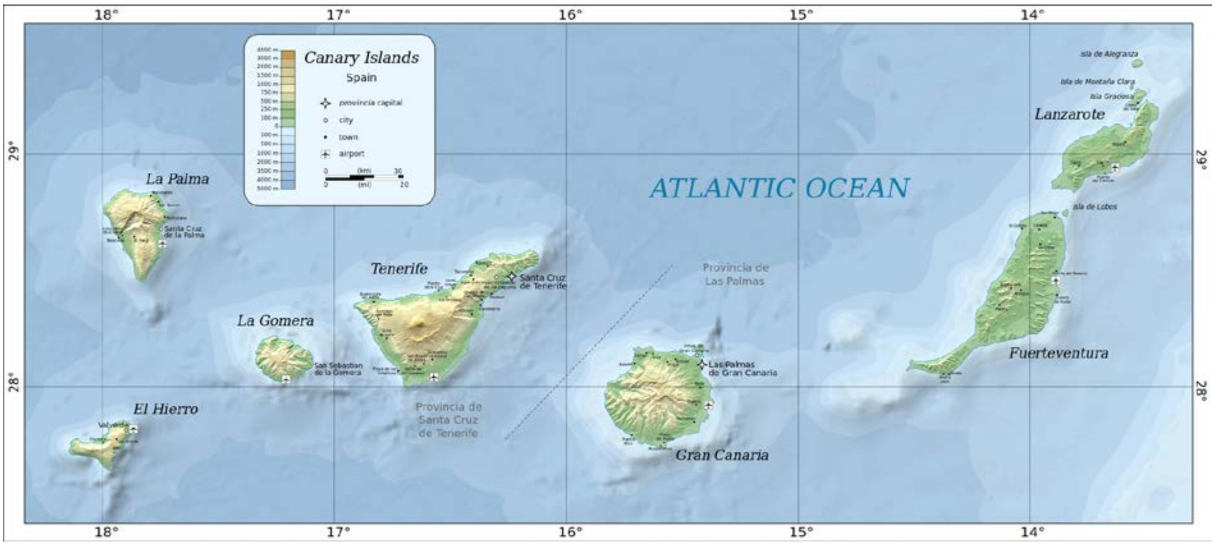


Figure 5-1: The Canary Islands (Source: Wikmedia)

5.1.2 CLIMATE AND ATMOSPHERE

Climate in the Canary archipelago is the result of the joint influence of geographic latitude (it is roughly located 4º north to the Tropic of Cancer), wind systems and ocean currents. In general, Canary Islands present a subtropical climate, with long, warm and dry summer seasons, and moderately warm winter seasons. However, the complexity of the factors affecting the climate in the region is translated in the occurrence of relevant phenomena which disturb this average pattern.

The trade winds, associated to the eastern branch of the Azores High, are prevailing in the Canary Islands, predominantly blowing from the northeast. They consistently blow during the whole year, but more intensively during the summer season (mostly from April to September). Although this pattern is dominant in the archipelago, the seasonality of the Azores High allows for the occasional arrival of polar air masses. On the other hand, due to the proximity to Africa (and, in particular, Sahara), dry and warm continental tropical air masses sporadically surge into the archipelago. The occurrence of these events results in a sudden change of the weather conditions, otherwise influenced by the dampening effect of the ocean. In these occasions, southeasterly/easterly winds may carry small particles of dust or sand from the desert into the islands. This phenomenon is called Calima and, during severe events, it decreases visibility. In Gran Canaria Calimas typically occur 5 to 7 times a year, lasting between 2 and 7 days until the direction of the wind changes or it starts raining.

Topography plays an important role in the local variations to the broad climatologic pattern on the islands. The high mountains of the archipelago present a barrier to the trades' circulation, so that clouds accumulate in the windward slopes generating high rainfall rates and Foehn winds prevail in the leeward slopes. Averaged annual precipitation in the Canary Islands varies between 8.5 mm in Fuerteventura and 557 mm in Tenerife. In Gran Canaria annual precipitation is 134 mm. Rainfall in the island is mostly concentrated in the winter months, i.e. from November to March and from June to August there is virtually no precipitation.

The Canary Current also plays an essential role in the archipelago's climate. It branches south from the North Atlantic Current, flowing along the African coast from north to south between 30°N and 10°N and offshore to 20°W, where it joins the Atlantic North Equatorial Current (Fedoseev, 1970). The Canary Islands partially block the flow of the current. The presence of the Canary Current is responsible for an important regulating or damping effect which prevents significant temperature variations in the region. In fact, the moderate temperatures along the year, with no significant seasonal variability, are a particular feature of the climate in the Canary archipelago. Yearly average temperatures in Gran Canary range from the average minimum temperature of 14.7°C that occurs in January and the average maximum temperature of 27.1°C is in both August and September.

5.1.3 OCEANOGRAPHIC CONDITIONS

In terms of wave climate, conditions north and south to the archipelago differ significantly. The wave climate off the north coast of Gran Canaria, concretely, is dominated by the swell systems generated in the North Atlantic. This means that longer and more energetic waves prevail in the sea states in this part of the island. In fact, monthly average significant wave heights H_s vary between values from 1 m to 3 m, with predominance in the range 1.5–2 m (data from the SIMAR-44 catalogue, Puertos del Estado). The predominant wave direction in the northern part of Gran Canaria is from the North. The south sector of Gran Canaria is less exposed to the North Atlantic swell systems, which are partially blocked by the islands. Monthly average H_s values vary between approximately 0.7 m and 2 m, with predominance in the range 1–1.5 m.

The current systems in the Canary Islands are quite complex, involving a Gulf Stream branch, the Canary Current and upwelling phenomena due to the trade winds action close to the west coast of Africa. The Canary Current, which is associated to this coastal upwelling, contains filaments, and eddies with length scales of 100–300 km which form along the coastal boundary of the current. As a consequence of highly variable upwelling events, sea surface temperature (SST) in the Canary archipelago presents significant variations in both time and space. SST in the Canary Islands is in the range 16–18°C in the winter months and 23–25°C in the summer months. Seasonal variations in the current systems may affect these ranges.

Salinity of surface water in the Canary Islands in in the range between 36.7 and 36.9. Current systems variability, variations in precipitation and evaporation levels may also produce noticeable variations in space and time of the salinity.

The western and eastern parts of the archipelago are well distinguishable when it comes to water productivity. While the zone covering the western islands is predominantly oligotrophic, the zone covering the eastern islands is affected by the upwelling processes taking place along the western coast of Africa and, consequently, presents high levels of primary productivity.

5.1.4 BATHYMETRY AND SEABED FEATURES

The bathymetry and seabed features of the Canary archipelago differ considerably, even between islands, due to their volcanic origin. The islands emerge from a seabed with east-west increasing depth, from around 4,000 m close to La Palma and El Hierro to around 3,000 m close to Lanzarote and Fuerteventura.

Since they are located in a volcanically active zone, the continental shelf in the Canary Islands is narrow and steep. In Tenerife, La Palma and El Hierro the continental shelf is practically inexistent. In Gran Canaria, Fuerteventura, Lanzarote and La Gomera the continental shelf is wider. In general, 200 m depth can be found at a relatively short distance from the shore (typically 1–8.7 km).

5.1.5 SEDIMENT QUALITY

Oceanic islands are continuously subjected to erosive processes, which are an important source for sediment. Giant landslides and avalanches are among the most significant processes contributing to the erosion of islands, both of which are predominant in the Canary Islands. Sediments in the archipelago are dominated by volcaniclastic rocks generated by eruptions, erosion, and flank collapse of the volcanoes.

5.1.6 WATER QUALITY

The quality of the coastal waters in the Canary Islands is, in general, very good, due to the absence of significant concentration of contaminants (Riera et al., 2007a, b). Riera et al. (2007a,b) reports included collection and subsequent analysis of large quantity of water and sediment along the entire coastline of Gran Canaria, with the ultimate goal of assess both chemical and ecological status of coastal water masses. The physic-chemical parameters were studied in all water sampling stations, while specific chemical or pollutant indicators were analysed only in water masses with risk under study and in water masses with risk.

Locally, small deviations from good status level of water may be observed in areas with localised pollution sources, such as areas of submarine discharges, but these are of very limited spatial importance (Riera et al. 2007a, b).

5.1.7 NATURAL HAZARDS

Since it is located on volcanic soil, the Canary archipelago is naturally subject to volcanic and seismic activity. The last known eruption in Gran Canaria was around 40 AD. A comprehensive study compiling data on volcanic activity on the island for the last 11,000 years enabled the production of a hazard map of Gran Canaria, indicating the areas with highest potential for volcanic risk in the future (Rodríguez-González *et al*., 2009). Main areas of hazard have been identified in the northeast part of the island (see TROPOS deliverable 2.3). However, geological hazards in the Canary Islands in general are moderate compared with other volcanic regions with equivalent demographic features (e.g. the Hawaiian Islands).

The occurrence of clouds of dust from the Sahara Desert (Calimas – see chapter 5.1.2 above) is another potential natural hazard in the archipelago. Severe events significantly decrease visibility. Calimas typically occur in Gran Canaria 5 to 7 times a year and last between 2 and 7 days.

Large storms are extremely rare in the Canary Islands. The first time that a tropical storm was recorded in the archipelago was in November 2005, causing considerable damage, including the destruction of the Dedo de Dios (God's Finger), natural rock structure that had stood for thousands of years in Gran Canaria.

5.1.8 NOISE CONDITIONS

Currently, the noise conditions are not well defined for the Canary archipelago. However, recent efforts to compile information for the Marine Strategy Framework Directive made it possible to perform an investigation considering all the activities that potentially generate noise in the marine environment. Data available made it possible to identify the main sources of noise and pressures that can be occurring in the marine environment. In spite of not being in actual maps of noise, this information allowed to identify areas where noise sources are located. The spatial analysis of accumulated pressures was based on vessel traffic made by mercantile ships and fishing vessels. Results showed that one location in Gran Canaria has potentially high levels of submarine noise (northeast of Gran Canaria). The main pressures identified were mercantile traffic, mostly including ferries between the islands, and fishing vessels traffic. On the area chosen for deployment of the TROPOS platform the potential for accumulated acoustic contamination appears to be low and the semi-quantitative noise index is of 0.60 (MAGRAMA. 2012f).

No information was found concerning the routes of the recreational fleet; nevertheless, their impacts should not be neglected and should be addressed. Moreover, to complete the analysis of pressures of accumulated noise, the noise generated by exploitation platforms should also be taken into account, as well as by hydrocarbons storage, areas of seismic research, etc.

The actual state of the environmental noise is currently unknown, apart from existing punctual measurements made by national or European projects. Consequently, to evaluate the actual levels and trends it would be necessary to have temporal series of direct measurements with hydrophones with sufficient spatial coverage.

Due to the importance of the Canary Islands as habitat for marine mammals, impacts generated by noise should be evaluated in areas of high density of cetacean and areas with potentially high submarine noise should be identified.

5.1.9 ECOSYSTEMS, HABITATS, AND SPECIES COMPOSITION

5.1.9.1 Pelagic Communities

In a global scale, the pelagic environment presents a much larger uniformity than the benthic environment and species that inhabit it have much larger distribution areas. Nevertheless, factors as light gradient, temperature, salinity, pressure and nutrients availability in the water column determine the structure of the pelagic species and their depth fluctuation between time and space. On the other hand, eddies, upwelling and ocean currents determine local differences in nutrient availability and, therefore, spatial heterogeneity, which affects the degree of concentration of plankton biomass and species diversity. In the pelagic sphere the plankton dominates, both in biomass and biodiversity of organisms (Templado et al., 2012).

In Canary Islands, a gradient is observed between the oligotrophic waters of the Western Islands and the most productive in the eastern, due to its proximity to the Saharan outcrop. In a study developed from the east of Fuerteventura to the north of Gran Canaria and La Palma Davenport *et al*. (2002) concluded that annual productivity diminishes progressively towards the west (MAGRAMAa, 2012).

Phytoplankton. In general, species diversity of the phytoplankton community of the Canary archipelago is dominated by small flagellates, dinoflagellates and diatoms. Other species of underrepresented groups also appear such as cyanobacteria, prasinophytes cryptophytes, and silicoflagellates euglenophytes. García-Rojas (2011), in a study focused on the Gran Canaria coastline, which concluded that the majority of groups of the phytoplankton community are diatoms and dinoflagellates; the study highlights that there are also cyanobacteria species (*Aphanocapsa sp., Arthrospira sp., Calothrix sp., Chrococcus turgidus, Lyngbya aestuarii, Microcoleus sp., Oscillatoria princeps, laetevirens Phormidium, Spirulina subsalsa*) prasinophytes, cryptophytes, euglenophytes (*Eutreptiella sp.)* and silicoflagellates (*Octactis octonaria*). Although diatoms and dinoflagellates are the groups with the greatest number of species, prasinophytes and cryptophyceae are those with the most abundant phytoplankton groups in relation to the total of organisms in the water column.

Zooplankton. Zooplankton biodiversity in Canary Islands is mostly composed by copepod, followed by amphipods, siphonophores appendicularians, ostracods, pteropods and heteropods mollusks, Euphausiacea, Chaetognatha and cladocerans, among others (Hernández, 2001). Considering biomass, copepods are also the most important group (with a total proportion of 60–75 %) followed by appendicularians, cladocerans, ostracods, chaetognaths and others. It should also be noted that approximately 70% of the benthic animal species have some plank tonic larval stage, so they are temporary inhabitants of the water column (Templado *et al*., 2012).

As for the ichthyoplankton, Moyano & Hernández-León (2009) have identified a total of 156 taxa in the Gran Canaria island. The Myctophidae family (*Lampanyctus sp., Ceratoscopelus warmingii, Diaphus holti, Diogenichthys atlanticus, Hygophum benoiti*) was the most abundant (30%), followed by the Sparidae (11%), the Clupeidae (*Sardina pilchardus, Sardinella aurita*) (9%) and the Gonostomatidae (*Cyclothone braueri, Gonostoma elongatum*) (7%). The neritic and oceanic taxa contribute in similar proportions which is characteristic to an oceanic island. The most abundant neritic larvae (Sparidae) showed a relationship with the lunar cycle, partially supporting a recent hypothesis about the effect of lunar illumination on larval survival and development in subtropical waters (Bécognée *et al.*, 2006).

Nekton. As a consequence of the low productivity in Canary Islands waters, there is a reduced biomass of nekton in relation to other regions but there is a large diversity of species. The epipelagic nekton can be divided into coastal, composed by species that stay always in the same oceanic area, and oceanic, formed by species that perform oceanic migrations (tunas and some sharks), that are not exclusive from oceanic areas and that can be found in coastal areas too (MAGRAMAa, 2012). These populations exhibit strong natural fluctuations due to zooplankton annual variations and the randomness of recruitment in the water column. The most widespread are the Atlantic chub mackerel (*Scomber colias*), the sardine (*Sardina pilchardus*), the Madeiran sardinella (*Sardinella maderensis*), the horse mackerel (*Trachurus trachurus, T. picturatus*), the sand smelt (*Atherina presbyter*), the European anchovy (*Engraulis encrasicolus*) and the bogue (*Boops boops*).

The pompano (*Trachinotus ovatus*), the garfish (*Belone belone*), the leerfish (*Lichia amia*), the bluefish (*Pomatomus saltatrix*) and the barracudas *(Sphyraena* spp.) are also typical of the littoral waters (Brito*,* 1984).

Considering large pelagic, there are several species of scombroid, such as the bluefin tuna (*Thunnus thynnus*), the yellowfin tuna (*Thunnus albacares*), the albacore tuna (*Thunnus alalunga*), the bigeye tuna (*Thunnus obesus*) and the Skipjack tuna (*Katsuwonus pelamis*). Other tunas can also appear in the Islands, although, in smaller numbers. These are the bullet tuna (*Auxis* rochei), the Atlantic bonito (*Sarda sarda*), the Wahoo (*Acanthocybium solandri*) or the plain bonito *(Orcynopsis unicolor).*

The swordfish or emperor (*Xiphias gladius*), the blue and white marlins (*Makaira nigricans* and *Tetrapturus albidus*) and the atlantic sailfish (*Istiophorus albicans*), also close to the oceanic tuna species, are caught sporadically in Canarian waters. To this group also belong the Greater Amberjack (*Seriola dumerilii*) of the Carangidae family. They gather in larger or smaller banks and perform important trophic and reproductive migrations (MAGRAMAa, 2012; Templado *et al*., 2012).

There are also sharks like hammerhead sharks (*Sphyrna spp.),* blue sharks (*Prionace glauca*) and mako sharks (*Isurus oxyrinchus*). Other pelagic sharks of the *Carcharinidae* and *Lamnidae* families are also present in the archipelago waters. Other representative of the large pelagic species are the manta rays (*Mobula mobular* and *M. tarapacana*), that are frequent in the coastal and oceanic waters that surround the islands. In contrast to these large pelagic swimmers, there is also the sunfish (*Mola mola*), a slow-moving and low hydrodynamic specie. In Spanish waters, there are also about 70–80 species of pelagic cephalopods, some of which also are of great commercial interest (Templado *et al.*, 2012).

Marine mammals. In Canary Islands, there have been recorded about 27 species of cetaceans (22 mysticetes and 5 odontocetes). The most characteristic are the short-finned pilot whale (*Globicephala macrorhynchus),* the common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*), Atlantic spotted dolphin (*Stenella frontalis*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), sperm whale (*Physeter macrocephalus*) and Cuvier's beaked whale (*Ziphius cavirostris*) (MARGRAMA, 2012a).

Marine Reptiles. In Canary Islands, the reptiles group is represented by five of the eight currently recognised species of sea turtles: the loggerhead turtle (*Caretta caretta*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), green turtle (Chelonia mydas), Kemp's ridley (*Lepidochelys kempii*) and the olive ridley (*Lepidochelys olivacea)* (MARGRAMA, 2012b).

5.1.9.2 Benthic Communities

Infralitoral soft bottom seabeds. Shallow sand banks and sand seabeds permanently submerged covered or not by marine phanerogams and seaweeds, until a depth of approximately 40 m (approximated lower limit depth, characterised by the paddle grass *Halophila decipiens)*.

The most extensive soft bottom infralittoral habitat in Canary Islands is dominated by algae of the genus *Caulerpa.* This habitat is unevenly distributed regionally (MARGRAMA, 2012b). These algae grow in sandy, muddy or mixed sea beds at depths from approximately 10 m down to a maximum that depends on authors; Barquín-Diez *et al.* (2005) states that they almost disappear beyond 50 m, although they may be present up to 60 m. They can coexist with representatives of other typical communities of sandy bottoms such as the seagrass *Cymodocea nodosa, Halophila decipiens*, the *Heteroconger longissimus* or the polychaete *Bispira viola* (MARGRAMA, 2012a).

Subsequently, the most extensive habitat is the community of sand eel (*Heteroconger longissimus*) (Barquín *et al.*, 2005). The habitats dominated by these two surfaces (Shallow sand banks and sand seabeds) represent more than 65% of the extent of the sedimentary soft bottom seabed.

The most widespread habitat among the infralitoral soft bottoms are the maerl beds that are present in almost all the islands, except for Fuerteventura and La Palma. This habitat is largely protected and is included in four habitat types considered in Annex I of the EC Habitats Directive: "sandbanks which are slightly covered by seawater at all times"; "large shallow bays and inlets"; "estuaries" and the priority habitat "lagoons" (MAGRAMA, 2012a; MAGRAMA, 2012d).

Cymodocea seagrass exists in Gran Canaria and its meadows are the dominant vegetative communities in shallow soft substrates, forming extensive subtidal meadows. Most of the sebadales are located in the eastern and southern coasts of the islands, always in sheltered areas, protected from the trade winds, at depths ranging between 2 m and 35 m (Pavón-Salas *et al.,* 2000). In some locations, *Cymodocea nodosa* meadows are mixed with species of the green alga *Caulerpa* (Pavón-Salas *et al.* 2000). Seagrass meadows are considered as a habitat in decline throughout the Canarian coastal areas, and hence *Cymodocea nodosa* is legislated as an endangered species (Barberá *et al*., 2005).

By contrast, the less extensive habitats were the *Halophila* meadows and the *Bispira violates* communities, and both represent 1.4% of the seabed (MAGRAMA, 2012b). Seagrass meadows of *Halophila* occupy only 2.48 km^2 in Tenerife and La Palma, although *Halophila decipiens* is documented in Gran Canaria.

Infralitoral hard bottom seabeds. The specific composition of this ecosystem varies greatly depending on the prevailing environmental factors found on each Canary island and as a result, the existing biocenoses are different in the north, south, east or west of the islands (MAGRAMA, 2012a). In the Canary Islands, the hard substrates are more extensive than the soft ones as a consequence of the island's young geologic age, with just 20 million years (González *et al.* 1986).

The most dominant benthic community in the infralitoral hard bottom is produced by the sea urchin *Diadema aff. antillarum*, covering 68% of the areas currently mapped. In these benthic communities, plant biomass production and its extension on the substrate is affected by the grazing activity of the lime sea urchin (*Diadema aff. antillarum*) that is very abundant on the rocky hard bottoms.

Subsequently, in order of importance, there are the rocky bottoms dominated by algae. This habitat represents approximately 30% of the entire infralitoral hard substrate seabed and is present in all islands.

According to the Marine Strategy Framework Directive, currently, the major threats to the benthic communities are the fishery and other anthropogenic activities such as the deployment of artificial reefs, cables and tubes, dredging, coastal erosion, anchorages, infrastructures for ports and discharges of dredged (MARGRAMA, 2012d).

5.1.9.3 Seabirds

Canary Islands include several Important Bird Areas (IBA's) that are in their vast majority marine extensions of coastal colonies, although some are areas of concentration in the sea. These islands are characterised by a high number of reproductive species of Procellariiformes. Currently, seven species of this group use these islands for reproductive purposes and at least three other extinct species also did. For several of these colonies Canary Islands represent the only breeding site in Spain, as the Bulwer's petrel (*Bulweria bulwerii*), Manx shearwater (*Puffinus puffinus*), little shearwater (*Puffinos assimilis)*, white-faced storm petrel (*Pelagodroma marina*) and the Madeiran storm petrel (*Oceanodroma castro*). The majority of the reproductive birds feed on exclusively pelagic waters or in areas of high productivity in the African continental shelf.

All of these species are vulnerable to several threats such as the loss of habitat, introduced land mammals, artificial lights, etc. Consequently, all of them, with the only exception being the Manx Shearwater, are included in Annex I of the Birds Directive. Due to its geographical location, the Canary Islands are also crossed by numerous European species during migration (Arcos *et al.,* 2009). On the cliffs, islets and rocks of the archipelago regularly reproduce other ten species of marine birds, such as the common tern (*Sterna hirundo*), the yellow-legged gull (*Larus argentatus*), the dark gull (*Larus fuscus*), the Madeiran storm petrel (*Oceanodroma castro*), the European storm petrel (*Hydrobates pelagicus*), the white-faced storm petrel (*Pelagodroma marina*), Cory's shearwater (*Calonectris diomedea*) the little shearwater (*Puffinus assimilis*), the Manx shearwater (*Puffinus Puffinus*) and the Bulwer's petrel (*Bulweria bulwerii*) (MAGRAMAa, 2012).

The TROPOS platform is going to be installed 8 km south of an IBA and/or Special Protection Area (SPA), under the Birds Directive of the Natura 2000 Network. This IBA/ SPA (ES395 Coasts and waters of Mogán/ ES0000530 Marine Space of Mogan – La Aldea), represents a seaward extension of the land colonies of Cory's Shearwater (*Calonectris diomedea*) and Bulwer's Petrel (*Bulweria bulwerii*) that nest on the sea cliffs of the IBAs coastline. Other species of interest in this IBA are the Manx shearwater and the yellow legged gull that present several colonies on the littoral of the IBA (Arcos *et al.,* 2009).

5.1.10 SPECIAL HABITATS

5.1.10.1 Environmental Protected Areas and Species

In the Canary Islands, there are protected areas at a regional, national, European and international level. The areas included in the Canary Network of Protected Natural Areas (Red Canaria de Espacios Naturales Protegidos (RCENP)) encompass 146 total spaces of different categories. At European level, there are the Natura 2000 networks, Important Bird Areas (IBA), RAMSAR areas. It is also worth noting that 6 of the 7 Canary Islands are part of the World Network of Biosphere Reserves: La Palma, Lanzarote, El Hierro, Gran Canaria, Fuerteventura and La Gomera (Alenta, 2013).

Natura 2000 Network – Habitats Directive. The location selected for the deployment of the TROPOS platform is protected under the Habitats Directive of the Natura 2000 framework. The location is within the Special Area of Conservation (SAC) "Franja Marina of Mogán".

"Franja Marina de Mogán" is located on the south-southwest coast of Gran Canaria. It covers an area of 29,993.09 hectares and is contiguous to 35,520 meters of the shoreline of San Nicolas de Tolentino, Mogán and San Bartolomé de Tirajana. This legal protection was declared in September 2011 with the purpose of ensuring the long-time survival of the threatened natural species and habitats, contributing to stopping the loss of biodiversity caused by the adverse impact of human activities. This SAC is the most extensive in the island and is sided by two others: "IS7011005 Sebadales de Giguüi" to the north, and "ES7010056 Sebadales de Playa del Inglés" to the east.

Its extensive shallow marine shelf and sandy bottoms together with its location sheltered from the prevailing wind and sea has led to the establishment of wide-ranging seagrass meadows, commonly known as *sebadales*, and populations of green algae. The most representative marine phanerogams in Canary Islands meadows, for its abundance and ecological role is *Cymodocea nodosa* that forms meadows known of great ecological importance that provide key areas of refuge, breeding and feeding for invertebrates and fish.

In this area, large abundance and diversity of rocky substrates (volcanic rocks, pebbles and rocks laying on sandy substrate) can also be found on which typical benthic reef communities settle. The faunal richness in the area is high, with considerable biodiversity of invertebrates, particularly where there are rocky outcrops with algae coverage. Within the fish community, several species stand out such as the short snouted seahorse (*Hippocampus hippocampus*), parrotfish (*Sparisoma cretense*), seabream (*Diplodus vulgaris*) or salema (*Sarpa salpa*). This area is also an important location of feeding and seasonal rest for several species of medium and large cetaceans such as the bottlenose dolphin (*Tursiops truncatus*), the spotted dolphin (*Stenella frontalis*), common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*) and the fin whale (*Balaenoptera physalus*) among others, as well as loggerhead turtle (*Caretta caretta)* and green turtle (*Chelonia mydas*).

In "Franja Marina de Mogán", there are also different types of natural habitats of communitary importance present such as the habitat 1110: "Shallow sand banks permanently submerged", the habitat 1170: "Reefs". The habitat 1110 includes sandy banks deprived of vegetation or associated with distinct biological communities (seagrass, maerl communities, etc.), always submerged (MARGRAMA, 2012g).

Biosphere Reserves. The Gran Canaria Biosphere Reserve covers approximately a third of the island and includes several natural protected areas and monuments. The Biosphere Reserve includes a transition area established at the contact point between the core area, the buffer zones, and the sea (UNESCO, 2013). The marine protected area in Gran Canaria is located between the beach of Maspalomas and the Punta de las Tetas. The marine area of the reserve represents the marine area with the major continental platform of the island and is on the coastline of Mogán. This reserve includes the area with highest productivity in the Gran Canaria Island, presenting large communities of seagrass meadows or *sebadales,* a basic marine ecosystem in the marine food web.

5.1.11 PROTECTED SPECIES

The Law nº4/2010, BOC n º 112 of June 9, has established the Canary Island Catalogue of Protected Species and integrates the necessary criteria to adapt the Canary legislation for species protection to the national and Community legislation. The Canary Island Catalogue of Protected Species includes in article 3 categories of species, subspecies or populations of endangered biodiversity: **1)** Endangered Species (a. Species "in danger of extinction "(Annex I), (b. "vulnerable" species (Annex II); **2)** Species "of interest to the Canary islands ecosystems"(Annex III); **3)** Species of "special protection" (Annex IV).

Included in Annexes V and VI, there are also the categories of species "sensitive to habitat alteration" or species with "special interest". In Annex VII category, there species present in the Canaries Island are included which, in spite of being protected by Community legislation or international agreements, are not included in the Canary Island Catalogue of Protected Species.

The Canary Island Catalogue of Protected Species only include 4 "endangered" marine species (Annex I), 8 "vulnerable" species, such as the red algae (*Alsidium corallinum*) and the marine sponge (*Neophrissospongia nolitangere*) (Annex II) and 36 species "of interest to Canary Islands ecosystems" (Annex III), such as the brown macroalgae (*Cystoseira abies-marina*). The marine species are included in Appendix I, II, III, IV, V and VI.

Tursiops truncatus (bottlenose dolphin) and *Caretta caretta* (loggerhead seaturtle) are the only two species protected by the Habitats Directive that were included in the Canarian document for species protection. This is the case of "Franja Marina de Mogán" where the TROPOS platform will be located.

5.1.12 INTRODUCED MARINE SPECIES

The existence of large ports, open to intense international traffic, such as the Puerto de la Luz in Las Palmas de Gran Canaria that is a traditional port of call and supply on the Middle Atlantic, represents an important potential route of entry of invasive species. Its geographic location in the transition zone between temperate and tropical climate, may also favour the settlement of species characteristic from both areas (MARGRAMA, 2012a).

In the context of the Marine Strategy Framework Directive, a study was performed that enabled the collection of 257 specific quotations about 59 alien species in the Canary Islands. It is important to notice that in this region, many species cannot safely be classified as alien due to the lack of previous studies as reference, so that the percentage of cryptogenic species in taxonomic listings Canaria is very high. Of the 59 species recorded, which can safely be considered alien, 30 have accredited invasive potential in other areas, but this does not mean that its impact on the region has been quantified and whether the impact on the ecosystem really deserves to be called negative. In fact, only 8 species have concrete data in the region. These are the algae *Asparagopsis armata, A. taxiformis, Caulerpa racemosa, Codium fragile, Grateloupia turuturu, Undaria pinnatifida, Stypopodium schimperi* and *Womersleyella setacea*; the amphipod *Caprella scaura*, the ascidia *Microcosmus squamiger* and the parasite *Sphaerospora testicularis*. Except for the parasite *Sphaerospora testicularis* knowledge on the impact of invasive species in this area is extremely scarce, and most studies are limited to spatial and temporal distribution of invasive species (MAGRAMA 2012c, 2012).

5.1.13 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

5.1.13.1 Tourism

The main economic sector in Canary Islands is tourism that represents 29.5% of the archipelago GDP, creating 262,823 jobs in 2011. More specifically, in 2011, Gran Canaria has received 2,913,431 tourist arrivals. The beaches are one of its main touristic attractions and Gran Canaria has 134 beaches, according to MARGRAMA data.

5.1.13.1 Ports

Gran Canaria includes an airport and port installations. The most important ports are the port of la Luz in Las Palmas, the larger city in Gran Canaria and the port of Ariaga, although there are other harbours of minor importance. Close to the deployment area, there exist small harbours and marinas as the La playa de Arguenin harbour, El Pajaro harbour, Puerto Rico harbour and the Pasto blanco harbour.

5.1.13.1 Fishing Fleet

Canary Islands fishing fleet can be grouped in two major categories according to its extraction capability, technical level and operational range: the industrial fleet and the artisanal fleet. In general, the artisanal fishing fleet shows a highly seasonal pattern, related to the biological cycle of the different target species and with the arrival of different species of tunas, particularly the skipjack tuna or oceanic bonito (*Katsuwonus pelamis).*

Recreational fishing in the whole archipelago is very heterogeneous, increasing in the islands with higher population and attraction, and may surpass professional fishing. It has also experienced a considerable increase in the Canaries.

5.1.13.1 Aquaculture

Canary marine aquaculture production peaked in 2009 with 8,200.4 ton, 3.2% of the total Spanish production. That same year, 45% of the production was destined for the domestic canary market, while 47% was sent to the Spanish mainland market and 6.6% was sold in European Union countries or other third world countries. Still, it is estimated that the contribution to the regional GDP of aquaculture was 3.3 times lower than fishing.

Most active farms are located in Gran Canaria, in the coastal strip of Melenara, Sandy Vargas and Castillo del Romeral, manufacturing 60% of the total produced in the entire archipelago.

Among the most important species for aquaculture in Canaries are the bream (*Sparus aurata*) and the sea bass (*Dicentrarchus labrax*), with and authorised production of 14,400 tonne, the second biggest production potential in Spain in 2011.

5.1.13.1 Energetic Installations

As for the energy production system, Gran Canaria has two power plants, one in Jinámar (Las Palmas de Gran Canaria) with 416 MW, and another in Barranco de Tirajana with 235 MW. In the latter location, there is also a combined cycle which the power is of 465 MW.

There are also two wind power plants in Gran Canaria, one in the vicinity of the Matorral (Santa Lucia) and another in the Carrizal (Ingenio).

5.1.13.1 Marine Traffic

The maritime traffic in Canary Islands is composed by mostly intra-insular movements between the islands and the peninsula. Additionally, the Canary Islands are located in the route of international traffic of boats between Europe and South Africa and between Europe and occidental Africa and the extreme south of Africa.

5.1.13.1 Cultural, archaeological and subaquatic patrimony

It is important to mention the existence of archaeological sites on the coastal perimeter of all the islands. However, as part of studies conducted within the Campaña Ambiental del Estudio de Fondo Marino, it was concluded that there is no underwater archaeological elements that can be affected (Tecnoambiente, 2013).

5.2 CRETE

The site selected for the TROPOS platform at Crete is on the north side of the island, in the Cretan Sea and the Southern Aegean sea. The map in Figure 5-2 shows the location. The area proposed is an approximately 20 km by 20 km rectangle.

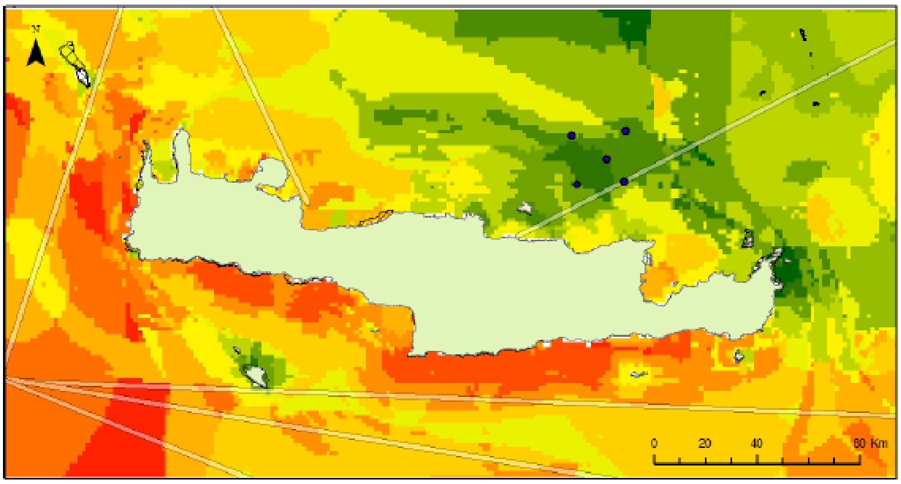


Figure 5-2: TROPOS site location north of Crete (square denoted by black dots) (source: D2.4, p 22)

5.2.1 PHYSICAL ENVIRONMENT

The Cretan Sea is bounded to the north by the Kikladhes Plateau at a depth of 400 m and to the south by the Cretan Arc islands. It attaches the Ionian and the Levantine Seas through a series of six Straits, namely the Cretan Arc Straits. Crete is the largest island in Greece and the second biggest of the east Mediterranean (after Cyprus). It lies at the southern Aegean Sea and at the crossroads of three continents, Europe, Asia and Africa. The length of the island is 260 km, the shore-length is 1,046 km. The largest width is 60 km while the smallest is 12 km. Heraklion (Iraklion) is the largest city in Crete.

5.2.2 CLIMATE AND ATMOSPHERE

The air can be quite humid, depending on the proximity to the sea. The winter is fairly mild and tolerable. Snow fall is practically rare in the plains, but quite frequent in the mountains. During summer, average temperature is between 20 ^{o}C to over 30 ^{o}C. "Bad weather" periods in winter are often interrupted, during January and the first fortnight of February, with sunny days. The climate in Crete is typically Mediterranean. There are two main seasons: a dry, hot summer (May– October) and a damp, rainy winter (November–April). The temperature along the south shores is high in the summer, while the "meltemia" (prevailing north strong winds) make the northern shores pleasantly cool from mid-June to the beginning of September.

5.2.3 OCEANOGRAPHIC CONDITIONS

Three main water masses occur in the eastern Mediterranean Basin: the Modified Atlantic Water (MAW), the Levantine Intermediate Water (LIW) and the Eastern Mediterranean Deep Water (EMDW). In addition to these water masses, in its northeastern sector the Aegean receives a considerable input of less saline waters (24.0–35.0 psu) of Black Sea (BSW) origin through the Straits of Dardanelles. Winter surface temperatures are in the range of 13–16^{o}C at the TROPOS site. Over 25^{o}C can be reached in summer, while deep water temperatures remain 10^{o}C or cooler, all year-round. During the warm season of the year, the warm, saline Levantine Surface Waters (LSW) can be detected in most of the regions of the eastern Mediterranean, developing particularly high salinity (39.5) by the end of summer, especially in the Rhodes area.
The site is exposed to wind and waves generated by the different local wind regimes with westerly winds being the dominant ones. Northerly winds are more common in summer. North–easterly winds also occur as a result of low pressure in the eastern Mediterranean. Although summer and winter climatology are quite different, severe sea conditions near shore may occur at any season. Wave directions at the TROPOS site are predominantly northwest to northeast. Regarding sea currents it seems that currents from west dominate at the TROPOS site, with typical speed in the range 16–22 cm/s.

5.2.4 BATHYMETRY AND SEABED FEATURES

The Cretan Sea constitutes the larger and deepest basin of the south Aegean with an average depth of 1,000 m and contains two depressions in the eastern part reaching 2,500 m. To the northwest the Myrtoan basin, between the Myrtoan and Cretan Sea depths are of the order of 600 m. The Cretan Sea is bounded to the north by the Kikladhes Plateau at a depth of 400 m and to the south by the Cretan Arc islands. It is connected to the Ionian and the Levantine Seas through a series of six Straits, namely the Cretan Arc Straits. These are characterised by high relief and have sill depths ranging from 150 m to 1000 m. Outside the Straits the sea bed plunges towards the deep basins of the Hellenic Trench.

5.2.5 SEDIMENT QUALITY

In the particular area of interest and towards the North coast the general characteristics of the seabed are summarised below.

- In the deep: clay
- Intermediate depths: sand
- Shore: rocky seamount.

5.2.6 WATER QUALITY

In the Mediterranean Sea, unlike in other ocean basins, phosphates, as opposed to nitrates, are considered to be the factor limiting phytoplankton growth. In the Cretan Sea the N/P (nitrogen/phosphorous) ratio is around 27. Nitrate shows a seasonal variation, with highest concentrations in the surface layer in autumn and winter. Values of Total dissolved inorganic Nitrogen (DIN) are generally low north of Crete, illustrating the oligotrophic character of the waters in general, in the eastern Mediterranean.

5.2.7 NATURAL HAZARDS

Many historical documents mention large earthquakes in or around Crete in ancient times. There have been no earthquakes causing major damage, death or serious injury for over 50 years or more in Crete. The most recent strong earthquake had a 6.4 on the Richter magnitude scale and occurred on 12 October 2013. The epicentre was 37 km off the city of Chania in western Crete. The epicentre was 40 km below the seabed. There were no reports of casualties or major damage. Tremors were felt as far away as Athens, the Greek capital 290 km away, and across southern Greece. A Crete earthquake occurred on 1 April 2011 and registered as 6.2 on the Richter scale with effects being felt clearly in Rethymnon.

5.2.8 NOISE CONDITIONS

We have not come across any particular information on natural noise level on the TROPOS site. Except for infrequent earthquakes, the noise level is expected to be normal, and consists of the prevailing wind, wave and rainfall pattern. Man-made noise will come from various sources such as ship traffic, seismic exploration activity, echo sounding and military sonars. The level of noise at the site from these sources is assumed to be low as it was carefully selected to avoid certain routes, e.g. ship traffic.

5.2.9 ECOSYSTEMS, HABITATS, AND SPECIES COMPOSITION

5.2.9.1 Pelagic Communities

Phytoplankton. The Mediterranean Sea, and particularly the eastern Basin, is considered as one of the least productive sea regions in the world, in terms of both primary productivity and chlorophyll a concentrations. This is mainly due to phosphorous deficiency. The Cretan Sea (South Aegean Sea) has low annual productivity (30–80 g $C*m^{-2}*year^{-1}$) with the maximum rates between late winter and early spring. The picoplankton fraction predominates and accounts for about 50% of total chlorophyll a and ca 44% of total primary production in the south Aegean Sea.

Zooplankton. A study in the southeastern Aegean Seas in 1986 showed a total of 19 taxonomic groups. They observed a decrease in the number of taxonomic groups with increasing depth, especially below 500 m. Copepods were by far the most dominant component of the samples; there were a total of 110 copepod species identified. Mesozooplankton distribution showed the lowest value of zooplankton abundances in the Cretan Sea.

Nekton. 519 fish species are considered to be native in the Mediterranean. Osteichthyes have shown to be an abundant demersal class. The majority of species are shallow living (i.e. from 50 m to 200 m). Only five osteichthyes have distributions restricted to the upper part of the continental slope. Species seem to be well represented at all depths with coastal species like *Dasyatis pastinaca*, and *Myliobatis aquila*; the Rajidae species are found from 50–500 m depth, *Scyliorhynus canicula* and *Torpedo marmorata* at mid-depths (300–500 m); and the remaining species at larger depths (500– 1000 m).

There are 28 commercially important fish species occurring in Greece. Tuna, and tuna-like species, are very importantas they are a significant source of food.

Marine mammals. A study from 2003 showed that twelve cetacean species were identified from a total of 821 sightings and 715 stranded animals in the Greek Seas (Frantzis 2003). The following species were sighted/found stranded off the northeastern coast of Crete, and west of the Karpathos: Striped dolphin (*Stenella coeruleoalba*), Bottlenose dolphin (*Tursiops truncatus*), Cuvier's beaked whale (*Ziphius cavirostris*), Sperm whale (*Physeter macrocephalus*) and Fin whale (*Balaenoptera physalus*).

Monk seals and turtles.The Mediterranean monk seal (*Monachus monachus*) is the most endangered pinniped species in the world, with an estimated total population size of 350– 450 animals, with 250–300 out of them living in the eastern Mediterranean within the largest subpopulation, out of which about 150–200 are in Greece and about 100 in Turkey. In the IUCN Red List of Threatened Species, the species is listed as "Critically Endangered". Today, the distribution is widespread, but fragmented into an unknown but probably relatively large number of very small breeding subpopulations. In the Mediterranean, the stronghold for the species is on islands in the Ionian and Aegean Seas, and along the coasts of Greece and western Turkey.

The Mediterranean region is an important breeding area for two marine turtle species such as the loggerhead turtle (*Caretta caretta*), with main nesting concentrations found in Greece, Turkey, Cyprus and the Libyan Arab Jamahiriya. IUCN Red List Status lists it as endangered. The green turtle's (*Chelonia mydas*) main nesting concentrations are found in Cyprus and Turkey. IUCN also list it as endangered. Another species distributed across the whole region is the leatherback (*Dermochelys coriacea*), although regular reproduction has not been observed. Some other turtle species, such as the hawksbill (*Eretmochelys imbricata*) and Kemp's ridley (*Lepidochelys kempii*) have also been observed occasionally. Nesting areas for loggerhead sea turtles have been found on the island of Crete, e.g. near Hania (northern coast of Crete).

Cephalopods constitute increasingly important resources for human consumption and a principal food for many top predators. An analysis of cephalopods data from the south Aegean Sea, identified 34 species of cephalopods (including 11 oegopsid squid, 3 myopsid squid, 7 octopod, 3 cuttlefish and 10 sepiolid) (Lefkaditou 2003). A total of 25 species have been known from the southern Aegean Sea.

12 species of deep sea molluscs cephalopods (between 40–1,570 m depth) have been identified in the Cretan Sea. The neon flying squid (*Ommastrephes bartramii*) has been recorded along the eastern Aegean and the periphery of the Cretan Sea.

5.2.9.2 Benthic Communities

The variability of benthic communities along the continental margins is mostly related to depth, which however may reflect changes in food supply, sediment characteristics or other factors. In the Mediterranean the continental shelf is very narrow and therefore the largest part of this enclosed sea is classified as deep sea. The Cretan continental shelf is rather large in comparison to most Mediterranean islands.

Mollusca. A total of 1,160 mollusc species (1 Solenogastra, 2 Caudofoveata, 771 Gastropoda, 308 Bivalvia, 19 Polyplacophora, 12 Scaphopoda and 47 Cephalopoda) have been recorded in the Hellenic Seas. A total of 27 of these species (17 bivalves, 4 gastropods and 6 cephalopods), comprising less than 2,5% of the molluscan fauna of the Hellenic Seas, are of commercial interest, particularly in fisheries and aquaculture since they are collected and/or cultivated for human consumption (Katsanevakis et al. 2008). A review of species with minor commercial interest identified 18 gastropod and 13 bivalve species in the Hellenic Seas (Katsenevakis 2008).

A study of macrofauna on the continental shelf (at 40–190 m depths) of Crete in 1988 identified 89 mollusc species; the most dominant species/taxa in the samples were: *Acinulus croulinensis*, *Axinulus crulinensis*, *Bathyarca grenophia, Caudofoveata*, *Kelia* sp., *Thyasira flexuosa* and *Turitella communis*.

The deep sea molluscan fauna of the southern part of the Cretan Sea was investigated in 1994–1995. Samples were taken between 40–1,570 m depths. They identified 147 mollusc species belonging to 6 different mollusc classes: Bivalvia (63 species) and Gastropoda (60 species) predominate in the collected molluscan fauna; Cephalopoda (12 species) and Scaphopoda (8 species) were the next most numerous taxa; Polyplacophora and Caudofoveata were represented by 2 species each.

The dominant species of the continental shelf assemblages (0–200 m) were the gastropods *Turritella* *communis*, *Aporrhais pespelecani* and the bivalve *Thyasira flexuosa*; the dominant species of the intermediate deep assemblages (200–500 m, upper bathyal slope) were the gastropod *Aporrhais serresianus* and the bivalve *Kelliella abyssicola*. Out of the 42 deep sea species (recorded also at depths below 500 m – lower bathyal slope) only 13 species, namely the gastropods *Propilidium pertenue*, *Danilia otaviana*, *Putzeysia wiseri*, *Benthomangelia macra*, *Mangelia nuperrima*, *Pleurotamella eurybrocha*, *Pyramidella octaviana*; the bivalves *Propeamussium fenestratum*, *Delectopecten vitreus*, *Cyclopecten hoskynsii*, *Notolimea crassa*, *Tbracia convexa*; and the scaphopod *Pulsellum lofotense* were confined to the deeper part (Koutsoubas et al. 2000).

Polychaeta. Many polychaete species have been identified on the shelf of Crete (at 40– 190 m depths). The most dominant species in the samples were *Filogranula stellata*, *Galathowenia oculata*, *Levinsenia gracilis*, *Lumberineris graacilis*, *Magelona minuta*, *Melinna palmata*, *Paradioptra* sp., *Pholoides dorsipapillatus*, *Prionospio steenstrupi*, *Serpula* sp. and *Tharyx heterochaeta*.

Other benthic organisms. Among macrofauna, on the continental shelf, 12 sipunculid, 23 echinoderm and 165 crustacean species were identified. The most dominant group was the sipunculids, and the most dominant species were *Aspidosiphon muelleri*, *Golfingia* sp. 2, *Onchnesoma steenstrupi* and *Phascolion strombi*.

Sponges. Commercial sponges are a natural resource for most of the Mediterranean countries. The honeycomb, Greek bathing sponge and Turkey cap have been found at stations on the northeastern coast of Crete (Sitia) (sampling depths between 12– 38 m).

Seagrasses\Macroalgae. Seagrass ecosystems are among the most productive and economically valuable on Earth, and are found along the coasts of every continent except Antarctica. Amongst the species, *Posidonia oceanica*, a species endemic to the Mediterranean, plays a key role, often compared to that of the forests. The *Posidonia* meadows provide important ecological functions and services and harbour a highly diverse community, with some species of economic interest. In the Aegean Sea, seagrasses are known to occupy an important area, but only a few sites have actually been mapped, e.g. Gulf of Geras, Lesvos Island, Saronikos Gulf, Gulf of Thermaikos and Palaeochori Bay. *Posidonia* beds also occur to the west of Sidero Peninsula on the northeastern end of Crete. Common bottle-nosed dolphins and Mediterranean monk seals have been recorded in the area.

An updated checklist of the brown (Phaeophyceae), and green (Ulvophyceae) seaweeds of Greece, identified 90 taxa Phaeophycea and 80 taxa Ulvophycea in the south Aegean Sea.

Seabirds. There are about 359 species of birds in Crete, of which 11 are globally endangered and 2 are reintroduced. Although costal and marine habitat variety in Greece is high, seabird abundance and diversity is generally lower than expected. Of the 334 species of seabirds occurring worldwide, 39 have been recorded here, of which only 12 breed, some occurring on the edge of their breeding range. Of the 39 seabirds recorded in Greece, 20 are present on the Crete bird checklist. There are many different bird migration patterns in the Aegean Sea. Migration is a perilous journey and involves a wide range of threats. Only a small number of birds are actually threatened by natural events. Human activities are the source for the most dangers migrating birds are exposed to, e.g. fisheries by-catch, illegal hunting, human disturbance (e.g. power lines, wind turbines), light and noise pollution and habitat destruction.

5.2.10 SPECIAL HABITATS

5.2.10.1 Environmental Protected Areas and Species

Hellenic Society for the Study and Protection of the Mediterranean monk seal (MOm) proposed a list of sensitive areas to be included in the National Contingency plan against oil spills in view of the presence of Mediterranean monk seals. Among them was the Dionisades islets north off the bay of Sitia and Dia Island in Crete. The island complex of Karpahtos and Kasos is one of the main breeding areas, for the Mediterranean monk seal, in Greece, and the most important in the Dodecanese.

Seabirds – endangered species. According to the Greek Red Data Book the red-breasted merganser (*Mergus merganser*) is classified as "critically endangered", the Mediterranean gull (*Larus melanocephalus*), and black tern (*Chlidonias niger*) as "endangered", while the Audouin's gull (*Larus audouinii*), slender-billed gull (*Larus genei*), gull-billed tern (*Sterna niloctica*) and sandwich tern (*Sterna sanvicensis*) as "vulnerable", and the

European shag (*Phalacrocarax aristotelis*), Cory's shearwater (*Calonectris diomedea*) and little tern (*Sternula albifrons*) as "near threatened".

On an international level in the IUCN Red Data List (IUCN 2012), the velvet scoter (*Melanitta fusca*) is classified as "endangered", the Yelkouan shearwater (*Puffinus yelkouan*) and long-tailed duck (*Clangula hyemalis*) are classified as "vulnerable", and the Audouin's gull as "near threatened".

Important bird areas (IBAs) are priority sites for the conservation of biodiversity and especially birds, often irreplaceable or vulnerable, as they may host on a regular basis significant populations of one or more endangered, endemic or congregatory species.

Ichthyofauna – endangered species. Of the 519 native marine fish species and subspecies assessed in the Mediterranean Sea, 43 species (approximately 8%) were regionally classified in threatened categories ("critically endangered", "endangered" or "vulnerable") (Figure 27). Of the 15 species (3%) listed as "critically endangered", the highest threat category, 14 (93%) are sharks and rays. Thirteen species (2.5%) are listed as "endangered", 9 being sharks and rays, while 15 species (3%) are listed as "vulnerable", with roughly equal numbers of sharks (8 species) and bony fish (7 species). An additional 22 species (4%), including 10 sharks and rays, were listed as "near threatened" (Abdul Malak et al. 2011).

5.2.11 INTRODUCED MARINE SPECIES

A catalogue of exotic species in the Mediterranean (a survey of recent marine "immigrants" in the Mediterranean, which is undergoing drastic and rapid changes to its biota) lists a total of 146 species of exotic fish in the Mediterranean Sea. In Greece there are 47 introduced fish species. A list of the 100 'worst invasive' alien species in the Mediterranean, lists 19 species of fish. Of those 19 species, 13 have been recorded in Greece.

5.3 LIUQIU ISLAND

5.3.1 OVERVIEW

In this section, each of the factors that require consideration in any site selection decision for a TROPOS platform design will be introduced. A number of parameters will be relevant to any combination of TEAL components, such as bathymetry and sea-bed geology. For each TEAL component, there will be a range of more specifically relevant parameters to be analysed. These will be presented in terms of their relative importance in a site-selection decision. Where the information on these parameters is available, it is shown here for each of the target regions. Figure 5.3 shows the case study site – Liuqiu Island, Taiwan.

Figure 5-4: Liuqiu Island

Figure 5-3: Location of Liuqiu island southwest off Taiwan

5.3.2 PHYSICAL ENVIRONMENT

Situated south of the mouth of Kaoping River, Liuqiu (Fig. 5-4) is governed by Pingtung County, and about 18 nautical miles (about 33 km) south-southwest of Kaohsiung City, the second large city of Taiwan. Liuqiu is made of coral and covered with limestone, and the coral substances can be easily found in the island. The coral with limestone on Liuqiu is similar to that of Fengsan. The soil on the four terraces of the island looks red due to plenty of the remains of iron oxide and silicon oxide after being weathered for a long period of time. Therefore, the land is dry and infertile and not suitable for planting.

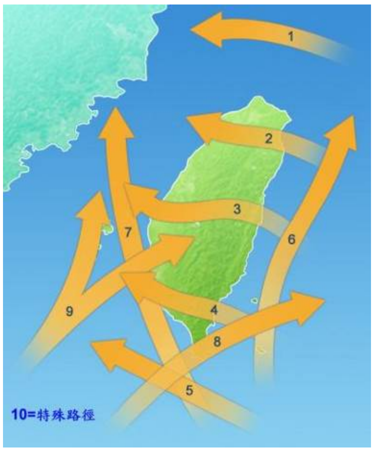


Figure 5-5: Major typhoon pathways around Taiwan (source: Central Weather Bureau)

As most of the islanders make their living by fishing, Liuqiu is characterised by various goods of local fish specialties and a lifestyle of fishing village. The ground inclines gently towards northeast. The area of the whole island is about 6.8 square kilometers with 4 kilometers long from north to south, and 2 kilometers wide from east to west.

Liuqiu's climate is dry and warm. Its highest average temperature is 28.4°C in July and lowest average temperature is 19.5°C in January. The rainfall is about 1,000 mm (2012 data). The maximum monthly rainfall is 548 mm in August and the minimum average monthly rainfall is 0 mm in January. In typhoon season during summer and fall, Liuqiu undergoes the highest frequency of being hit by typhoons in all of Taiwan's islands. Therefore, the islander takes the threat of typhoon, such as strong winds and huge waves, into consideration before constructing buildings and facilities.

5.3.3 NATURAL HAZARDS

The Seismological Bulletin, Taiwan summarised the information of earthquakes quarterly observed by the CWBSN24. 9,453 earthquakes were recorded in the entire area (July–September 2013). The earthquake monitoring station in Liuqiu island recorded about 44 earthquakes, and only two earthquakes could be classified as the intensity scales. The result represented that the impact from earthquake is related low in Liuqiu island.

In 2012, Liuqiu island received heavy rain because typhoon passed through route 9. According to the record from 2001 to 2013, there are 85 typhoon alerts, which include 7 typhoons through path 9 (see Fig. 5-5). The probability of typhoon hitting the Liuqiu island in the past 10 years is about 14.12%.

5.3.4 NOISE CONDITIONS

In spring and summer, the noise peak of average is 5 dB to 10 dB higher than autumn around Liuqiu island offshore area (Wei et al., 2008). Figure 5-6 shows the average noise per hour: the average peak of noise can reached to 500 Hz in spring and summer. Compare to other season, that value was 7 dB to 10 dB higher.

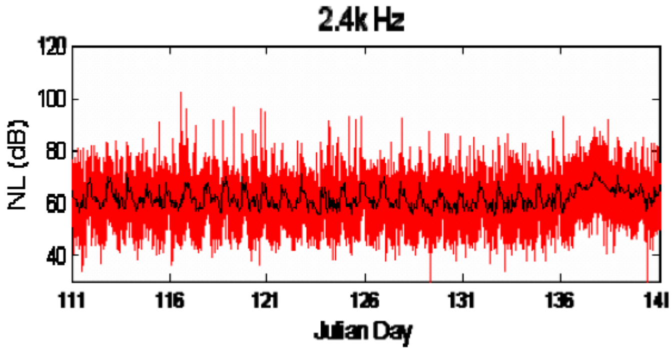


Figure 5-6: Noise average of each hour in Liuqiu island (Wei et al., 2008)

5.3.5 ECOSYSTEMS, HABITATS AND SPECIES COMPOSITION

This section will describe ecology, communities, relative protected areas, important habitats, and will analyse existing distribution and conservation status of the species. It can be as a follow-up EIA assessment of the platform reference information in Liuqiu Island.

Due to the fact that the major part of Liuqiu island catches are transactions in Donggang fish market, this section adopted statistical data of adjacent field Donggang. Statistics from the trading volume of economic transactions shows that major species around Liuqiu island are blue marlin (*Makaira nigricans*), yellowfin tuna (*Thunnus albacares*), common dolphinfish (*Coryphaena hippurus*), swordfish (*Xiphias gladius*) and the Sakura shrimp (*Sergia lucens*) (Fig. 5-7).

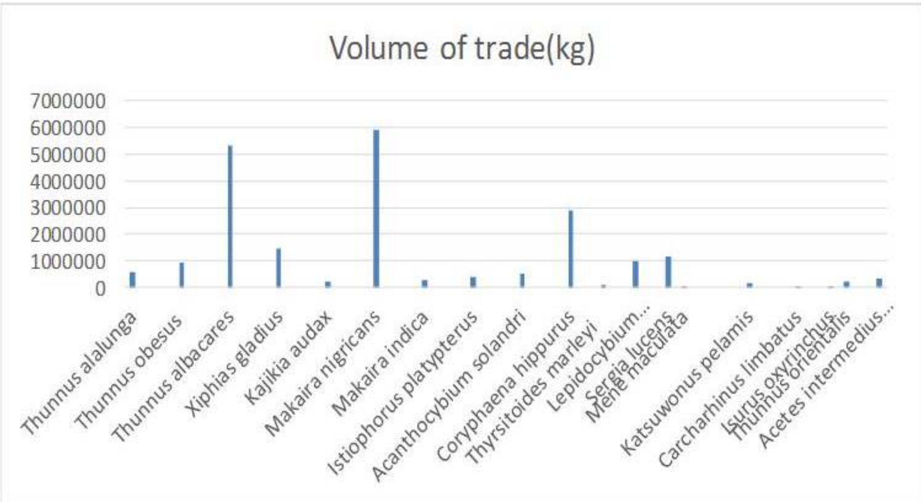


Figure 5-7: Volume of fish trade in Donggang Market (source: Fisheries Agency, 2012)

Fewer marine mammal species are found surrounding Liuqiu waters. The major cetacean group is Delphinidae which is distributed in the deep water around Liuqiu (Taiwan Cetacean Society, 2008). Furthermore, there are several critical bird species in this area. Most of these species are non-migratory birds and only 9 species are migratory species. The major protected species are all migratory species, including Chinese sparrowhawk

(*Accipiter soloensis*), little tern (*Sterna albifrons*), black-naped tern (*Sterna sumatrana*), brown shrike (*Lanius cristatus*).

In addition to fish and birds, another important migratory animal is green turtles (*Chelonia mydas*) in Liuqiu island. Green Turtle is an endangered species of marine reptiles and has been listed as one of the highest level of conservation species in Taiwan. Liuqiu island is one of the few coral islands in Taiwan; there is a place there that green turtles come ashore to lay eggs from May to October each year. About 90% of the coastal area around Liuqiu island is composed by coral reefs and rest is sandy beach. From 2011 to 2012, about 20 to 30 nest eggs have been found in the beach of Liuqiu island. The average female turtle has 4 to 8 nests which contain 81 to 100 eggs per nest. The spawning locations are throughout beaches in the islands (Pingtung County Governmnent, 2014).

5.3.6 ENVIRONMENTAL PROTECTED AREAS AND SPECIES

To address the overuse of fisheries resource, launching of artificial reefs has been used worldwide for rebuilding fishing grounds and enhancement of their environment. Artificial reefs can be diverted to multifunctional developments as angling sites and marine tourism attractions. Also, artificial reefs launched in reef protection zones form a barrier along the coast to protect fisheries' resources from illegal trawl fishing and thus safeguarding the environment of coastal habitats (Fisheries Agency, 2009). Liuqiu island has built five artificial reefs and those surrounding areas are announced as no-fishing marine protected area by Fisheries Agency. Pingtung County Government has established "Liuqiu Fisheries Resource Conservation Area" in 2000 and announced that harvesting abalone, lobster, seaweed and agar is strictly prohibited 200 meters seaward from the low tide (Fig. 5-8).

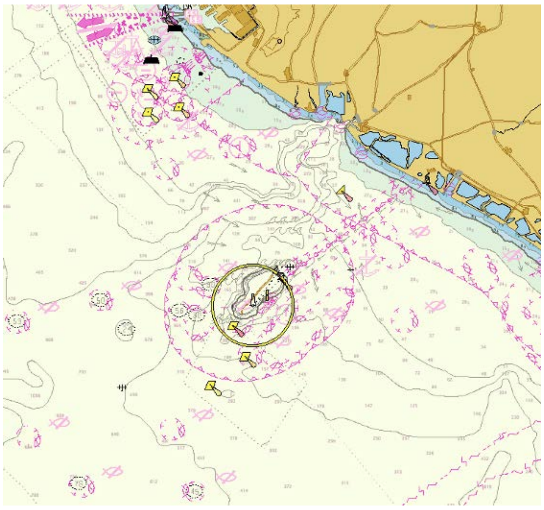


Figure 5-8: Protected areas around Liuqiu Island

5.3.7 KEY FAUNA SPECIES

Table 5-1 shows the protection level of major fish species, sea birds, crustacean, marine mammals and reptiles of Liuqiu island based on IUCN Red List. The related laws in Taiwan are also listed in the table. In fish species, *Thunnus obesus* is the Vulnerable (VU) species. Amongst sea birds, there are several species listed as Least Concern (LC) in the IUCN list, and as level II to III protection respectively in the Wildlife Protection Act, Taiwan. *Chelonia mydas* is listed in the highest level of protection based on IUCN and Taiwan laws, which is known as Endangered Species.

Table 5-1: Liuqiu Island fauna species with special protection status in IUCN and Taiwanese Law

Scientific name	Protection level	
Fish fauna	IUCN Red List[1]	Wildlife Conservation Act of Taiwan[2]
Thunnus alalunga	NT	No regulation
Thunnus obesus	VU	No regulation
Thunnus albacares	NT	No regulation
Xiphias gladius	LC	No regulation
Carcharhinus limbatus	NT	No regulation
Isurus oxyrinchus	VU	No regulation
Sea birds		
Accipiter soloensis	LC	II
Sterna albifrons	LC	II
Sterna sumatrana	LC	II
Lanius cristatus	LC	III
Crustacean		
Birgus latro	DD	I
Marine mammals		
Stenella coeruleoalba	LC	II
Orcinus orca	DD	II
Pseudorca crassidens	DD	II
Feresa attenuata	DD	II
Peponocephala electra	LC	II
Reptiles		
Chelonia mydas	EN	I

Source: Search and re-arrangement from Biodiversity Research Center B, 2014.

[1]LC: Least Concern; NT: Near Threatened; VU: Vulnerable; EN: Endangered; CR: Critically Endangered; EW: Extinct in the Wild; EX: Extinct

[2] I: Endangered Species；II: Rare and Valuable Species；III: Other Conservation - Deserving Wildlife

5.3.8 INTRODUCED MARINE SPECIES

In Liuqiu island, there are 109 introduced species, of which 30 species are invasive species. The white lead tree, *Leucaena leucocephala*, is one of the most serious invasion species among all. Among marine species, only *Saron marmoratus* is recorded as introduced species which is used as aquarium species frequently.

5.3.9 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

Liuqiu island is known as one of the major tourism sites in south of Taiwan (Fig. 5-9). The island is famous for its limestone rocks, caves, marine resources and endless sea views. Most visitors take a long day-trip from Kaohsiung or stay overnight. There are plenty of hotels, restaurants and a seaside camping in the area. The number of tourists has grown significantly in the past few years.

The major marine transport is a ferry from Donggang Port to Liuqiu island. There are two types of ferries in Donggang Port. Privately operated ferries usually arrive to Baisha Port and the distance is about 8 nautical miles (about 15 km). Publicly operated ferries usually arrive to Dafa Port and the distance is about 8.9 nautical miles (approximately 16.6 km).

Baisha Port, which is situated near the beautiful ChungAu beach, is the main port for tourists to get in or out of Liuqiu. Visitor Information Center at the port provides tourists with ferry service as well as with tour boat and glass bottom boat services. In addition, Baisa Port is the best place to enjoy a fascinating night view in summer. Dafu Port is situated southeast of Liuqiu. As the main docking area for many deep-sea fishing boats, Dafu Port has a typical feature of fishery industry. A publicly operated ferry has 10 departures daily between Dafu Port and the main island. There are several attractions of Liuqiu Island (see Fig. 5-10); the description of them follows below.

Tidal area is one of the major attractions for watching fish around coral reefs, sea cucumbers, sea urchins, starfish, hermit crabs and various fiddler crabs. The best places to observe the tidal areas of Liuqiu are Duozaiping, which is located between Camping Area and Sanfu Ecological Path. Swimming, snorkeling, boating, diving, etc. are the popular water activities in the island. Baishawei, located on the southeastern shore of the island, has clear water and is suitable for exploring the underwater environment by glass bottom boat. Distinctive rocks, caves compose unique landscape, and attract visitors. Vase Rock is one of the most famous tourist attractions, and is often the first destination for visitors. It was formed by the rising of the coastal coral reefs.

Fishing is the major business in Liuqiu island and faith is very important to the local fishermen. Therefore, there are the religious places and temples in the island. Biyun Temple is one of the famous temples, which situated on the top of the hill at Daliaozhuang between Shangfu Village and Dafu Village. As it is said that Buddha of the Biyun Temple would satisfy people's praying, the temple attracts many worshippers.

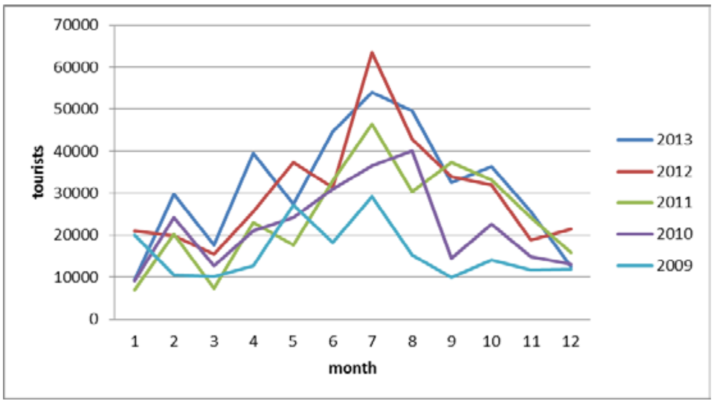


Figure 5-9: Monthly number of tourists in Liuqiu island in 2009 to 2013

Figure 5-10: Tourist attractions in the Liuqiu Island (image reference: http://liuqiu.pthg.gov.tw/)

Every year, the warm Black Tide becomes divided up into two currents flowing along both sides of the island. In addition, the water around the island is clean. Therefore, it is very suitable for net-cage fish farming. For years, the islanders have been keeping grouper, cobia and greater amberjack with net-cage fish farming and exporting harvests to Japan. Since it is different from the traditional fish farming, the fish farm becomes a big tourist attraction on the island.

In Liuqiu island, all water and electricity supply is transmitted from the main island of Taiwan. There are six submarine cables between the main island of Taiwan and Liuqiu island, including water pipes, electricity wires and optical fiber.

6 IMPACT ASSESSMENT

6.1 SCOPE

This chapter deals with the assessment of potential environmental impacts resulting from the TROPOS platforms and associated activities, and the methodology used to carry out this assessment. Impacts that may arise during any of the phases of the project, the construction, operational and decommissioning phases, are considered. As the TROPOS scenarios, so far, are still in a design stage, and since there are no similar existing multi-use offshore installations that can be used as an example, the approach used to assess the environmental impact of the TROPOS scenarios is based on state-of-the-art knowledge and experience, using the knowledge gathered from different single-use platforms or comparable installations if possible. Anyway, this Environmental impact assessment (EIA) will provide the guideline for future real EIAs when the platforms are going to be built. The first step towards impact assessment was the definition of the scope (so-called *scoping*) based on an extensive literature survey. This part was completed in deliverable D6.1. Though socio-economic aspects are usually part of EIAs, they are not particularly considered here as they are discussed in other deliverables, mainly of D6.4. Here, the focus is on the environmental aspects.

The base for this EIA is (i) platform design specifications, as provided in deliverables of WP3 and WP4, and (ii) the detailed description of the environments where the platforms are supposed to be built (see chapter 5 above). These two variables are essential to evaluate potential impacts of the TROPOS scenarios (see chapter 4 above). The EIA methodology used here firstly involved the identification and definition of potential "stressors" and "receptors". The term "*stressor"* refers to features that may cause an adverse effect on the environment, and the term "*receptor"* refers to elements of the ecosystem that may be affected or respond to an impact. Then, the nature and type of each impact are identified. For each TROPOS module/satellite in the three scenarios, the potential environmental impacts (activity, stressors, receptors, nature and type of impact) are analysed. Subsequently, the significance of each impact is estimated. This methodology gives a valuable overview on the major stressors and most significant impacts for each scenario, thereby providing the opportunity to adapt the platform design and to develop appropriate mitigation strategies to reduce or avoid negative impacts and cumulative effects.

Beside the EIAs and mitigation options, the development of an appropriate monitoring strategy for these multi-use offshore installations is an essential element of the TROPOS project (see D6.3). The monitoring will focus on stressors and receptors identified in the scope of this impact assessment, and will include baseline studies, and monitoring during construction, operational and decommissioning phases. The monitoring will significantly improve knowledge on the impacts of multi-use offshore facilities on the environment and the efficiency of applied mitigation strategies.

Parts of the methodology used to assess the environmental impacts of the TROPOS platforms were adopted from the methodology used in the Prelude FLNG Project (Prelude 2009).

6.2 IMPACT ASSESSMENT METHODOLOGY

6.2.1 RECEPTORS CONSIDERED

For the evaluation of the potential environmental impact of the different components of the TROPOS scenarios (see Chapter 4) in the particular environments (see Chapter 5), different receptors were considered (*Table 6-1*). The term "*receptor*" refers to elements of the ecosystem that may be affected or respond to an impact. The elements considered involve receptors from the abiotic, biotic as well as the socio-economic environment.

Table 6-1: Receptors considered in the EIA

Environment	Receptor	Acronym
Abiotic	Air Quality (including climate)	AQ
	Water Quality	WQ
	Water Temperature	WT
	Sediment Dynamics	SD
	Sediment Quality	SQ
	Landscape/Seascape	L/S
Biotic	Microorganisms	MI
	Benthic Fauna & Flora	BFF
	Pelagic Fauna & Flora	PFF
	Fish & Turtles	FT
	Birds & Bats	BB
	Marine Mammals	MM
	Humans	H

6.2.2 STRESSORS CONSIDERED

The stressors considered in the assessment of the EIA of the platform components and scenarios include:

- Physical impacts.
- Shading.
- Light reflections.
- Artificial lighting.
- Heat energy.
- Electromagnetic fields.
- Noise and vibration.
- Solid and liquid wastes (organic and inorganic).
- Harmful substances and materials.
- Emissions to atmosphere.
- Risk of accidents and unplanned events.

- Introduction of alien species.
- Escape of fish.
- Attraction of wild animals.
- Consumption of energy.
- Consumption of freshwater.
- Consumption of goods.

Details on these stressors are given below.

6.2.2.1 Physical impacts

Impact may arise from the installation and presence of physical features, such as a mooring or ships/vessels, and also from the platform structure with associated installations. The most straightforward effect is the risk of collisions, e.g. the collision of whales, fish and turtles with ships or moving underwater and surface structures, or the collision of birds and bats with physical structures above the water. In particular, for offshore wind turbine installations increased collision risk was observed for migratory birds (Vanermen et al. 2013). However, collision risk seems to be species specific, as some species apparently avoid offshore structures.

Below the water surface, the impact of physical installations is diverse. The acute introduction of physical structures directly to the sea floor may affect sediment quality and the benthic in- and epifauna close to the structure, (i) due to direct forces (sediment scouring), and (ii) due to changes in sediment dynamics following changes in currents patterns (e.g. Schroeder et al. 2013, Wilding 2014). However, in soft-bottom habitats the introduced installations represent new artificial hard substrates, in the long term, and may provide settling ground and new habitat for benthic invertebrates (artificial reef effect; e.g. bivalves, ascidians, etc.; Krone et al. 2013a,b). Installations in the sea may also function as fish aggregation devices. In the shaded area below offshore structures such as platforms, often large aggregations of fish are found, using the structures as shelter and feeding ground (e.g. Reubens et al. 2011, 2013), and maybe even as a nursery ground. Physical structures thus may support local species diversity and recovery of exploited fish stocks (Reubens et al. 2011, 2013).

Depending on oceanographic features of the area, turbulence, stratification and vertical mixing of water masses (by wind and wave action) may be locally hampered by installations covering a larger area of the water surface. Alterations in mixing and stratification, again, may affect the vertical movement and aggregation pattern of the pelagic flora and fauna, and their predators.

6.2.2.2 Shading

As algae depend on natural light for photosynthesis, shading or shadowing of water surfaces by installations may particularly affect microalgae and macroalgae production in the shaded area. Also, light might trigger vertical migration of zooplankton and their predators might be affected (for details, see 6.2.2.4 below), as well as aggregation of fish. The strength of these effects depends on the spatial and temporal dimension of shading, and on oceanographic features in the area, i.e. currents moving the water masses horizontally.

6.2.2.3 Light reflection

Onshore, in terrestrial habitats, light reflections from objects such as solar panels are mistaken for the reflecting water surface of lakes by water birds and insects. However, offshore, surrounded by the reflecting ocean's surface, such a mistake is unlikely to happen and even if it did, the effect would be negligible (compared to the effect onshore). Whether or not seabirds may suffer from blinding by the light reflection from the panels is unknown so far, but it should be monitored. As the platforms will be far enough offshore, coastal residents should not be disturbed by the reflections.

6.2.2.4 Artificial lighting

Many processes and cycles in marine (and terrestrial) ecosystems are driven, triggered or regulated by natural light and the periodic day/night cycle, e.g. phytoplankton production (photosynthesis), daily vertical (feeding) migration of zooplankton and fish, and migration, spawning and development of invertebrates of fish, and reptiles. Artificial lighting alters the natural light regimes in ecosystems. The so-called "photopollution" or "ecological light pollution" (Longcore & Rich 2004) may hamper, alter, or disrupt the natural biological processes, cycles and interactions. In marine ecosystems, the light pollution is usually less compared to terrestrial systems (due to city lighting); therefore, the effect of a single artificial light source offshore may be even stronger. Ecosystems in the tropical regions, where daily cycles are more or less constant year-round, might be more sensitive to light pollution than ecosystems in temperate and polar and sub-polar regions where daily cycles are naturally fluctuating over the year.

The responses to lighting will differ between species and may include disorientation, attraction, or repulsion. Artificial lighting may disrupt trophic interactions among species, thereby affecting the entire community. It may alter the diel vertical migration behaviour of zooplankton (Moore et al. 2000), and the foraging behaviour of bats, birds, fish and mammals (as reviewed in Longcore & Rich 2004). Moreover, an increased accumulation of artificial light sources may cause fatal disorientation, resulting in increased mortality of nocturnally migrating birds (reviewed in Witherington 1997) and disruption of turtle hatchlings' sea-finding behaviour (Berry et al. 2013, Bourgeois et al. 2009). The potential ecological impact of artificial lighting should not be ignored.

6.2.2.5 Heat energy

Heat energy may be produced offshore and enter the marine habitats in different ways, e.g. by ejecting warm water into a colder one, or emitted by undersea cables. Marine invertebrates, fish and reptiles (turtles) are all poikilothermal organisms, i.e. body temperature and physiological functions are determined by the temperature of the surrounding water masses. Every organism not capable of regulating its body temperature has an optimum habitat temperature, at which physiological performance is best. A particular range of temperature below and above this optimum is usually tolerated, even though performance (i.e. growth, reproduction, etc.) is below the optimum. When the so-called critical temperature limit is reached or even exceeded, individuals or populations are threatened by death (e.g. Pörtner 2010 and references therein). The same holds true for performance and production of macroalgae and phytoplankton. The natural distribution of species usually reflects their preferences, i.e. species occur in areas where water temperature is in the optimum range or close to it. Changes in water temperature therefore may significantly affect individuals' performance, growth, production, and survival. Changes in local habitat temperature may alter species distribution and the composition of local the living community. As for lighting and shading, temporal and spatial dimension of the introduction of heat energy determine the strength and significance of this impact as well as the amount. For sensitive species with a narrow thermal tolerance range even acute small-scale introduction of water exceeding the critical temperature might be extremely harmful.

Heat energy may affect organisms not only directly, but also indirectly. Water temperature determines sea water density, and sea water density is a major factor driving water column stratification. Changes in water temperature of introduction of heat energy may result in vertical shifts of the thermocline, thereby affecting distribution and performance of less mobile species aggregating in particular strata.

Alterations in water temperature in the long run have a potential to significantly change the local living community and the food web structure by altering/disrupting trophic interactions among species. The production or introduction of heat energy by offshore installations poses a threat to marine organisms. Birds (and bats) may also be injured by heat produced from solar panels when they are landing or resting on the structures.

6.2.2.6 Electromagnetic fields

When energy is produced offshore, many cables are involved in transmitting electrical energy (e.g. among installations, array to transformer, transformer to shore, etc.). The electrical currents transmitted in undersea cables induce electromagnetic fields, and these fields may affect marine organisms (Ohman et al. 2007, Boehlert & Gill 2010). In particular, magneto-sensitive and electro-sensitive species, such as many fish and whales, often use electromagnetic fields for spatial location, large-scale orientation, feeding and mate finding; these activities may be adversely affected by electromagnetic fields (Boehlert & Gill 2010). Human-made electromagnetic fields are, among other factors, suspected for being a major cause for stranding of cetaceans. Though little is known about the long-term effect of electromagnetic fields on marine organisms so far, the potential impact of this parameter needs to be considered.

6.2.2.7 Noise and vibrations

Noise and vibrations are generated offshore, both above and under the water, by e.g. construction activities, moving wind rotors, ships traffic, and underwater installations. Acoustic signals can travel long distances underwater (longer than in air). As sound is a mean of communication, navigation, orientation and echolocation in vertebrates, marine mammals are sensitive to noise pollution. Noise may affect animal behaviour and disrupt social interactions; it may damage hearing, and is, as electromagnetic fields, suspected for being a cause for whale strandings (Bradley et al. 2008, Southall et al. 2007, Haelters et al. 2012). Potential effects of human-generated underwater noise on fish range from behavioural changes and (temporal) hearing loss to immediate death. However, empirical data of the impact of noise on fish is extremely scarce, so this should be monitored to verify potential effects (Popper & Hastings 2009a,b).

6.2.2.8 Solid and liquid wastes

Solid wastes produced on offshore installations such as the TROPOS scenarios involve (1) general waste, such as paper, plastic, metal, packaging material, and organic waste; (2) scenario specific wastes, such as nets and ropes and waste from fish processing; and (3) hazardous wastes, such as batteries or oil-contaminated material (for hazardous waste see 6.2.2.9). When solid waste is disposed into the environment animal may be hurt by ingestion of waste, or entanglement in plastic debris, nets and ropes. Even the release of organic waste may affect the environment by attracting scavengers, altering food web relationships and water quality. The incineration of inorganic solid wastes will contribute to the emissions to the atmosphere (see 6.2.2.10).

Liquid wastes include (1) grey water (generated from wash hand basins, showers, baths, discharge from laundry, dishwasher, kitchen, etc.), which usually can be recycled/reused on-site, e.g. toilet flushing; (2) black water (wastewater containing faecal material and urine), which may contain pathogens and medical residues and thus does not suit for being reused; and (3) the desalination brine (or high-salinity seawater) from desalination units. The release of grey water into the environment is not desirable, but it is not an issue of a major concern. The accidental release of black water, in contrast, may significantly affect water quality and flora & fauna, due to the contamination with pathogens and nutrients. The production of freshwater in desalination units result in the discharge of seawater with an increased salinity (desalination brine). If the salt concentration in the brine is not too high, the impact of the discharge on the environment should be negligible. However, if the concentration is high (compared to natural sea water salinity) and/or the amount of released brine is very high, negative impacts, particularly on phyto- and zooplankton, are to be expected.

6.2.2.9 Harmful substances and materials

There are multitude substances and materials that may harm the marine flora and fauna, e.g. oil and oil contaminated material (oily waste, oil filters), antifouling paint and other chemical pollutants, pharmaceuticals, and hazardous waste such as batteries.

In the case of oil pollution, diesel oil from fishing boats, tourist boats and maintenance vessels is considered less harmful compared to bunker oil, because diesel oil evaporates to a relatively high degree (even more at warmer air and water temperature). The "worst case scenario" is the pollution from collision with an oil tanker, due to the low evaporation rate of bunker oil and its destructive impact. Lubricating or hydraulic oil leaking from installations, such as wind turbines, as well as leakage of diesel oil from substations has to be avoided, but it is usually not an issue of a major concern, due to the limited amount of oil and/or the high evaporation rate of diesel oil. As most oil types float, therefore, organisms swimming or floating at the sea surface, such as seabirds, seals, sea otters, fish, turtles, cetaceans, but also plankton, fish eggs and larvae are affected by oil spills. Organisms are harmed by oil through physical contact, ingestion, inhalation and absorption. Organisms may be directly affected and poisoned by toxic oil. Feather and fur of birds and mammals stick together when coming in contact with oil, making the organisms loose the protective function of their skin. By contaminating plankton oil enters the food web and may poison consumers. When washed ashore, oil may contaminate entire beaches. In some cases, the long-term effects of oil spills are still evident after decades (Kingston 2002).

Batteries, oil contaminated materials, pharmaceutical, and various chemical pollutants may affect water quality and organisms; they may for example inhibit phytoplankton photosynthesis and growth (Walsh 1978). All these substances have to be appropriately disposed of to avoid harm of the environment.

Antifouling paint is commonly used on submerged structures, such as ships' hulls or platform piles, to prevent the surfaces from being heavily colonised by marine organisms such as barnacles, mussels and algae (biofouling). Historically, the main ingredients in biocidal antifouling coatings were copper or tributylin (TBT), the latter one was banned for recreational boat use in 1987 due to its detrimental effects on the environment. Since then, the majority of antifouling paints are copper based, with the main biocide being cuprous oxide, and some organic biocides also added. Cuprous oxide is toxic and stops biofouling. The biocides are controlled under the *Biocidal Products Directive (98/8/EC)*. Biofouling components such as copper can accumulate along the food chain when concentrations are high, resulting in damage of target species as well as non-target species. However, more research is needed to verify the impact of antifouling paint ingredients on marine life.

6.2.2.10 Emissions to atmosphere

Though the majority of the energy demand of the TROPOS platform scenarios is supposed to be covered by renewable energies, diesel generators are installed for security reasons as a backup source and to supply power for particular systems which cannot be supplied by renewable energy only (see D3.2). Emissions to the atmosphere are also produced by the ship engines of maintenance vessels and shuttle boats. Diesel exhaust is a complex mixture of gases and fine particles; diesel emissions include fine particulate matter (PM), carbon monoxide and dioxide (CO, CO_2), nitrogen and sulfur oxides (NO_x, SO_x), hydrocarbons (HC), and volatile organic compounds (VOCs). These emissions strongly affect air quality by adding to greenhouse gases and ozone formation, thereby also affecting human health (e.g. Goldsworthy 2010, Goldsworthy & Galbally 2011) and contributing to climate change and global warming. Similar emissions are generated when burning solid waste. Some of these emissions to the air may be reduced by exhaust scrubbing.

6.2.2.11 Risk of accidents and unplanned events

An increase in offshore activities and ships traffic goes along with an increased risk of accidents and unplanned events. Potential accidents involve ship collisions, as well as collisions between ships and offshore structure and installations. The consequences of such collisions depend on many things, e.g. the type of ship (tanker or tourist boat), cargo, the type of offshore installation, degree of damage, local environment (currents, water depth, fauna and flora), weather conditions, etc. Potential effects of such accidents on the environment include the pollution of water by spills of oil, chemicals and/or hazardous substances which directly affect water quality and indirectly the marine flora and fauna. Accidents and unplanned events may also occur on board of offshore platforms, resulting in the release of hazardous substances, or alterations of the natural environment. To prevent or reduce the risk of accidents and unplanned events, and to minimise their detrimental impact, an effective risk and emergency management is needed.

6.2.2.12 Introduction of alien species

Biological invasions due to the spread of species by ships is a global problem, in particular, in the light of increasing trade and transport at sea worldwide. However, there are some invasion hotspots and specific countries act as a gateway to invasions (Seebens et al. 2013, Nunes et al. 2014). Alien species are introduced in ships' ballast water or on ships' hulls (biofouling) and may threaten the native living community. Most invaders fail to establish, either because they do not survive the transit in dark and dirty ballast tanks, or due to unfavourable conditions at the place of release. However, there are successful marine invaders, including seaweed (Lowe et al. 2000), gelatinous zooplankton (Shiganova 1998), molluscs (Probst 2013), and crabs (Grosholz et al. 2000). Invasive alien species may significantly affect habitat structure, native community composition, local biodiversity, food web structure, and ecosystem services.

6.2.2.13 Escape of fish

During normal operation of the fish aquaculture, and particularly during stocking of fry and harvesting of market-size fish, individuals may accidentally escape from the fish cages due to severe weather, equipment failure or human error. Depending on the number of escaped individuals, their habitat preferences and reproduction cycle, individuals may reproduce and compete with natural fish populations. Escaped animals may introduce pathogens, medicines, diseases and parasites into the ecosystem which affect native communities. Local species should be used in open ocean aquaculture, as most severe impacts are expected associated with escapes of non-native species. However, natural communities and habitats are also threatened by escapes of local species, as the offspring may differ in behaviour or genetically when the cultured species reproduces in captivity.

6.2.2.14 Attraction of wild animals

Different kind of species of a native community may be attracted by offshore installations and aggregate close to the structures. Some species may be attracted by lighting or by the presence of humans, others by aquaculture, i.e. cultured individuals and their food, residuals and excrements. The offshore facilities may, hence, cause a change in animals' natural behaviour. Depending on the species attracted and the density of aggregations, trophic interactions may be disrupted or altered, and composition of local community may change.

6.2.2.15 Consumption of energy

Most activities and processes associated with daily operations of the TROPOS scenarios will require energy. The higher the energy consumption, the higher is the demand, and the risk that the demand cannot be fully met by renewable energy will be also higher. Accordingly, energy should be used with care and saved wherever possible, to keep overall energy consumption at the lowest possible level.

6.2.2.16 Consumption of freshwater

Freshwater will be consumed in all TROPOS scenarios; it will be required for direct consumption, in the kitchen, showers, for cleaning, etc. There is no need to import freshwater from the shore, as the TROPOS concept includes desalination units to produce freshwater from seawater. However, as the desalination units (i) consume energy and (ii) the release of the desalination brine may harm organisms (see above), it is important not to waste any freshwater, and to recycle/reuse water wherever possible.

6.2.2.17 Consumption of goods

Several kinds of goods are consumed by human beings and/or by their activities. The consumption of goods *per se* does not necessarily adversely affect the environment, but the production of the consumed goods is often based on the use natural resources, so goods should always be used with care. Moreover, most goods come with a package, or the good is a packaging material (e.g. for the packaging of fish in the fish procession unit), and packaging materials include paper, wood, plastic, metal, etc. Ecological, recyclable material should always be preferred whenever possible.

6.2.3 NATURE AND TYPE OF IMPACT

The term "impact" does not necessarily always refer to a negative effect. An impact can be of positive or negative nature, and it can be direct or indirect (secondary) and/or cumulative. Nature and type of impact are defined as follows:

- *Negative impact* – an adverse, detrimental effect causing significant changes from baseline conditions.
- *Positive impact* – a favorable effect that represents an improvement of baseline conditions.
- *Direct impact* – an impact resulting from direct interaction between activity/stressor and receptor.
- *Indirect impact* – an impact resulting from another (direct) effect of an activity.
- *Cumulative impact* – several impacts, often caused by different activities/stressors, affecting the same receptor in combination.

6.2.4 IMPACT SIGNIFICANCE

Impact significance is estimated to evaluate the strength of a particular effect (positive and negative), following the PRELUDE approach. Impact significance is determined by impact likelihood and impact magnitude. Impact magnitude, is a function of impact duration, frequency and extent. The sensitivity of a particular receptor is also taken into account to evaluate impact magnitude.

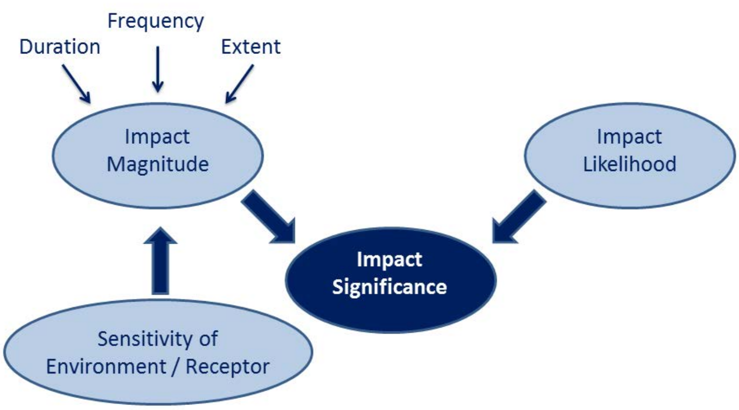


Figure 6-1: Determination of impact significance

The assessment of impact significance identifies the most important and most detrimental impacts which need to be particularly considered in terms of mitigation, monitoring and management.

6.2.4.1 Sensitivity of receptor/environment

The sensitivity of a particular receptor or environment is an important point to consider when estimating the consequences of impacts, and sensitivity may differ significantly among different ecosystems/habitats (e.g.

coral reef vs. sand bottom communities). Following the PRELUDE approach, it is distinguished between low, medium and high sensitivity:

Low:

- Abundant environment, common species, broad distribution.
- Robust, proven to be adaptable to changing environments.
- Valuable but not unique.

Medium:

- Range and abundance of ecosystem/species restricted to a limited number of areas.
- Under some pressure, slow but existing adaptability to changing environment.
- Locally and regionally valued as important species/environment.

High:

- Rare or unique species/environment, species listed in IUCN red list of threatened species.
- Under significant pressure, low/very low adaptability to environmental change, likely to be irreversibly damaged.
- Globally valued as an important species/environment.

6.2.4.2 Impact Magnitude

Impact magnitude is a function of impact duration, frequency and extent (see Figure 6-1). Impact duration and frequency are relative parameters that depend on impact topic. The categories of the three variables are as follows:

Impact duration:

- Short.
- Moderate.
- Long.

Impact frequency:

- Rare.
- Occasional.
- Regular.

Impact extent:

- Local.
- Regional.
- National.
- Global.

The evaluation of impact magnitude is following a qualitative (or at least semi-qualitative) approach. The above described parameters (impact duration, frequency, extent and receptor sensitivity) all have to be considered and judged carefully using all available information, to evaluate overall magnitude of a particular impact.

6.2.4.3 Impact likelihood

The likelihood or probability that a particular impact will occur is an important variable when estimating impact significance. Impact likelihood range from unlikely to possible, probable or certain. These four categories are defined as follows:

Unlikely:

- Improbable or unusual, not expected to occur.

Possible:

- May occur, but not frequently.
- E.g. unplanned events and unusual planned events.

Probable:

- Likely to occur.
- Typical and expected impacts during construction, operational and decommissioning phases of the project.

Certain:

- Inevitable, impacts that will definitely occurs.

6.2.4.4 Assessment of Impact Significance

When the variables to determine impact magnitude (duration, frequency, extent) and likelihood are defined, impact significance can be estimated using the matrix given in Table 6-2. Impact significance ranges from minor, to moderate, major or critical. Negative impacts classified as being major and critical, will need to be mitigated and/or particularly managed. Negative impacts classified as minor or moderate may be acceptable depending on the sensitivity of the affected environment (see below, 6.2.4.4).

Table 6-2: Matrix for the assessment of impact significance (adopted from PRELUDE)

Impact Significance Assessment		**Likelihood**			
		Unlikely	**Possible**	**Probable**	**Certain**
Magnitude	**Low**	Minor	Minor	Moderate	Moderate
	Medium	Minor	Moderate	Moderate	Major
	High	Moderate	Moderate	Major	Critical

6.3 DETAILS FOR SELECTED TROPOS CASE STUDY ELEMENTS

Environmental impacts are assessed and summarised for the central unit, the modules and the satellites of the TROPOS platform concepts. In each case, three different phases are taken into account: the construction, the operational and the decommissioning phases. As vessel traffic is a common feature for all 3 scenarios, and so is part of all module and satellite operation and maintenance, the impact of ships traffic is assessed once for all. For the assessment, all receptors and stressors described above are considered, and impact nature is determined. Tables summarising the impacts of each element, as described below, are in the ANNEX, Chapter 11-2.

6.3.1 VESSEL TRAFFIC

Different kinds of vessels will be involved in several actions during all three phases; they are essential for transport, supply, service, and maintenance of the offshore installations. As vessel traffic is a common feature for all three TROPOS scenarios, and is part of all module and satellite operation and maintenance, the impact of vessel traffic is assessed once for all. The general impact of vessel traffic is always the same; therefore, the three phases (construction, operation, decommission) are not distinguished in the summary table (see ANNEX, Table 11-1), but will be considered in the assessment of impact significance.

Increase in vessel traffic goes along with an increased risk of accidents and collisions, both, between different ships and between ships and other offshore structures or animals. The presence of many ships may also negatively affect the seascape, and noise and vibrations caused by ships' machines will disturb not only animals but also humans.

Pollution by solid and liquid wastes (sewage), as well as contamination by harmful substances such as oil, oily waste or leakage of anti-fouling paint may affect water and sediment quality and harm organisms directly or indirectly. Emissions from the ships' machines pollute the air and contribute to anthropogenic climate change.

Exotic species may be introduced via the ships' ballast water of bio-fouling on the ship's hull. Invasive species may significantly harm native communities and interactions (see 6.2.2.12 above). The higher the amount of vessels and traffic, the higher is the risk of successful invasion.

6.3.2 CENTRAL UNIT

According to the EIA methodology to identify the potential risks, the stressors affecting the Central Unit have been identified within three stages of the entire life cycle: the installation phase, operational phase and decommissioning phase (see ANNEX, Table 11-2).

Installation of the Central Unit requires both positioning and mooring installation activities, that need some specific equipment with the subsequent risks associated of accidents and unplanned events such as possible spillage of petroleum and other harmful substances. In a case of occurrence of these unplanned events apart from the negative impact on water and sediments quality, the potential receptors of the damage would all be the biotic components of marine flora and fauna. Definition of protocols for quick treatment of pollutants should be considered in case this occurs. Nevertheless, a careful design and plan of the installation activities would be the best prevention, trying to reduce to the minimum the installation machinery required and the time span for installation maneuvers by selecting the correct weather window and ensuring that the equipment remains in optimum working conditions.

The presence of the equipment would have an impact as well by hindering migration birds' routes. A good practice to prevent collisions is to use adequate signals and indications. Also, the use of machinery might cause air emissions to the atmosphere due to fuel consumption and noise generation that might disturb fish, birds and mammals.

The submerged part of the machinery required, such as the jack up's legs or the action of mooring installing, might affect the seabed causing temporary increases in sediment deposition, turbidity, smoothering of seabed sediment/rock, fine sediment deposition. The main receptors affected by these actions may be benthic and pelagic habitat and communities. Again, a proper design would help minimising the impact, so careful selection of landing sites would reduce noise and disturbance to a minimum, elasticated mooring risers and increase time spacing between operations would allow for turbidity decrease.

The equipment needed for de-installation is similar to the installation one it is assumed to cause the same impacts. In this phase, the impact caused by the part of the structure that is not removed in case it is not feasible, should also be considered as well as the interaction and disturbance caused to marine mammals and other marine habitats.

During the operational phase some other impacts have been identified covering, on the one hand, the presence of the structure itself, and on the other hand the impacts derived from the activities developed in the central unit.

The upper part of the structure may act as a barrier for migrating and foraging birds and the submerged part acts as a barrier or disturbance for marine mammals that implies fragmentation and alteration of habitat. Again, previous analysis of the placement of the structure would be a good practice to mitigate these effects, but also performance of models involving flight lines and densities recorded during preliminary boat surveys and study of the habitats of marine mammals would reduce the impacts.

The main platform operation activities would be the evacuation of accumulated water from bilge tanks and ballasting process. Bilge water pumped from the engine may be contaminated with fuel and oil so it needs to be passed through a bilge separator before being discharged to the sea. Ballast water might contain invasive aquatic species that may survive and establish a reproductive population in the host environment and may even become invasive out-competing native species and multiplying into pest proportions. It could be prevented with bio-fouling treatment of ballast tanks.

In terms of platform consumptions, emissions of air pollutants from exhaust gases from engines include sulphur oxides (SO_X), nitrous oxides (NO_X) and volatile organic compounds affect air quality and natural environment.

Also desalination for the freshwater generation may be part of the CU's daily activities. Salinity increase and other chemical products release, such as surfactants and detergents, used in the desalination process triggers chemical unbalance in microorganisms and flora habitat, changing species distribution. Mitigation measures for this would be brine water dilution with seawater or cooling water or brine water harvesting.

Artificial lighting is another potential stressor that may cause photopollution that affects life cycle patterns of local fauna, and alter daily vertical migration patterns, thereby disrupting trophic interactions.

Solid and liquid wastes are generated regarding accommodation for crew or staff but also as part of daily operations on board. The potential risk associated waste from the CU is fecal bacterial contamination, uncontrolled chemicals and turbidity increase affecting microfauna and benthic flora and fauna. Mitigation can be done through dilution of releases with marine water, secondary treatments implementation for bacterial decay and correct use of sanitation systems.

Another risk associated with daily operations could be incidents of fuel, oil and chemical pollution from storage and sedimentation tanks or accidental release of sewage and solid waste and leachates (plastics and other harmful elements) into the marine habitat that affect water and sediment quality and organisms.

6.3.3 MODULE LEISURE

Leisure 1 – Leisure Island, Gran Canaria

The marine environment is sensitive to external influences and represents a multifaceted compound of air, water, fauna and flora which is vital for human welfare, health and climate environmental impacts for TROPOS Leisure Platform have been considered for each module during operational phase (see ANNEX, Table 11-3):

- Module 1: Visitors center.
- Module 2: Food & Beverage.

- Module 3: Accommodation.
- Module 4: Nautical Activities.

Visitors Center

The main educational & research activities that may be affected (Ichthyofauna, Mammals & Birds Observatories), focused on the exploitation of environmental resources of the area, are as follows:

- Fauna (fish, turtles, birds, and marine mammals) will be affected by physical disturbance due to visitors' ferry traffic.
- Animals and humans affected by noise and vibrations from machinery and equipment or different areas.
- Sea, due to emission of pollution to water (fuel from motors, lubricant oils, welding remains, etc.).
- Emission of pollution to air (CO_2, NO_X, SO_2, CO and dust).
- Artificial lighting. The light used for activities at night may affect the ecosystem, causing mainly physical disturbance and disorientation to marine birds, plankton, fish and turtles during the night
- Impacts on mammals, mainly noise and physical disturbance, caused by platform visitors and ferries transport. Referring to cetaceans' behaviour, local experts consider a low impact magnitude (no changes on whale watching local industry related to platform recreational activities).
- Noise disturbance. Around 1,200 visitors daily will require a level of comfort and convenience and occupational noise levels on board will have to be reduced.

Some impacts are closely linked to the user's behaviour and will have to be addressed through measures and actions aimed at a better informing of the public.

Food & Beverage

Food & beverage services' environmental footprint and excess usage and stressors related to this activity may be:

- Excessive consumption of energy and freshwater.
- Emission of pollution to air from air conditioning and air extraction systems.
- Noise pollution from machinery and staff and clients during activity.
- Disorientation that may be caused to birds & mammals due to artificial lighting at night, considering night leisure offer. Artificial lighting may also affect nocturnal migrations of plankton and fish, and may also affect turtles.

Providing food and beverage services with environmental-friendly technologies and products will minimise the environmental impact of these activities.

Accommodation

Considering the accommodation and facilities for crew and tourists, some environmental impacts cause the following stressors:

- Consumption of energy, even if opting for energy efficient appliances, daily activity will generate excessive heat and noise.
- Emission of pollution to air from air extraction systems.
- Solid and liquid wastes generated.
- Disorientation of birds & mammals due to artificial lighting at night. Artificial lighting may also affect

nocturnal migrations of plankton and fish, and may also affect turtles.

- The submerged part of the hotel might affect local fauna.

The hotel model business with infrastructure and services for high quality tourism will adopt some measures to promote sustainable development (cleaner production, eco-tourism, etc.) during the operational phases of the project.

Nautical Activities

The two nautical activities considered are diving and sailing, also the marina have been considered even when pending design of the area doesn't allow to review all impacts. "Clear blue" boating and diving installations and equipment will combine emission-free technologies and the use of low emission products for nautical industry in order to fully comply with the current EU legislation, limiting pollution to sea in this protected area under the Natura 2000 framework.

Regarding the environmental impact of nautical activities, these are the risks:

- Sea might be polluted (fuel from motors, lubricant oils, welding remains paint or embedded materials).
- Hydrocarbons as well as other oil residues might be released from recreational craft and private water craft engines, caused by poor operation and maintenance of marine engines.
- Noise disturbances by recreational engines might be caused to the ecosystem and in particular to animal life (fish, marine mammals, birds).
- Black water or sewage collected on board might be leaked.
- Grey water from all onboard aqueous washings and operations might be leaked.
- Litter and other waste generated onboard have to be disposed of at nearest ports since it can pollute the sea.
- Physical damage might happen to the environment such as bad anchorage or wave generation.
- Depletion in fish stocks might happen from recreational fishing and angling.
- Introduction of non-indigenous species through long voyages might happen.

The review of the various environmental impacts will show that the nautical industry can efficiently limit some of the risks through technological improvements. Also, protection of fauna from noise disturbances could be achieved by limiting access and speed within specific areas which were identified as environmentally sensitive.

Leisure 2 – Green & Blue Concept, Liuqiu Island

For leisure module (Taiwan), the main function is accommodation. The main environmental impact risks are the discharge of sewage and the leak of heavy metals. The impact and mitigations opinions are listed in the ANNEX, Table 11-4.

There already exists a variety of water activities in Liuqiu island and the proposed site of platform is close to the island. The high-end hotel will be provided for the leisure module in Taiwan, and other water activities will retain in Liuqiu island.

Considering the construction phase of the hotel, some environmental impacts may arise, such as:

- Impact on fauna (fish, turtles, birds, bats and marine mammals).
- Noise and vibrations from building machinery and related behaviors may affect animals and humans
- Emission of pollution to air (CO_2, NO_X, SO_2, CO and dust).
- Emission of pollution to water (fuel from motors, lubricant oils, welding remains, batteries, dissolvent and paint remains).

Impact on mammals and birds is mainly noise and physical disturbance, which is caused by the construction activities. The impact may extend during the entire construction phase, and it might end once the construction has finished. Vessels and machinery during the construction may generate air and water pollution. Moreover, dangerous residues may be released into water such as lubricants, welding and paint remains from panels structure, dissolvent, etc. These emissions are a negative, direct, accumulative impact with reversible, short duration and mitigable characteristic.

Considering the operational phase, several environmental impacts may arise, such as:

- Impact on fauna (fish, turtles, birds, bats and marine mammals).
    - Artificial lighting: The light of hotel in the night may affect the ecosystem.
- Emission of pollution to water (sewage from living use and fuel from motors and lubricant oils).

The light disturbing may cause physical disturbance and disorientation during the night. This can cause a negative environmental impact during maintenance. The machinery fuel and oils leaks may affect the water quality. These emissions have negative impacts to the surrounding habitats. Sewage discharged may influence the marine environment. Even though sewage will be treated by the treatment system before being discharged, it may still enhance the concentration of organic nutrients and vary the marine ecosystem. This impact is cumulative, and can be considered as a moderate impact.

During the decommissioning phase, some environmental impacts may arise such as:

- Impact on fauna (fish, turtles, birds, bats and marine mammals):
    - Noise and vibrations from demolition machinery and related activities may affect the ecosystem.
- Emission of pollution to air (CO_2, NO_X, SO_2, CO and dust).
- Emission of pollution to water (fuel from motors, lubricant oils, welding remains, batteries, dissolvent and paint remains).

The decommissioning phase is similar to the construction phase. Impacts on mammals and birds are mainly caused by the machinery, during decommissioning. These machinery operations may generate noise pollution and physical disturbance, cause air pollution from the exhaust system and water pollution from leak oils and fuels. This is considered as a negative, direct and accumulative impact.

6.3.4 MODULE AQUACULTURE

The impacts related to the aquaculture module onboard the CU are summarised in the ANNEX, Table 11-5. The main stressors arising from the aquaculture activities in the module are those related to the release of solid and liquid waste and harmful substances and materials. The accidental release of cleaning chemicals and other products used in the production of fish and algae products can affect the water quality and the wild fauna throughout the food web. The effects of these products vary depending on the composition and the properties of the agent. As all the water used for processing (including ice) is generated by desalisation, no precious freshwater from ashore is wasted.

The environmental impact of the activities in the module is reduced due to the desalinisation of the water that allows the sustainable generation of fish and algae products.

6.3.5 MODULE PV PLANT

Environmental impact of producing renewable energy is very low compared to other energy sources, especially in terms of air and water contamination. By replacing traditional unsustainable energy generation, renewable energy contributes to reduction of gas emissions responsible for the greenhouse effect and acid rain.

Photovoltaic (PV) Solar Energy generation is the most environmentally-friendly production of energy up to date (see ANNEX Table 11-6). PV systems do not cause gas emissions, noise or vibration and their visual impact is reduced due to adaptation to the morphology of any place or building where they are installed. Also, the panels generate energy close to the consumption points which avoids energy transport losses.

However, PV impacts cannot be considered non-existent. Most of the impacts are the noise and pollution emitted by machinery involved during the manufacturing of the panels and their installation, operation and maintenance, and decommissioning. Also, light reflection may blind birds and navigation vessels when sun is in low positions.

During the construction phase some environmental impacts may arise such as:

- Impact on fauna (mammals and birds):
  - Noise: from installation vessels, on board machinery, etc.
  - Physical disturbance: vessels navigation.
- Emission of pollution to air (CO_2, NO_X, SO_2, CO) and to water (fuel from motors, lubricant oils, welding remains, batteries, dissolvent and paint remains).
- Visual impact due to panels' structure and light reflection.

Construction of the PV plant does not affect the environment around the platform since it is carried out onshore and just adjusted to the platform deck. Therefore, the construction impact of the PV plant itself is considered to be minor. The impact on mammals and birds mainly comes from the noise and the physical disturbance caused by the vessels carrying out the assembly of the panels on the platform; machinery onboard might also disturb the surrounding fauna. These impacts are present during the construction phase but will cease once the PV plant installation has finished. Some impact will continue due to other platform activities such as staff transportation, maintenance, etc.

The PV plant does not have a risk of fuel spilling which means that there is no special handling of panels required apart from avoiding breaking them. However, vessels and machinery involved in the installation of the plant emit pollution into the air and water through the exhaust of their combustion motors. Moreover, harmful residues such as lubricants, welding and paint remains from panels structure, dissolvent, etc. may be released into the water. Such pollution causes a direct negative impact on the environment; however, with careful handling and appropriate management such pollution can be avoided. The visual impact of the PV structure can be considered moderate during its construction; however, because the structure will be installed co-planar with the sea, the visual impact will disappear after the construction. The light blinding during the installation may cause considerable impact on personnel involved in the installation and on birds in the surrounding area. This impact may cause physical disturbance but since the duration of the reflection during installation is short the amount of reflection is comparatively low (5% of incident light to panels is reflected).

For the Green & Blue Platform concept, there is another activity that can be involved in the PV plant construction which is the subsea cable installation. This export cable will be used by all the systems installed on the satellite modules (wind, PV panels, aquaculture, algae production). Subsea cable installation comprises of a set of activities such as trenching the seabed, laying the cable, burying it and connecting tails. Seabed preparation and trenching/ploughing have a direct effect to the habitat living on the seafloor but can be mitigated by adding artificial components to re-establish the habitat. The cable must be buried at least 2 meters deep to avoid effects of the electromagnetic field generated.

During the operational phase of the PV plant, not only impacts arising from operation of the PV plant but also impacts due to maintenance activities need to be taken into account. The stressors identified within this phase are the following:

- Impact on habitat:
  - Noise: from maintenance vessels and operations, and platform personnel.
  - Disorientation: from panels' reflection.
- Pollution emission to atmosphere from maintenance vessels (CO_2).

- Electromagnetic radiation from cables.

PV plants operation does not cause adverse impact to the environment except for the disorientation of birds that may be caused by light reflection, and the electromagnetic radiation caused by the export cable due to the induction field generated by the electricity conduction. In regard to the light reflection, it has been mentioned before that it may cause physical disturbance and disorientation. Exposure to electromagnetic fields negatively affects organisms (see chapter 6.2.2.6). Symptoms can be such as overstimulation of nerve system and the increase of temperature of body fibers among others. Nevertheless, the exposition to electromagnetic fields which is within the established limits by the Spanish Royal Decree 1066/2001 does not cause adverse effects to health. Taking into account the peak power of the biggest cable (one of the twelve that will be installed in the Leisure Island platform – 1.5 MW), its section, voltage and current intensity, it has been determined that the electromagnetic field remains below the limits established by the Royal Decree. During the operation, panels' temperature will be approximately 60ºC which is very high for birds to land on; at night though when panels are still warm, birds can use the plant to rest, especially, since the panels are laid flat which eases their landing. This, however, may result in increased dirt on the panels significantly reducing the efficiency of the PV plant. So, maybe close to sunrise panels will have to be cleaned for maximum efficiency of the plant.

In terms of maintenance, there are three main sources for potential environmental impact. Firstly, maintenance vessels emit pollution into the air (CO_2) and could leak fuel and oils to the water (see chapter 6.3.1 above). Secondly, maintenance in terms of panels replacement, structure modifications, etc., that may involve welding, cutting and other processes, can cause impact on habitats by residues from remains into the water as well as noise pollution. Considering the low occurrence, the level of impact and the duration of the maintenance activities which is not supposed to be high, the impact can be considered as low. Finally, maintenance activities involve panels' cleaning. Cleaning of the panels will be done with demineralised water, only, without any detergent: so no harmful substances will we washed to the sea during cleaning.

Regarding the decommissioning phase of the PV plant, most of the impacts are the same as for the construction phase with some additions. The stressors found are as follows:

- Impact to mammals and birds:
    - Noise: caused by vessels, machinery, etc.
    - Physical disturbance: caused by vessels navigation.
- Pollution emissions to air (CO_2, NO_X, SO_2, CO) and to water (fuels and oils from motors) from vessels.
- Remaining components in deep water.

As it was mentioned, the impact on mammals and birds is mainly caused by vessels decommissioning the plant. These vessels cause noise pollution and physical disturbance of fauna, emit polluted air from the exhaust system and can leak oils and fuels from motors as well. The main difference from the construction phase is the solid residues that may be left at the bottom of the sea as remains of the plant (pieces of panels, structural profiles, screws, lubricants, etc.).

Regarding the **Green & Blue concept**, the subsea cable may be required to be buried out of the seabed. In this case, it must be ensured that the cable has been disconnected to avoid contamination by the electromagnetic field. During digging activities, the marine habitat will be directly affected by machinery (noise, physical disturbance), but this impact will be short-term. During operation it has to be assured that emission of electromagnetic radiation from the cables is mitigated.

6.3.6 SATELLITE UNITS ALGAE AND FISH FARM

The environmental impact of the algae and the fish farm are summarised in the ANNEX, Table 11-7 and 11-8.

During the construction phase the main stressors are:

- Noise. This is produced by shipping and assembling the structures. It has a moderate effect on the local fauna and humans but only for a short time.

- Emissions to the atmosphere. These are generated by the shipping activities. Its effect is low due to the duration of the activity being temporary.
- Physical impact of structures. The installation of the mooring can destroy the local benthic fauna and flora. This significant negative effect is temporary and local, can turn into positive as the mooring will eventually become a new substrate for the benthic flora and fauna. This positive effect will last as long as the mooring is installed.

The stressors generated by the fish farm and by the algae farms during its operational phase are similar, although their relevance relies strongly on the activity. The main stressors are the attraction of wild animals, the liquid and solid wastes and the release of harmful materials.

During the operational phase of the algae farm, the stressors with a main significant impact are:

- Attraction of wild animals. The structures can attract fish, turtles, birds and marine mammals. Due to this, the structures can eventually break, generating some pieces that can damage the wild animals. The breakage of the structure can release the algae culture, affecting the water quality and the wild fauna. The significant release of the culture can produce blooms, hypoxia, nitrification and/or eutrophication of the area; the effect of these processes will depend on the duration and the currents.
- Solid and liquid wastes. The regular maintenance and control of the structures and the thorough calculation and control of nutrient and food addition, are essential to reduce the adverse impact of liquid wastes on the environment. The release of nitrate and phosphate to the water can affect the water quality and the local fauna and flora, producing nitrification processes.
- Emissions to the atmosphere. The accidental release of CO_2 to the atmosphere during CO_2 injection to the algae units can locally affect the water quality due to the acidification of the water.

The stressors related to the operational phase of the fish farm with a higher impact are those related to the biological aspects of the activity:

- Solid and liquid organic wastes. Due to the feeding processes and the faeces production by the encaged fish the accumulation of organic matter can lead to eutrophication and nitrification processes of the area affecting the water quality, the sediment quality and the local flora and fauna. The release of organic matter will increase the attraction of the wild animals. The significance of this stressor is critical, and its effect can extend from regular to long periods.
- Attraction of wild animals. The farmed fish and the cages can attract wild animals. The interaction of the wild animals onto the structures can lead to the damage of the structure, release of fish, and the damage to the wild animals with released parts of the structure. Escape of fish. The fish can be released during the introduction of juvenile fish in cages, the harvesting and the monitoring processes. The interaction between the domestic fish and the wild animals is uncertain, and can be insignificant or can lead to the modification of the distribution of the species, modifying the ecology of the area.
- Introduction of alien species. Due to the release of fish and the introduction of the juvenile fish that can transport different microorganisms some alien species can be introduced to the ecosystem. The effect of these organisms on the food web and the ecosystem is unpredictable.
- Solid and liquid inorganic waste and harmful materials. The accidental release of cleaning chemicals and products for fish treatment can affect the water quality and the wild fauna across the food web. The effects of these products are variable and depending on the composition and the properties of the agents.

6.3.7 SATELLITE WIND

Assessing the potential environmental impact of the wind Satellite Units off the coastline of Crete is not easy because this wind turbine floating technology is in demonstration phases across the world's seas and there experience with multi-use platforms does not exist especially, on a commercial scale. Application of EIA techniques and knowledge of monopile wind turbine and floating demonstration technologies have been used in this analysis.

The existing marine ecology off the coast of Crete is already highly stressed because of decades of overfishing, other recreational activities, and various air and water pollution sources (see Chapter 5.2). Therefore, the introduction of any additional activities, such as the construction and operation of floating wind turbines, will affect human-environment interactions. In addition, the construction impact of the turbine units on land, in a coastal shipyard not yet identified, are also need to be considered. There is an assumption that the shipyard will need to be expanded to accommodate the assembly of these units and floating the units out 45 km from shore would introduce more vessel traffic and potential impact to the marine environment, as noted in the EIA Table 11-9 (ANNEX).

One of the most important potential impacts from a multi-purpose project of this size within the existing ecology off Crete could be a threat to the endangered and/or protected wildlife and plant life in this region during migrations and sensitive breeding periods. The commercially important and protected or threatened species – including fish, marine mammals (both cetaceans and pinnipeds), benthic resources, and birds – are all detailed in the environmental description of Crete (Chapter 5.2).

Although each stressor is considered for each phase of the project, state-of-the-art environmental analyses would consider the cumulative impacts and an integrated analysis across site activities and their potential benefits and environmental consequences. Also, in some design documents, the activities or the electrical components may be integrated. For example, the Satellite Unit for the production of algae may be connected with the wind Satellite Unit (see D3.4) and this would have important implications for marine spatial planning and environmental impacts of this platform and site. Moreover, without a comparative framework of multiple stressors in the marine and shore ecosystems of Crete, there are significant levels of uncertainties when estimating risks and benefits associated with this innovative multi-purpose project. Moreover, assessing environmental effects are linked to the unknowns surrounding stakeholder and public engagement as well as governance of the marine environment.

The EIA Table 11-9 identifies the activities associated with the construction, operation, and decommissioning of the wind Satellite Units in Crete. Given the ecological condition of the baseline island and offshore environment, the siting and construction phase would have the most potential for negative impact with the selection and expansion of the shipyard for staging areas for the units (not included in the EIA table), increasing vessel transports for shipping components and towing the assembled units out to sea, installation of the units and mooring lines, and the laying and connecting of the HVAC cable. All these activities will be taking place in an otherwise open ocean space. This is reflected across most of the discussions of stressors and receptors, and the first four sets of activities are discussed below.

Tow and Installation of 30 platforms with two 3.3 MW turbines on each platform. Installation of anchors and mooring lines (4 anchors per platform) and installation of the substation on the CU

The frequent presence of construction vessels, other transportation related ships, and ROVs (Remotely

Operated Vehicles) will create additional traffic in the already active marine environment and may have a variety of potential impacts, including:

- Physical impact including, habitat fragmentation from turbine hub height and mooring lines; entangling or disturbing wildlife during this phase that may result in injury or mortality.
- Where the mooring lines are placed, benthic flora and fauna will be temporarily impacted and potential long term effects with the presence of new invasive species and/or increase of biodiversity.
- Limitation of all fishing activities (especially trawling) in the project area could have benefits to flora and fauna but can pose negative impact on fishing community (see socio-economic section D6.4).
- Recreational fishing and other boating activities related to tourism would be excluded from the construction site providing opportunities for fish aggregation but also posing negative effects on tourism; prohibiting trawling and other industrial fishing activities over a longer period of time could help increase the diversity of microorganisms, plants, and fish species.
- Changes in sediment dynamics, scouring.
- Lighting at the construction site may create temporal negative impact to micro-organisms and species in the marine habitat, but could also reduce the risk of collisions and other worker related incidents (see accidents below).
- Generation of noise and vibrations from installing 60 turbines, mooring lines, and 30 floating units could adversely affect marine life and workers.
- Marine activity over long periods of time may generate heat energy and affect water temperatures and surrounding habitat, benthic resources, and wildlife (directly or indirectly); the actual levels of heat energy are not known so the potential impacts are uncertain.
- Accidental release of solid or liquid wastes and/or other hazardous materials could increase air and water pollution during towing or installation of the turbines and units (including the substation) and have limited or widespread impact depending on the nature of the accident and/ releases and the level of response.

25 year lifetime of mooring lines, anchors, 30 floating platforms, and 60 3.3 MW turbines in the marine environment

The physical impact above and below the waterline include habitat fragmentation from turbine hub height and anchors/mooring lines, respectively. The potential limitation of fishing (trawling) in the project area could have benefits for protecting marine wildlife but negative impact on the fishing community (see D6.4 on socio-economic impacts). Small boats and limited fishing gear (no trawling) would be allowed during the operational phase so recreational activities could potentially benefit.

Other impacts include:

- Changes in sediment dynamics and quality due to installation of artificial hard substructures. Could be negative or positive impacts.
- Where the mooring lines are placed benthic flora and fauna will be temporarily affected and potential long term effects may introduce new invasive species or new benthic habitats; new artificial hard substrate for settlement colonies would be provided with potential presence of new micro-organisms, benthic habitat, and food web patterns, as benefits.
- Operational aspects of the ballast waters are not fully known, but release of ballast waters could affect immediate marine environment with temperature changes and/or introduced organisms; invasive alien species may significantly affect habitat structure, native community composition, local biodiversity, food web structure, and ecosystem services.

- Wind structures and mooring lines could serve as fish aggregation devices that may protect fish species and lead to a greater diversity.
- Increases in vessels, diving and ROV traffic, could disturb the mooring lines and might also entangle or disturb wildlife during routine or accidental activities that may result in injury or death; also, increased noise and vibration impact may disturb wildlife, especially, endangered or protected species, such as cetaceans and pinnipeds.
- Visual impact from the project are expected on recreational and tourist activities 45 km off the island and in the ocean (see D6.4).
- The transformer and other fluids from the turbines, or more likely the substation, could leak into the ocean and cause a variety of effects on the flora and fauna depending on the level of release.
- This new floating technology may have accident risks and uncertainties throughout the operational life of the turbines and the substations.

Installation and presence of high voltage transformer/substation in the CU, installation of inter-array cables between 30 floating Satellite Units, and one cable from CU to shore

Physical impact include installation of substation on the CU, trenching of seabed for cable laying and associated impact to the benthic communities along its pathway; inter-array cables would be buried between 30 units and would have direct and indirect impacts associated with habitat disruptions. The length and location of the cables would impact the marine environment from satellite site to CU and then to shore. Cable connection to shore has a potential to affect shoreline and coastal habitat. The height of the CU and substation may impact the habitat both above and below the waterline. Other impacts include:

- Potential EMF effects from high voltage cables on particular species, e.g., rays and sharks; most of the EU studies about EMFs effects from subsea cables have concluded that these impacts are largely uncertain and difficult to assess.
- Potential leakage of liquid wastes from the transformer could have serious consequences above and below the waterline depending on the amount released to the environment and the extent of the damage.
- Increasing water pollution and hazardous substances from vessel collisions, equipment malfunctions, substation explosions would impact water quality and these disturbances would also impact area marine wildlife.

The **annual maintenance** and inspections of the units and the cables would have temporal impacts related to greater vessel, ROV, and human traffic in the marine and coastal environment.

Removal of 60 3.3 MW Turbines & cables to shore; mooring lines are removed and anchors are left on the seabed; turbines towed to shipyard for decommissioning

The decommissioning phase would remove the mooring lines but keep the anchors in place to minimise potential impact on the seabed and the substrate that would have been formed after years of operation. All material from the units would be available for recycling which would eliminate the need for waste sites for these materials (see mitigation strategies, Chapter 7).

6.3.8 SATELLITE UNIT OTEC PLANT

There is not much experience from the long-term operation of OTEC plants, only from demonstration plants. The assessment of environmental problems is mostly based on theoretical studies. In general, OTEC is regarded as a clean form of renewable energy when located, designed and operated adequately. Impact of small plants is considered to be insignificant. In this study, the different parameters and possible stressors will be highlighted, to assess the impact (see ANNEX Table 11-10).

The primary (in volume) waste from an OTEC plant is used seawater, to be discharged below the euphotic zone. Large water flow is involved, about 3 m^3/s per MWe. The mixture of warmed deep water and cooled surface water will be heavier than the ambient water at the discharge depth, and sink to intermediate depths. This water will contain the constituents of the deep water, such as salinity a bit lower than in the upper layers, a temperature lower than the surface layer, and somewhat diluted nutrient concentrations relative to the deep water that usually exceed the concentrations in the surface and upper layer. Excess nutrient supply in the euphotic zone can cause enhanced primary production and although this in some circumstances is regarded as a positive effect, it usually is considered as a stressor that should be avoided.

To have an effective heat transfer, it is necessary to protect the heat exchangers from bio-fouling. It has been determined that, with adequate design, bio-fouling only occurs in OTEC heat exchangers exposed to surface seawater (the warm water flow). Therefore, it is only necessary to protect the OTEC evaporators by, for example, intermittent chlorination (50–100 parts per billion chlorine for 1 h/day). This amount, for example, is well below what is allowed under current US regulations.

Other waste under operation should be held to a minimum, or zero. Sewage and grey water from living quarters should be collected (using vacuum toilets to reduce water consumption) in a central tank, for biogas production. The number of staff for a 8 MW OTEC plant will be small, estimated to 1–2 persons per shift, so waste and sewage figures will also be small. The solid remains after fermentation can be recycled as nutrients and substrate in the aquaculture units, after screening for any contaminants (see the Aquaculture design).

Used cold water, or part of the fresh cold water, can be used for air conditioning (SWAC); this is already being utilized in many places around the world. The Leisure compartments are most likely to benefit from this, but also production and processing units in TROPOS can benefit, provided the used water. There is also significant potential to combine OTEC with aquaculture. The nutrients from the deep water can be basis for enhanced primary production in enclosures. The microalgae can nourish zooplankton, which in turn becomes feed for larger species and so a controlled food chain can be established, with edible fish in the end. In the present study, however, such synergies are not anticipated to happen on the short term.

A single OTEC plant in a given region or water mass will not impact the overall heat balance of the water masses to a degree that would give rise to concern. Although more analysis of this problem needs to be performed, the perturbations are considered small compared to the persistent natural anomalies that are known to be affecting ocean dynamics and, as a minimum, regional climates (CRRC 2010). According to model study by Jia et al. (2012), changes of the physical environment resulting from the presence of a single 100 MW OTEC device in operation are small. Notable changes in flow and stratification were observed in that model study for 16 similar OTEC plants distributed regionally, although the physical environment would recover to normal state in about two weeks in the event of switching off OTEC operations. Considering that the plant in Taiwan will be smaller than 10 MW, it is not anticipated that the plant will change the physical environment beyond the near field.

Fabrication of parts will mostly be done overseas. Assembly of the plant will happen in a nearby port, only lowering of the cold water pipe, and anchoring will take place at the site. In the harbour, a stressor such as noise will probably be realistic, but will not reach the existing noise level in harbour. Anchoring will be similar to anchoring of the Central Unit. No impact is expected from the installation of the cold water pipe. Recovering anchors and the cold water pipe on site should not pose any particular problems.

6.3.9 CONSTRUCTION AND DISASSEMLBY IN THE SHIPYARD

In this environmental impact assessment, the focus is on the potential impacts of the TROPOS scenarios at the offshore sites. Impacts during construction and decommissioning phase in the shipyard, are not considered in the EIA tables (Chapter 11) and the descriptions above. Nevertheless, there is no doubt that there will be environmental impacts arising during the work in the shipyard, as well. Even though not considered in detail in this EIA, a short summary of the potential impacts is given below:

Increased shipyard activity could have a variety of physical impacts related to construction on land and along the coast, more vessel traffic (cars, trucks, trains, boats) to ship components needed for assembly and site expansion into potential pristine, recreational areas. It may increase air, water, hazardous substances need to be managed at the site; see details on impacts below:

- Construction, particularly if it is around the clock schedule, may add lights that disturb neighbours and wildlife, including foraging behaviours for birds and bats and endangered turtle breeding grounds.
- Construction may increase heat energy from equipment use, new land-based substations, or cabling that may disturbs workers and neighbours, flora and fauna, including organisms in surface and ground waters.
- Shipyard construction and assembly of platform parts and units may create significant noise levels and vibrations that disturb neighbors, flora, and fauna.
- Construction may introduce new solid and hazardous wastes as well as potentially harmful materials used in assembling components and expanding the shipyard.
- Potential planned or unplanned discharges of wastewater and increased management of other liquid wastes may affect (directly or indirectly) surface and ground waters and flora and fauna around the shipyard as well as habitats on land and sea.
- Construction and assembly at the shipyard could add a range of emissions (e.g., NO_x, SO_x, CO_2) from vehicles, trucks, and marine vessels related to these construction and expansion activities. Depending on the level of emission, this could impact the landscape and seascape with air pollutants as well as worker and public health. Indirect effects may affect organisms, habitats and sediments along the coastal plain.
- Any construction related activities at the shipyard have associated risks of accidents that may lead to injury or death of workers, as well as neighbours, flora, and wildlife including release of hazardous substances that affect air and water resources and coastal ecology.

6.4 SUMMARY OF MAJOR IMPACTS FOR EACH TROPOS SCENARIO

6.4.1 RECEPTOR SENSITIVITY

Based on the descriptions of the existing environments in Chapter 4, the receptors' sensitivities at the three locations are estimated as shown in Table 6-3.

Table 6-3: Sensitivity of the receptors considered in the assessment at the three TROPOS locations

Receptor	Canary Islands	Crete	Liuqiu Island
Air Quality (including climate)	Medium	Medium	Low
Water Quality	High	Medium	Medium
Water Temperature	Low	Low	Medium
Sediment Dynamics	Low	Low	Medium
Sediment Quality	Medium	Low	Medium
Landscape/Seascape	Medium	Low	Low
Microorganisms	Medium	Low	Low
Benthic Fauna & Flora	High	Medium	Medium
Pelagic Fauna & Flora	High	Low	Low
Fish & Turtles	High	High	High
Birds & Bats	High	Medium	Medium
Marine Mammals	High	High	Medium
Humans	Medium	Medium	Medium

The area off **Gran Canaria Island** where the Leisure Island is characterised by oligotrophic, low productivity waters. The water quality and sediment quality are good, and not very pre-stressed, but as the platform will be located will be located rather shallow and within an environmentally protected area, water and sediment quality were categorised as being of high and medium sensitivity, respectively. There are many marine mammals (mainly dolphins), birds, and turtles. As the area is a specially protected, all the receptors have to be categorised as highly sensitive. The receptor 'Landscape/Seascape' is considered of medium sensitivity, because the platform is not so far away from the coast as are the other two scenarios, and the Leisure Island concept involves more vessel traffic due to the tourist shuttles.

The coastal area of North **Crete**, south of the Green & Blue Scenario, is one of the few areas where the monk seal still occurs. This seal is the most endangered pinniped species in the world; accordingly, the sensitivity of the receptor 'marine mammals' is high. Two endangered sea turtle species are also found in the area. The sea is rather oligotroph, phosphorous limited, and expected to be of medium sensitivity.

Around **Liuqiu Island,** marine mammals are not very abundant and mainly constitute of dolphins. 'Marine mammals' are therefore considered to be of medium sensitivity. There are some protected bird species in the area, but no 'critically endangered' species will be affected. The receptor 'Fish & Turtles' is categorised as being of high sensitivity because Liuqiu Island and the waters around are inhabited by the endangered green turtle.

All three locations are more or less close to touristic sites (islands). The receptor 'human' is therefore considered to be of medium sensitivity. Consumptions of energy, freshwater and goods are not considered in the impact significance assessment tables.

6.4.2 LEISURE ISLAND, GRAN CANARIA (SPAIN)

The Leisure Island scenario involves a lot of vessel traffic (Table 6-4) due to the daily shuttles for tourists, and also the marina. The leisure module involves several leisure facilities, bars, restaurants, and accommodation. The platform location is within the Special Area of Conservation (SAC) "Franja Marina of Mogán" (Natura 2000 network); accordingly, most receptors are highly sensitive to any kind of stressor (see 6.4.1 above). The impact significances are summarised for each element of the scenario in Tables 6-4 to 6-7 below.

The emissions released from vessel traffic (Table 6-4) and from the Leisure module (Table 6-6) are rated as a major impact on air quality and humans. The impact of noise and vibrations from vessel traffic, and generated by leisure facilities and daily operations on the central unit (Table 6-5) are expected to be of major/critical significance for fish and turtles, birds (and bats), marine mammals and also for humans living at the coast, because this scenario is in only 2 miles away from the shore. That is also the reason why the physical presence of the platform is expected to have a major impact on landscape/seascape in this area. However, depending on the acceptance by the public, this effect can also be considered positive (attracting visitors).

The central unit and the associated leisure module both have several impacts of moderate significance; only a few are of minor significance for the Gran Canaria environment. Produced solid and liquid wastes are considered to have a major effect on water quality, the benthic as well as the pelagic flora and fauna, fish and turtles, and marine mammals. Artificial lighting of the Central Unit and leisure module (restaurants, bars, hotel) is a major/critical impact on benthic and pelagic flora and fauna, fish and turtles, and marine mammals. The impact of artificial lighting on birds and bats in not clear; it can be negative, positive, or neither. This needs to be clarified by monitoring. Some of the activities related to leisure facilities, such as the marine and the diving center, may have physical effects of major significance for benthos, plankton, fish and turtles, and marine mammals. The physical presence of the structure, the Central Unit including mooring, may also have a positive effect on the pelagic flora and fauna, fish and turtles, and marine mammals due to the existence of new artificial hard substrate for settlement and the exclusion of commercial fisheries in the vicinity of the platform.

The impacts of the PV module (Table 6-7) on the Gran Canaria environment are all expected to be of minor or moderate significance, only.

Information and education concerning environmental and species protection should be an integral part of services in the observatories and science center of Leisure Island, to make this concept contributing to public's awareness of these issues.

*Table 6-4: Impact significance assessment for **Vessel Traffic** in the **Leisure Island scenario, Gran Canaria**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Regular	Global	Long	Medium	Certain	Major	X	X	X
Receptor:	**Water Quality**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Risk of accidents and unplanned events	(-)	Rare	Regional	Long	High	Possible	Moderate	X	X	X
Receptor:	**Water Temperature**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Regional	Long	Medium	Possible	Moderate	X	X	X
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Regular	Regional	Long	Medium	Certain	Major	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Microorganisms**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X

Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Regular	Regional	Long	Medium	Certain	Major	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	High	Unlikely	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	High	Unlikely	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Receptor:	**Birds & Bats**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise and vibration	(-)	Regular	Regional	Long	Low	Certain	Moderate	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	High	Unlikely	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	High	Unlikely	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	low	Possible	Minor	X	X	X
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Regular	Regional	Long	High	Possible	Moderate	X	X	X
Noise & vibration	(-)	Regular	Regional	Long	High	Certain	Critical	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	High	Unlikely	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	High	Unlikely	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Rare	Local	Short	Medium	Possible	Moderate	X	X	X
Noise & vibration	(-)	Regular	Regional	Long	Medium	Certain	Major	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Emissions to atmosphere	(-)	Regular	Global	Long	Medium	Certain	Major	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X

*Table 6-5: Impact significance assessment for the **Central Unit** in the **Leisure Island scenario, Gran Canaria**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Regular	Regional	Moderate	Low	Certain	Moderate	X	X	X
Receptor:	**Water Quality**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Physical Impacts	(-)	Regular	Local	Short	Low	Possible	Minor	X		
Solid & liquid waste	(-)	Occasional	Regional	Moderate	High	Probable	Major		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Minor		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	**Water Temperature**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Short	Low	Possible	Minor	X		X
Receptor:	**Sediment Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical impact	(-)	Regular	Local	Long	Low	Possible	Minor	X		
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impacts	(-)	Regular	Regional	Long	Medium	Certain	Major	X	X	
Receptor:	**Microorganisms**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Regional	Local	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Unlikely	Minor	X		
Solid & liquid waste	(-)	Occasional	Local	Moderate	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	High	Unlikely	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X

Physical Impacts	(-)	Rare	Local	Short	Low	Unlikely	Minor	X		
	(+)	Regular	Local	Long	Medium	Probable	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	High	Probable	Major		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Unlikely	Minor	X		
	(+)	Regular	Local	Long	Medium	Probable	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	High	Probable	Major		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Long	High	Certain	Critical		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Unlikely	Minor	X		
	(+)	Regular	Local	Long	High	Probable	Major		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	High	Probable	Major		X	
Noise & vibrations	(-)	Regular	Local	Long	Medium	Certain	Major	X		
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Long	High	Certain	Critical		X	
Shading	(-)	Regular	Local	Long	Low	Possible	Minor		X	
	(+)	Regular	Local	Long	High	Probable	Major		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X	X	X
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Noise & vibrations	(-)	Regular	Local	Long	Low	Certain	Moderate	X		
Artificial Lighting	(-)	Long	Local	Long	Medium	Probable	Moderate		X	
	(+)	Long	Local	Long	Medium	Probable	Moderate		X	
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X	X	X
	(+)	Regular	Local	Long	Medium	Possible	Moderate		X	
Solid & liquid waste	(-)	Occasional	Local	Moderate	High	Probable	Major		X	
Noise & vibrations	(-)	Regular	Local	Long	High	Certain	Critical	X		
Artificial Lighting	(-)	Long	Local	Long	Medium	Probable	Moderate		X	

Introduction of alien species	(-)	Long	Local	Short	Medium	Unlikely	Moderate		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X		X
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Short	Low	Possible	Minor		X	
Emissions to atmosphere	(-)	Regular	Regional	Long	Low	Possible	Minor		X	

Table 6-6: Impact significance assessment for the ***Leisure 1 Module*** *in the* ***Leisure Island scenario, Gran Canaria****. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Regular	Regional	Moderate	Medium	Certain	Major		X	
Receptor:	**Water Quality**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Regular	Local	Long	Low	Certain	Moderate		X	
Solid & liquid waste	(-)	Rare	Regional	Moderate	High	Possible	Moderate		X	
Risk of accidents & unplanned events	(-)	Rare	Regional	Short, Moderate, Long	High	Unlikely	Moderate		X	
Receptor:	**Water Temperature**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Moderate	Low	Probable	Moderate		X	
Receptor:	**Sediment Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate		X	
Risk of accidents & unplanned events	(-)	Rare	Regional	Short Moderate Long	Medium	Unlikely	Minor		X	
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Moderate	Medium	Probable	Moderate		X	
Receptor:	**Microorganisms**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Moderate	Low	Probable	Moderate		X	
Solid & liquid waste	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate		X	
Risk of accidents & unplanned events	(-)	Rare	Regional	Short Moderate	Medium	Unlikely	Minor		X	

				Long						
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Moderate	High	Probable	Major		X	
Solid & liquid waste	(-)	Rare	Regional	Moderate	High	Possible	Moderate		X	
Risk of accidents & unplanned events	(-)	Rare	Regional	Short Moderate Long	High	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Moderate	High	Certain	Critical		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Moderate	High	Probable	Major		X	
Solid & liquid wastes	(-)	Rare	Regional	Moderate	High	Possible	Moderate		X	
Risk of accidents & unplanned events	(-)	Rare	Regional	Short Moderate Long	High	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Moderate	High	Certain	Critical		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Moderate	High	Probable	Major		X	
Solid & liquid waste	(-)	Rare	Regional	Moderate	High	Possible	Moderate		X	
Risk of accidents & unplanned events	(-)	Rare	Regional	Short Moderate Long	High	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Moderate	High	Certain	Critical		X	
Noise & vibration	(-)	Regular	Local	Moderate	High	Certain	Critical		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Moderate	High	Probable	Major		X	
Solid & liquid waste	(-)	Rare	Regional	Moderate	High	Possible	Moderate		X	
Risk of accidents & unplanned events	(-)	Rare	Regional	Short Moderate Long	High	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Moderate	Low	Certain	Moderate		X	
Noise & vibration	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Moderate	High	Probable	Major		X	
Solid & liquid waste	(-)	Rare	Regional	Moderate	High	Possible	Moderate		X	
Risk of accidents & unplanned events	(-)	Rare	Regional	Short Moderate Long	High	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Noise & vibration	(-)	Regular	Local	Moderate	High	Certain	Critical		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Moderate	Medium	Probable	Moderate		X	
Solid & liquid waste	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate		X	
Noise & vibration	(-)	Regular	Local	Moderate	Medium	Possible	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Moderate	Medium	Probable	Moderate		X	
Emissions to atmosphere	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Risk of accidents &	(-)	Rare	Local	Short	Medium	Unlikely	Minor		X	

unplanned events				Moderate Long						

*Table 6-7: Impact significance assessment for the **PV Plant** in the **Leisure Island scenario, Gran Canaria**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Water Quality**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Occasional	Local	Short	Low	Probable	Moderate	X		X
Receptor:	**Water Temperature**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Unlikely	Minor			X
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Light reflection	(-)	Regular	Local	Regular	Medium	Probable	Moderate	X	X	
Receptor:	**Microorganisms**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Occasional	Local	Short	Low	Possible	Minor			X
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Occasional	Local	Short	Medium	Possible	Moderate			X
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Occasional	Local	Short	Medium	Possible	Moderate			X
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Noise & vibration	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Solid & liquid waste	(-)	Occasional	Local	Short	Medium	Possible	Moderate			X
Receptor:	**Birds & Bats**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Noise & vibration	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Light reflection	(-)	Regular	Local	Moderate	Medium	Probable	Moderate	X	X	
Electromagnetic fields	(-)	Occasional	Local	Short	Medium	Possible	Moderate		X	
Heat energy	(-)	Rare	Local	Short	Medium	Unlikely	Minor		X	

Solid & liquid waste	(-)	Occasional	Local	Short	Medium	Probable	Moderate			X
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Noise & vibration	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Light reflection	(-)	Regular	Local	Moderate	Medium	Probable	Moderate	X	X	
Solid & liquid waste	(-)	Occasional	Local	Short	Medium	Probable	Moderate			X
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Light reflection	(-)	Regular	Local	Moderate	Low	Probable	Minor	X	X	
Electromagnetic fields	(-)	Occasional	Local	Short	Medium	Possible	Moderate		X	

6.4.3 GREEN & BLUE CONCEPT, CRETE (GREECE)

The existing marine ecology off the coast of Crete is already stressed from decades of overfishing, other recreational activities, and various air, water, and hazardous pollution sources (see Chapter 5 and Annex). Therefore, the introduction of any additional activities, such as the Green & Blue platform with its wind and aquaculture satellites, will affect human-environment interactions. The impact significances are summarised for each element of the scenario in Tables 6-8 to 6-14 below.

Most stressors from vessel traffic (Table 6-8) have only minor or moderate impact, but noise and vibration generated from ship's machine are of major significance for fish and turtles, marine mammals and also humans. Many stressors related to the Central Unit (Table 6-9) are of moderate significance for the environment. All impacts related to the aquaculture module onboard the Central Unit (table 6-10) are rated as minor or moderate, only. The only major impact related to the PV plant (Table 6-13) is a physical impact on the benthos.

However, there are some major/critical negative and also positive impacts involved in the Green & Blue scenario off Crete. One major/critical threat for the environment is solid and liquid wastes from the Central Unit, primarily from the fish aquaculture units (feed and faeces; Table 6-11). The wastes pose a critical impact on water quality, microorganisms, benthic flora and fauna, fish and turtles, birds (and bats) and marine mammals, and pose an impact of major significance on sediment quality, plankton and humans. The waste/nutrients released from the fish aquaculture units are of particular significance in this area because the water is highly phosphorous-limited (see Chapter 5), and input of phosphorous from the fish farm may change the whole system by boosting primary production. However, the inclusion of the algae cultures will reduce the impact. The receptor "marine mammals" is particularly sensitive in this area because of the presence of the rare monk seal (see Chapter 5). Another major/critical stressor related to the fish and algae farms (Tables 6-11 & 6-12) is the attraction of wild animals, which directly or indirectly affects fish and turtles, marine mammals and birds and bats.

The wind farm (Table 6-14) has a multitude of potential effects which are considered to be of minor significance. The visual impact of the wind turbines on landscape/seascape and humans is considered to be of critical significance, and strongly depends on public engagement and perceptions of the concept. The moorings may have a major physical impact on benthos, but also a positive effect because structures may provide additional settling ground for sessile benthic organisms. Whether the impact of artificial light on birds and bats has (as expected) a negative, or a positive or no effect remains to be seen.

Another major/critical threat on fish and turtles, birds and bats, and marine mammals is the stressor "noise and vibrations", not only from ship's machine, but also generated by the turning wing turbines. For birds and bats, also, the collision risk with the structures represents a potential major impact.

However, the potential positive effects of the Central Unit and the wind farm involve the exclusion of large fishing vessels and shipping traffic (except for platform related service and maintenance) from the entire area for 25 years, which could have a positive effect on air and water quality, microorganisms, benthic flora and fauna, fish and turtles and marine mammals. Fish and turtles are also expected to benefit from the shading in this area which may provide shelter from predators.

*Table 6-8: Impact significance assessment for **Vessel Traffic** in the **Green & Blue scenario, Crete**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Occasional	Global	Long	Low	Certain	Moderate	X	X	X
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Regional	Long	Medium	Unlikely	Minor	X	X	X
Receptor:	**Water Temperature**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Regional	Long	Low	Unlikely	Minor	X	X	X
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Regional	Long	Low	Certain	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid wastes	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X

Risk of accidents & unplanned events	(-)	Rare	Regional	Moderate	Low	Unlikely	Minor	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	Low	Unlikely	Minor	X	X	X
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	Medium	Unlikely	Minor	X	X	X
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Medium	Possible	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Unlikely	Moderate	X	X	X
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Long	Medium	Certain	Major	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	High	Unlikely	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Unlikely	Moderate	X	X	X
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Regional	Long	Low	Certain	Moderate	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	Low	Unlikely	Minor	X	X	X
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Long	Medium	Possible	Moderate	X	X	X
Noise & vibration	(-)	Occasional	Local	Long	Medium	Certain	Major	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		

Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Physical Impact	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X	X	X
Noise & vibration	(-)	Occasional	Regional	Long	Medium	Certain	Major	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Emissions to atmosphere	(-)	Occasional	Global	Long	Low	Certain	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X

*Table 6-9: Impact significance assessment for the **Central Unit** in the **Green & Blue scenario, Crete**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Regular	Regional	Long	Low	Certain	Moderate	X	X	X
Receptor:	**Water Quality**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Probable	Moderate	X	X	X
Physical Impacts	(-)	Occasional	Local	Short	Medium	Possible	Moderate	X		
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Minor		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	**Water Temperature**			**Sensitivity:**		**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**			**Sensitivity:**		**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Regional	Short	Low	Probable	Moderate	X		X
Receptor:	**Sediment Quality**			**Sensitivity:**		**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Occasional	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical impact	(-)	Regular	Local	Long	Low	Possible	Minor	X		
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Receptor:	**Landscape/Seascape**			**Sensitivity:**		**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impacts	(-)	Regular	Regional	Long	Low	Certain	Moderate	X	X	
Receptor:	**Microorganisms**			**Sensitivity:**		**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X

Harmful substances & materials	(-)	Occasional	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Unlikely	Minor	X		
Solid & liquid waste	(-)	Rare	Regional	Moderate	Low	Probable	Moderate		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Possible	Minor	X		
	(+)	Regular	Local	Long	Medium	Probable	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Unlikely	Minor	X		
	(+)	Regular	Local	Long	Medium	Probable	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Long	Medium	Probable	Moderate		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	Fish & Turtles				Sensitivity:	High				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Low	Possible	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Possible	Minor	X		
	(+)	Regular	Local	Long	High	Probable	Major		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Noise & vibrations	(-)	Regular	Llocal	Short	Medium	Probable	Moderate	X		
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Long	Medium	Probable	Moderate		X	
Shading	(-)	Regular	Local	Long	Low	Possible	Minor		X	
	(+)	Regular	Local	Long	High	Probable	Major		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Possible	Moderate	X	X	X
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Noise & vibrations	(-)	Regular	Local	Long	Low	Certain	Moderate	X		
Artificial Lighting	(-)	Long	Local	Long	Medium	Probable	Moderate		X	

	(+)	Long	Local	Long	Medium	Probable	Moderate		X	
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	High	Unlikely	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	High	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	High	Possible	Moderate	X	X	X
	(+)	Regular	Local	Long	Medium	Possible	Moderate		X	
Solid & liquid waste	(-)	Occasional	Local	Moderate	High	Probable	Major		X	
Noise and vibrations	(-)	Regular	Local	Long	Medium	Probable	Moderate	X		
Artificial Lighting	(-)	Long	Local	Long	Medium	Possible	Moderate		X	
Introduction of alien species	(-)	Long	Local	Short	Medium	Unlikely	Moderate		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents and Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X		X
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Short	Low	Possible	Minor		X	
Emissions to atmosphere	(-)	Regular	Regional	Long	Low	Possible	Minor		X	

Table 6-10: Impact significance assessment for the ***Aquaculture Module (on CU)*** *in the* ***Green & Blue scenario, Crete****. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Occasional	Global	Long	Low	Possible	Moderate		X	
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Receptor:	**Water Temperature**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Possible	Moderate		X	
Harmful substances	(-)	Rare	Local	Long	High	Possible	Moderate		X	

& materials										
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Probable	Moderate		X	
Harmful substances & materials	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Emissions to atmosphere	(-)	Occasional	Global	Long	Low	Possible	Minor		X	
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Emissions to atmosphere	(-)	Occasional	Global	Long	Low	Possible	Minor		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Regional	Long	Medium	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Regional	Long	High	Possible	Moderate		X	
Emissions to atmosphere	(-)	Occasional	Global	Long	Low	Possible	Minor		X	

*Table 6-11: Impact significance assessment for the **Satellite Unit Fish Farm** in the **Green & Blue scenario, Crete**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	Air Quality			Sensitivity:		Medium				
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	Water Quality			Sensitivity:		Medium				
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local	Moderate	Medium	Possible	Moderate		X	
Solid & liquid waste (feed & faeces)	(-)	Regular	Local	Long	High	Certain	Critical		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate		X	
Receptor:	Water Temperature			Sensitivity:		Low				
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	Sediment Dynamics			Sensitivity:		Low				
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Physical impact of structures	(-)	Regular	Local	Moderate	Low	Probable	Moderate	X	X	X
Receptor:	Sediment Quality			Sensitivity:		Low				
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local	Moderate	Medium	Possible	Moderate		X	
Solid & liquid waste (feed & faeces)	(-)	Regular	Local	Long	Medium	Certain	Major		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate		X	
Receptor:	Landscape/Seascape			Sensitivity:		Low				
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	Microorganisms			Sensitivity:		Low				
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local	Moderate	High	Possible	Moderate			
Solid & liquid waste (feed & faeces)	(-)	Regular	Local	Long	High	Certain	Critical		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	High	Possible	Moderate		X	
Receptor:	Benthic Fauna & Flora			Sensitivity:		Medium				
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Physical impact of structures	(-)	Rare	Local	Short	Low	Certain	Moderate	X	X	X
Noise & vibration	(-)	Occasional	Local	Short	Low	Certain	Moderate	X		X
Escape of fish	(-)	Rare	Local/	Long	Medium	Possible	Moderate		X	

			Regional							
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local	Moderate	Medium	Possible	Moderate		X	
Solid & liquid waste (feed & faeces)	(-)	Rare	Local	Long	High	Certain	Critical		X	X
Introduction of alien species	(-)	Rare	Local/ Regional	Long	High	Possible	Moderate		X	
Attraction of wild animals	(-)	Rare	Local	Moderate	Medium	Probable	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Short/ Moderate	Medium	Possible	Moderate		X	
Receptor:	**Pelagic Fauna & Flora**			**Sensitivity:**		**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Short	Low	Certain	Moderate	X		
Physical impact of structures	(-)	Regular	Local	Short/ Moderate	Low	Certain	Moderate		X	
Escape of fish	(-)	Rare	Local/ Regional	Long	Medium	Possible	Moderate		X	
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local	Moderate	Medium	Possible	Moderate			
Solid & liquid waste (feed & faeces)	(-)	Rare	Local	Long	Medium	Certain	Major		X	X
Introduction of alien species	(-)	Rare	Local/ Regional	Long	Medium	Possible	Moderate		X	
Attraction of wild animals	(-)	Rare	Local	Moderate	Medium	Probable	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate		X	
Receptor:	**Fish & Turtles**			**Sensitivity:**		**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Short	Low	Certain	Moderate	X	X	
Physical impact of structures	(-)	Regular	Local	Short/ Moderate	Medium	Possible	Moderate	X	X	
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local/ Regional	Moderate	Medium	Possible	Moderate			
Solid & liquid waste (feed & faeces)	(-)	Regular	Local/ Regional	Long	High	Certain	Critical	X	X	X
Escape of fish	(-)	Rare	Local/reg ional	Long	High	Possible	Moderate		X	
Attraction of wild animals	(-)	Regular	Local/ Regional	Long	High	Certain	Critical		X	
Introduction of alien species	(-)	Rare	Local/reg ional	Long	High	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Local/ Regional	Moderate	Medium	Possible	Moderate		X	
Artificial lighting	(-)	Occasional/ regular	Local	Short/ Moderate	Low	Certain	Moderate		X	
Receptor:	**Birds & Bats**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Short	Low	Certain	Moderate	X	X	
Physical impact of structures	(-)	Regular	Local	Short/ Moderate	Medium	Unlikely	Minor	X	X	
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local/ Regional	Moderate	Medium	Possible	Moderate			

Solid & liquid waste (feed & faeces)	(-)	Regular	Local/ Regional	Long	High	Certain	Critical	X	X	X
Escape of fish	(-)	Rare	Local/regional	Long	High	Possible	Moderate		X	
Attraction of wild animals	(-)	Regular	Local/ Regional	Long	High	Probable	Major		X	
Introduction of alien species	(-)	Rare	Local/regional	Long	High	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Local/ Regional	Moderate	Medium	Possible	Moderate		X	
Artificial lighting	(-)	Occasional/ regular	Local	Short/ Moderate	Low	Certain	Moderate		X	
Receptor:	**Marine Mammals**			**Sensitivity:**		**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Short	Low	Certain	Moderate	X	X	
Physical impact of structures	(-)	Regular	Local	Short/ Moderate	Medium	Possible	Moderate	X	X	
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local/ Regional	Moderate	Medium	Possible	Moderate			
Solid & liquid waste (feed & faeces)	(-)	Regular	Local/ Regional	Long	High	Certain	Critical	X	X	X
Escape of fish	(-)	Rare	Local/regional	Long	High	Possible	Moderate		X	
Attraction of wild animals	(-)	Regular	Local/ Regional	Long	High	Certain	Critical		X	
Introduction of alien species	(-)	Rare	Local/regional	Long	High	Possible	Moderate		X	
Harmful substances & materials	(-)	Rare	Local/ Regional	Moderate	Medium	Possible	Moderate		X	
Artificial lighting	(-)	Occasional/ regular	Local	Short/ Moderate	Low	Certain	Moderate		X	
Receptor:	**Humans**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Short	Low	Certain	Moderate	X	X	
Solid & liquid waste (cleaning & maintenance)	(-)	Rare	Local/ Regional	Moderate	Medium	Possible	Moderate			
Solid & liquid waste (feed & faeces)	(-)	Regular	Local/ Regional	Long	Medium	Certain	Major	X	X	X
Harmful substances & materials	(-)	Rare	Local/ Regional	Moderate	Medium	Possible	Moderate		X	

Table 6-12: Impact significance assessment for the ***Satellite Unit Algae Farm*** *in the* ***Green & Blue scenario, Crete****. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Rare	Global	Moderate /Long	Medium	Unlikely	Minor		X	
Receptor:	**Water Quality**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of accident & unplanned event	(-)	Rare	Regional	Moderate /Long	High	Possible	Moderate		X	

Solid & liquid waste	(-)	Occasional	Regional	Moderate /Long	Medium	Possible	Moderate		X	
Emissions to atmosphere	(-)	Rare	Regional	Moderate /Long	Medium	Unlikely	Moderate		X	
Receptor:	**Water Temperature**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate /long	Medium	Possible	Moderate		X	
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	National	Long	Medium	Possible	Moderate			X
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of accident & unplanned event	(-)	Rare	Regional	Moderate /Long	High	Possible	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate /Long	Medium	Possible	Moderate		X	
Emissions to atmosphere	(-)	Rare	Regional	Moderate /Long	Medium	Unlikely	Minor		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of accident & unplanned event	(-)	Rare	Regional	Moderate /Long	High	Possible	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate /Long	Medium	Possible	Moderate		X	X
Emissions to atmosphere	(-)	Rare	Regional	Moderate /Long	Medium	Unlikely	Minor		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of accident & unplanned event	(-)	Rare	Regional	Moderate /Long	High	Possible	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate /Long	Medium	Possible	Moderate		X	X
Emissions to atmosphere	(-)	Rare	Regional	Moderate /Long	Medium	Unlikely	Minor		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structure	(-)	Regular	Local	Short/ Moderate	Medium	Possible	Moderate	X	X	
Solid & liquid waste	(-)	Rare	Local/ Regional	Moderate /long	High	Possible	Moderate	X	X	X
Risk of accident & unplanned event	(-)	Rare	Regional	Moderate /Long	High	Possible	Moderate		X	
Attraction of wild animals	(-)	Regular	Local/ Regional	Moderate /long	High	Certain	Critical		X	
Emissions to	(-)	Rare	Regional	Moderate	Medium	Unlikely	Minor		X	

atmosphere				/Long						
Noise & vibrations	(-)	Occasional	Local	Short	Low	Certain	Moderate		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structure	(-)	Regular	Local	Short/ Moderate	Medium	Possible	Moderate	X	X	
Solid & liquid waste	(-)	Rare	Local/ Regional	Moderate /long	Medium	Possible	Moderate	X	X	X
Risk of accident & unplanned event	(-)	Rare	Regional	Moderate /Long	High	Possible	Moderate		X	
Attraction of wild animals	(-)	Regular	Local/ Regional	Moderate /long	High	Probable	Major		X	
Emissions to atmosphere	(-)	Rare	Regional	Moderate /Long	Medium	Unlikely	Minor		X	
Noise & vibrations	(-)	Occasional	Local	Short	Low	Certain	Moderate		X	
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structure	(-)	Regular	Local	Short/ Moderate	Medium	Unlikely	Minor	X	X	
Solid & liquid waste	(-)	Rare	Local/ Regional	Moderate /long	High	Possible	Moderate	X	X	X
Risk of accident & unplanned event	(-)	Rare	Regional	Moderate /Long	High	Possible	Moderate		X	
Attraction of wild animals	(-)	Regular	Local/ Regional	Moderate /long	High	Certain	Critical		X	
Emissions to atmosphere	(-)	Rare	Regional	Moderate /Long	Medium	Unlikely	Moderate		X	
Noise & vibrations	(-)	Occasional	Local	Short	Low	Certain	Moderate		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local/ Regional	Moderate /long	Medium	Probable	Moderate	X		X
Emissions to atmosphere	(-)	Rare	Regional	Moderate /Long	Medium	Unlikely	Minor		X	
Noise & vibrations	(-)	Occasional	Local	Short	Low	Certain	Moderate		X	

Table 6-13: Impact significance assessment for the ***PV Plant*** *in the* ***Green & Blue scenario, Crete****. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Medium**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Occasional	Local	Short	Low	Probable	Moderate	X		X
Receptor:	**Water Temperature**				**Sensitivity:**	**Low**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:		**Sediment Dynamics**			**Sensitivity:**		**Low**			
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**

Physical impact	(-)	Regular	Regional	Moderate	Medium	Probable	Moderate	X		X
Receptor:	**Sediment Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Electromagnetic fields	(-)	Occasional	Regional	Moderate	Medium	Unlikely	Minor		X	
Physical impact	(-)	Regular	Regional	Moderate	Medium	Probable	Moderate	X		
Solid & liquid waste	(-)	Rare	Local	Short	Low	Unlikely	Minor			X
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Light reflection	(-)	Regular	Local	Regular	Medium	Probable	Moderate	X	X	
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Electromagnetic fields	(-)	Occasional	Regional	Moderate	Medium	Unlikely	Minor	X	X	
Physical impact	(-)	Regular	Regional	Moderate	Medium	Probable	Moderate	X		
Solid & liquid waste	(-)	Rare	Local	Short	Low	Unlikely	Minor			X
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Electromagnetic fields	(-)	Occasional	Regional	Moderate	Medium	Unlikely	Minor	X	X	
Physical impact	(-)	Regular	Regional	Moderate	High	Probable	Major	X		X
Solid & liquid waste	(-)	Rare	Local	Short	Medium	Unlikely	Minor			X
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Electromagnetic fields	(-)	Occasional	Regional	Moderate	Medium	Unlikely	Minor	X	X	
Solid & liquid waste	(-)	Rare	Local	Short	Medium	Unlikely	Minor			X
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Noise & vibration	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Electromagnetic fields	(-)	Occasional	Regional	Moderate	Medium	Unlikely	Minor	X	X	
Solid & liquid waste	(-)	Occasional	Local	Short	Medium	Possible	Moderate			X
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Noise & vibration	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Light reflection	(-)	Regular	Local	Moderate	Medium	Probable	Moderate	X	X	
Electromagnetic fields	(-)	Occasional	Local	Short	Medium	Possible	Moderate	X	X	
Heat energy	(-)	Rare	Local	Short	Medium	Unlikely	Minor		X	
Solid & liquid waste	(-)	Occasional	Local	Short	Medium	Probable	Moderate			X
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		X
Noise & vibration	(-)	Regular	Local	Short	Medium	Probable	Moderate	X		
Light reflection	(-)	Regular	Local	Moderate	Medium	Probable	Moderate	X	X	
Electromagnetic fields	(-)	Occasional	Local	Short	Medium	Possible	Moderate	X	X	
Solid & liquid waste	(-)	Occasional	Local	Short	Medium	Probable	Moderate			X
Receptor:	**Humans**				**Sensitivity:**	**Medium**				

Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Light reflection	(-)	Regular	Local	Moderate	Low	Probable	Minor	X	X	
Electromagnetic fields	(-)	Occasional	Local	Short	Medium	Possible	Moderate	X	X	

Table 6-14: Impact significance assessment for the ***Satellite Unit Wind Farm*** *in the* ***Green & Blue scenario, Crete****. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	Air Quality			Sensitivity:	Medium					
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Physical impact	(-)	Rare	Local	Long	Low	Possible	Minor	X		X
	(+)	Regular	Local	Long	Medium	Probable	Moderate		X	
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	
Risk of accidents & unplanned events	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Receptor:	**Water Quality**			**Sensitivity:**	**Medium**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Occasional	Local	Long	Low	Possible	Minor	X	X	X
	(+)	Regular	Local	Long	Medium	Probable	Moderate		X	
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Harmful substances & materials	(-)	Occasional	Local	Short	low	Possible	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Heat energy	(-)	Rare	Local	Long	Low	Unlikely	Minor		X	
Receptor:	**Water Temperature**			**Sensitivity:**	**Low**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Rare	Local	Long	Low	Unlikely	Minor	X	X	
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	
Heat energy	(-)	Occasional	Local	Long	Medium	Possible	Moderate		X	
Receptor:	**Sediment Dynamics**			**Sensitivity:**	**Low**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local/ regional	Long	Medium	possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local/ Regional	Long	High	possible	Moderate	X	X	
Receptor:	**Sediment Quality**			**Sensitivity:**	**Low**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Rare	Local/ regional	Long	Low	Unlikely	Minor	X	X	X
Solid & Liquid Waste	(-)	Rare	Local/ regional	Short	Medium	Unlikely	Minor	X	X	
Harmful substances & materials	(-)	Rare	Local/ regional	Short	Medium	Unlikely	Minor	X	X	
Risk of accidents & unplanned events	(-)	Rare	Local/ regional	moderate	High	possible	Moderate	X	X	X
Receptor:	**Landscape/Seascape**			**Sensitivity:**	**Low**					

Stressor	Impact							Phase		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Long	High	Certain	Critical		X	X
Solid & Liquid Waste	(-)	Rare	Local/ regional	Short	Low	Unlikely	Minor		X	
Risk of accidents & unplanned events	(-)	Rare	Local/ regional	Short	Medium	Possible	Moderate		X	X
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Long	Low	Probable	Moderate	X	X	X
	(+)	Regular	local	Long	Medium	Probable	Moderate		X	
Artificial Lighting	(-)	Regular	Local	Long	Low	Probable	Moderate	X	X	
Heat energy	(-)	Occasional	Local	Moderate	Low	Unlikely	Minor	X	X	
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Shading	(-)	Regular	Local	Long	Low	Unlikely	Minor		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local	Long	Medium	Certain	Major	X	X	X
	(+)	Regular	Local	Long	Medium	Certain	Major		X	
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Heat energy	(-)	Rare	Local	Moderate	Low	Unlikely	Minor		X	
Shading	(-)	Regular	Local	Long	Low	Unlikely	Minor		X	
Electromagnetic fields	(-)	Regular	Local	Long	Low	Possible	Minor		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local/ regional	Long	Low	Possible	Minor	X	X	X
	(+)	Regular	Local/ regional	Long	Medium	Certain	Major		X	
Artificial lighting	(-)	Regular	Local	Moderate	Low	Probable	Moderate	X	X	
Heat energy	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Noise & vibration	(-)	Regular	Local/ regional	Long	Low	Certain	Moderate	X		
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Minor	X	X	X
Shading	(-)	Regular	Local	Long	Low	Unlikely	Minor		X	
Electromagnetic fields	(-)	Regular	Local	Long	Low	Possible	Minor		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local/	Long	Medium	Possible	Moderate	X	X	X

			regional							
	(+)	Regular	Local/ regional	Long	High	Certain	Critical		X	
Artificial lighting	(-)	Regular	Local	Moderate	Low	Probable	Moderate	X	X	
Heat energy	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	
Noise & vibration	(-)	Regular	Local/ regional	Long	Medium	Certain	Major	X	X	X
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	HIgh	Possible	Moderate	X	X	X
Shading	(-)	Regular	Local	Long	Low	Unlikely	Minor		X	
Electromagnetic fields	(-)	Regular	Local	Long	Low	Possible	Minor		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local/ regional	Long	High	Probable	Major	X	X	X
Artificial lighting	(-)	Regular	Local	Moderate	Low	Possible	Minor	X	X	
	(+)	Regular	Local	Moderate	Low	Possible	Minor		X	
Noise & vibration	(-)	Regular	Local/ regional	Long	High	Probable	Major	X	X	X
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Marine Mammals**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local/ regional	Long	HIgh	Possible	Moderate	X	X	X
Artificial lighting	(-)	Regular	Local	Moderate	Low	Probable	Moderate	X	X	
Noise & vibration	(-)	Regular	Local/ regional	Long	High	Certain	Critical	X	X	X
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Heat energy	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X		
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Local/ regional	Long	Medium	Certain	Major	X	X	X
Artificial lighting	(-)	Regular	Local	Moderate	Low	Probable	Moderate	X	X	
Noise & vibration	(-)	Regular	Local/ regional	Moderate	Low	Possible	Minor	X	X	X
Solid & Liquid Waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X

Shading	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	

6.4.4 GREEN & BLUE CONCEPT, LIUQIU ISLAND (TAIWAN)

The impact significances of the Green & Blue concept off Liuqiu Island are summarised for each element of the scenario in Tables 6-15 to 6-21 below.

Most impacts of vessel traffic (Table 6-15) are of minor or moderate significance, but noise and vibrations from ship's machine are considered as a major effect on fish and turtles, marine mammals, and humans. Noise and vibrations is also considered a major/critical stressor from the Central Unit (Table 6-16) and the associated Leisure module (Table 6-17) on fish and turtles, marine mammals and birds and bats. Shading from the Central Unit is supposed to have a positive effect on fish and turtles; the physical presence of the structure is expected to provide shelter with a positive impact on fish and turtles and marine mammals.

The stressor artificial lighting from Central Unit and leisure module is considered only of moderate significance on many receptors in this scenario, because Leisure 2 in this Green & Blue scenario has (in contrast to Leisure Island, Gran Canaria) only limited leisure facilities, mainly accommodation, and no lighting from an underwater bar. Anyway, the impact of artificial lighting on fish and turtles was rated as being of major significance in this scenario. Whether the impact of artificial light on birds and bats has a positive, negative or no effect remains to be seen.

Solid and liquid wastes coming from the daily operations of the leisure and the aquaculture modules (Table 6-18) onboard the Central Unit, will most likely have a major effect on water and sediment quality, benthos, fish and turtles, marine mammals and humans. An additional major/critical threat is posed by waste from the fish (Table 6-19) and algae farms (Table 6-20) in this scenario. Noise and vibrations from the fish farm are expected to have a major impact on fish and turtles and marine mammals, the mooring will significantly affect sediment dynamics. The artificial lighting of the fish farm units is expected to pose a major impact on marine mammals, birds and bats, and fish and turtles. The escape of fish from the fish cages and the introduction of alien species are rated to be of major significance for plankton, benthos, and fish and turtles in this scenario.

The OTEC plant (Table 6-21) is expected to have mainly moderate effects on the environment. Only the stressor heat energy has a major effect on water temperature and the pelagic flora and fauna. The pelagic flora and fauna may also be affected by physical stressors owing to potential changes in sea water salinity and water column stratification.

Table 6-15: Impact significance assessment for ***Vessel Traffic*** *in the* ***Green & Blue scenario, Liuqiu Island****. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Occasional	Global	Long	Low	Certain	Moderate	X	X	X
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Harmful substances	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X

& materials										
Risk of accidents & unplanned events	(-)	Rare	Regional	Long	Medium	Unlikely	Minor	X	X	X
Receptor:	**Water Temperature**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Regional	Long	Medium	Unlikely	Minor	X	X	X
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Regional	Long	Low	Certain	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Regional	Moderate	Low	Unlikely	Minor	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	Low	Unlikely	Minor	X	X	X
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Possible	Minor	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	Medium	Unlikely	Minor	X	X	X
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Medium	Possible	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Unlikely	Moderate	X	X	X
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Long	Medium	Certain	Major	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X

Harmful substances & materials	(-)	Rare	Local	Moderate	High	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	High	Unlikely	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	High	Unlikely	Moderate	X	X	X
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Regional	Long	Low	Certain	Moderate	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	Low	Unlikely	Minor	X	X	X
Receptor:	**Marine Mammals**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Occasional	Local	Long	Medium	Possible	Moderate	X	X	X
Noise & vibration	(-)	Occasional	Local	Long	Medium	Certain	Major	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Introduction of alien species	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impact	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X	X	X
Noise & vibration	(-)	Occasional	Regional	Long	Medium	Certain	Major	X	X	X
Solid & liquid waste	(-)	Rare	Local	Moderate	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Emissions to atmosphere	(-)	Occasional	Global	Long	Low	Certain	Moderate	X	X	X
Risk of accidents & unplanned events	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X

*Table 6-16: Impact significance assessment for the **Central Unit** in the **Green & Blue scenario, Liuqiu Island**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Regular	Regional	Long	Low	Possible	Minor	X	X	X
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Probable	Moderate	X	X	X
Physical Impacts	(-)	Occasional	Local	Short	Medium	Possible	Moderate	X		

Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Possible	Moderate		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	**Water Temperature**				**Sensitivity:**	**Medium**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Medium**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact	(-)	Regular	Regional	Short	Low	Probable	Moderate	X		X
Receptor:		**Sediment Quality**			**Sensitivity:**		**Medium**			
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Occasional	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical impact	(-)	Regular	Local	Long	Low	Probable	Moderate	X		
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical Impacts	(-)	Regular	Regional	Long	Low	Certain	Moderate	X	X	
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Occasional	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Unlikely	Minor	X		
Solid & liquid waste	(-)	Rare	Regional	Moderate	Low	Probable	Moderate		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Possible	Minor	X		
	(+)	Regular	Local	Long	Medium	Probable	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor				**Impact**					**Phase**	
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Unlikely	Minor	X		
	(+)	Regular	Local	Long	Medium	Probable	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Introduction of	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	

Stressor Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
alien species							Moderate			
Artificial Lighting	(-)	Long	Local	Long	Low	Certain	Moderate		X	
Shading	(-)	Regular	Local	Long	Low	Probable	Moderate		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Low	Possible	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		
	(+)	Regular	Local	Long	High	Probable	Major		X	
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Noise & vibrations	(-)	Regular	Local	Long	Medium	Certain	Major	X		
Introduction of alien species	(-)	Rare	National	Short	Medium	Possible	Moderate		X	
Artificial Lighting	(-)	Long	Local	Long	Medium	Certain	Major		X	
Shading	(-)	Regular	Local	Long	Low	Possible	Minor		X	
	(+)	Regular	Local	Long	High	Probable	Major		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Possible	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Low	Possible	Moderate	X	X	X
Solid & liquid waste	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Noise and vibrations	(-)	Regular	Local	Long	Low	Certain	Moderate	X		
Artificial Lighting	(-)	Long	Local	Long	Medium	Probable	Moderate		X	
	(+)	Long	Local	Long	Medium	Probable	Moderate		X	
Receptor:	**Marine Mammals**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	High	Unlikely	Moderate	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X	X	X
Physical Impacts	(-)	Rare	Local	Short	Medium	Probable	Moderate	X	X	X
	(+)	Regular	Local	Long	Medium	Possible	Moderate		X	
Solid & liquid wastes	(-)	Occasional	Local	Moderate	Medium	Probable	Moderate		X	
Noise & vibrations	(-)	Regular	Local	Long	High	Probable	Major	X		
Artificial Lighting	(-)	Long	Local	Long	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Long	Local	Short	Medium	Unlikely	Moderate		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of Accidents & Unplanned Events	(-)	Rare	Local	Short	Medium	Unlikely	Minor	X		X
Harmful substances & materials	(-)	Rare	Regional	Moderate	Medium	Possible	Moderate	X		X
Introduction of alien species	(-)	Rare	National	Short	Medium	Unlikely	Moderate		X	
Solid & liquid waste	(-)	Occasional	Regional	Short	Low	Possible	Minor		X	
Emissions to atmosphere	(-)	Regular	Regional	Long	Low	Possible	Minor		X	

*Table 6-17: Impact significance assessment for **Leisure 2 Module** in the **Green & Blue scenario, Liuqiu Island**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Regular	Local	Short	Low	Probable	Moderate	X	X	X
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Water Temperature**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA	X	X	X
Receptor:	**Sediment Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA	X	X	X
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Low	Certain	Moderate		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Low	Certain	Moderate		X	
Artificial lighting	(-)	Regular	Local	Moderate	Medium	Possible	Moderate		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibrations	(-)	Regular	Local	Long	High	Certain	Critical	X	X	X
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Artificial lighting	(-)	Regular	Local	Moderate	Medium	Possible	Moderate		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibrations	(-)	Regular	Local	Long	High	Certain	Critical	X	X	X
Artificial lighting	(-)	Regular	Local	Moderate	Medium	Possible	Moderate		X	
Receptor:	**Marine Mammals**				**Sensitivity:**	**Medium**				

Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Noise & vibrations	(-)	Regular	Local	Long	High	Certain	Critical	X	X	X
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Artificial lighting	(-)	Regular	Local	Moderate	Medium	Possible	Moderate		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibrations	(-)	Regular	Local	Long	Low	Certain	Moderate	X		X
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Artificial lighting	(-)	Regular	Local	Moderate	Low	Possible	Minor		X	

Table 6-18: Impact significance assessment for the ***Aquaculture Module (on CU)*** *in the* ***Green & Blue scenario, Liuqiu Island****. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	Air Quality				Sensitivity:	Low				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Regular	Local	Short	Low	Probable	Moderate	X	X	X
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Water Temperature**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA	X	X	X
Receptor:		**Sediment Quality**			**Sensitivity:**		**Medium**			
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Low	Certain	Moderate		X	
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Low	Certain	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Low	Certain	Moderate	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				

Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Solid & liquid waste	(-)	Regular	Local	Moderate	Low	Certain	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Low	Certain	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate		X	
Emissions to atmosphere	(-)	Regular	Local	Short	Low	Probable	Moderate	X	X	X
Receptor:	**Marine Mammals**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Emissions to atmosphere	(-)	Regular	Local	Short	Low	Probable	Moderate		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate		X	
Emissions to atmosphere	(-)	Regular	Local	Short	Low	Probable	Moderate		X	

Table 6-19: Impact significance assessment for the ***Satellite Unit Fish Farm*** *in the* ***Green & Blue scenario, Liquiu Island****. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Long	High	Certain	Critical	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Water Temperature**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structures	(-)	Regular	Local	Long	Medium	Certain	Major	X	X	X

Receptor:	Sediment Quality			Sensitivity:	Medium					
Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Solid & liquid waste	(-)	Regular	Local	Long	Medium	Certain	Major	X	X	X
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X		X
Receptor:	**Landscape/Seascape**			**Sensitivity:**	**Low**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Microorganisms**			**Sensitivity:**	**Low**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Regional	Moderate	Medium	Certain	Major		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Low	Possible	Minor		X	
Receptor:	**Benthic Fauna & Flora**			**Sensitivity:**	**Medium**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structures	(-)	Regular	Local	Long	Medium	Probable	Moderate	X	X	X
Noise & vibration	(-)	Occasional	Local	Short	Medium	Probable	Moderate	X		
Escape of fish	(-)	Occasional	Regional	Long	High	Probable	Major		X	
Solid & liquid wastes	(-)	Regular	Local	Long	High	Certain	Critical		X	X
Introduction of alien species	(-)	Occasional	Regional	Long	High	Probable	Major		X	
Attraction of wild animals	(-)	Occasional	Local	Long	Medium	Probable	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Moderate	Medium	Possible	Moderate	X	X	X
Receptor:	**Pelagic Fauna & Flora**			**Sensitivity:**	**Low**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Short	Low	Probable	Minor	X		
Physical impact of structures	(-)	Regular	Local	Long	Medium	Certain	Major	X	X	
Escape of fish	(-)	Occasional	Regional	Long	High	Probable	Major		X	
Solid & liquid wastes	(-)	Regular	Local	Long	Medium	Certain	Major		X	X
Introduction of alien species	(-)	Occasional	Regional	Long	Medium	Probable	Major		X	
Attraction of wild animals	(-)	Occasional	Local	Moderate	Medium	Probable	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Long	Medium	Possible	Moderate	X	X	X
Receptor:	**Fish & Turtles**			**Sensitivity:**	**High**					
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Short	High	Probable	Major	X	X	X
Physical impact of structures	(-)	Regular	Local	Long	Medium	Probable	Moderate	X	X	
Solid & liquid waste	(-)	Regular	Local	Long	High	Certain	Critical	X	X	X
Escape of fish	(-)	Occasional	Regional	Long	High	Probable	Major		X	
Attraction of wild animals	(-)	Occasional	Local	Moderate	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Occasional	Regional	Long	High	Probable	Major		X	
Harmful substances & materials	(-)	Rare	Local	Long	High	Possible	Moderate	X	X	X

Artificial lighting	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Regional	Short	Medium	Probable	Moderate	X	X	X
Physical impact of structures	(-)	Rare	Local	Long	Medium	Unlikely	Minor	X	X	
Solid & liquid wastes	(-)	Rare	Local	Long	Low	Unlikely	Minor	X	X	X
Escape of fish	(-)	Occasional	Local	Long	Low	Probable	Moderate		X	
Attraction of wild animals	(-)	Occasional	Local	Moderate	Medium	Possible	Moderate		X	
Introduction of alien species	(-)	Occasional	Local	Long	Low	Probable	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Long	Low	Possible	Minor	X	X	X
Artificial lighting	(-)	Regular	Local	Regular	Medium	Certain	Major		X	
Receptor:	**Marine Mammals**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Regional	Long	High	Probable	Major	X	X	X
Physical impact of structures	(-)	Occasional	Regional	Long	High	Possible	Moderate	X	X	
Solid & liquid wastes	(-)	Regular	Regional	Long	High	Certain	Critical	X	X	X
Escape of fish	(-)	Occasional	Regional	Long	Low	Probable	Moderate		X	
Attraction of wild animals	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Introduction of alien species	(-)	Occasional	Regional	Long	Medium	Probable	Moderate		X	
Harmful substances & materials	(-)	Rare	Local	Long	Medium	Possible	Moderate	X	X	X
Artificial lighting	(-)	Regular	Local	Moderate	Medium	Certain	Major		X	
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Occasional	Local	Short	Low	Possible	Minor	X	X	
Solid & liquid waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Harmful substances & materials	(-)	Rare	Local	Long	Low	Possible	Minor		X	

*Table 6-20: Impact significance assessment for the **Satellite Unit Algae Farm** in the **Green & Blue scenario, Liuqiu Island**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Probable	Moderate	X	X	X
Receptor:	**Water Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of accident & unplanned event	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Solid & liquid waste	(-)	Regular	Regional	Moderate	Medium	Certain	Major		X	
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	
Receptor:	**Water Temperature**				**Sensitivity:**	**Medium**				

Stressor	Impact							Phase		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Sediment Dynamics**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Receptor:	**Sediment Quality**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Long	Medium	Certain	Major	X	X	X
Receptor:	**Landscape/Seascape**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Regular	Local	Long	Low	Possible	Minor		X	
Receptor:	**Microorganisms**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of accident & unplanned event	(-)	Rare	Local	Short	Low	Possible	Minor		X	
Solid & liquid waste	(-)	Regular	Regional	Moderate	Medium	Certain	Major		X	
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of accident & unplanned event	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Solid & liquid waste	(-)	Regular	Local	Moderate	Medium	Certain	Major	X	X	X
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Risk of accident & unplanned event	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Solid & liquid waste	(-)	Regular	Local	Moderate	Low	Certain	Moderate	X	X	X
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structure	(-)	Regular	Local	Long	High	Possible	Moderate	X	X	
Solid & liquid waste	(-)	Regular	Regional	Long	High	Certain	Critical	X	X	X
Risk of accident & unplanned event	(-)	Rare	Local	Short	Low	Possible	Minor	X	X	X
Attraction of wild animals	(-)	Occasional	Local	Moderate	Medium	Possible	Moderate		X	
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	
Noise & vibrations	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	X
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structure	(-)	Rare	Local	Long	Medium	Unlikely	Minor	X	X	
Solid & liquid waste	(-)	Rare	Local	Long	Low	Unlikely	Minor	X	X	X
Risk of accident & unplanned event	(-)	Rare	Local	Short	Low	Possible	Minor		X	

Attraction of wild animals	(-)	Occasional	Local	Moderate	Medium	Possible	Moderate		X	
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Noise & vibrations	(-)	Rare	Local	Moderate	Medium	Unlikely	Minor	X	X	
Receptor:	**Marine Mammals**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structure	(-)	Occasional	Regional	Long	High	Possible	Moderate	X	X	
Solid & liquid waste	(-)	Regular	Regional	Long	High	Certain	Critical	X	X	X
Risk of accident & unplanned event	(-)	Rare	Regional	Short	Low	Possible	Minor	X	X	X
Attraction of wild animals	(-)	Occasional	Regional	Moderate	Medium	Probable	Moderate		X	
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	
Noise & vibrations	(-)	Occasional	Regional	Long	High	Possible	Moderate	X	X	X
Receptor:	**Humans**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Solid & liquid waste	(-)	Rare	Local	Short	Low	Unlikely	Minor	X	X	X
Emissions to atmosphere	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	
Noise & vibrations	(-)	Occasional	Local	Short	Low	Possible	Minor		X	

*Table 6-21: Impact significance assessment for the **OTEC Plant** in the **Green & Blue scenario, Liuqiu Island**. For the methodology see 6.2.4. Positive impacts are marked in green. Phase: construction (C), operational (O), decommissioning (D); not applicable (NA).*

Receptor:	**Air Quality**			**Sensitivity:**		**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Water Quality**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impacts	(-)	Regular	Regional	Long	Low	Probable	Moderate		X	
Harmful substances & materials	(-)	Occasional	Local	Short	Low	Probable	Moderate		X	
Receptor:	**Water Temperature**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Heat Energy	(-)	Regular	Local	Long	Medium	Certain	Major		X	
Receptor:	**Sediment Dynamics**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structures	(-)	Occasional	Local	Moderate	Low	Probable	Moderate	X		X
Receptor:	**Sediment Quality**			**Sensitivity:**		**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Harmful substances & materials	(-)	Rare	Local	Short	Low	Unlikely	Minor		X	
Receptor:	**Landscape/Seascape**			**Sensitivity:**		**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
No impact	NA	NA	NA	NA	NA	NA	NA			
Receptor:	**Microorganisms**			**Sensitivity:**		**Low**				

Stressor	Impact							Phase		
Name	Nature	Frequency	Extent	Duration	Magnitude	Likelihood	Significance	C	O	D
Harmful substances & materials	(-)	Occasional	Local	Moderate	Low	Possible	Minor		X	
Receptor:	**Benthic Fauna & Flora**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structures	(-)	Occasional	Local	Moderate	Low	Probable	Moderate	X		X
Noise & vibration	(-)	Rare	Local	Short	Low	Probable	Moderate	X		
Receptor:	**Pelagic Fauna & Flora**				**Sensitivity:**	**Low**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structures	(-)	Regular	Local	Long	Medium	Certain	Major		X	
Noise & vibration	(-)	Rare	Local	Short	Low	Possible	Minor	X		
Heat Energy	(-)	Regular	Local	Long	Medium	Certain	Major		X	
Harmful substances & materials	(-)	Occasional	Local	Short	Low	Probable	Moderate		X	
Receptor:	**Fish & Turtles**				**Sensitivity:**	**High**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structures	(-)	Regular	Local	Long	Medium	Possible	Moderate		X	
Noise & vibration	(-)	Occasional	Local	Short	Medium	Probable	Moderate	X		
Heat Energy	(-)	Regular	Regional	Long	High	Possible	Moderate		X	
Harmful substances & materials	(-)	Occasional	Local	Short	Medium	Probable	Moderate		X	
Receptor:	**Birds & Bats**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Rare	Local	Moderate	Low	Possible	Minor	X		
Receptor:	**Marine Mammals**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Physical impact of structures	(-)	Regular	Regional	Long	Low	Probable	Moderate		X	
Noise & vibration	(-)	Rare	Regional	Short	Medium	Possible	Moderate	X		
Receptor:	**Humans**				**Sensitivity:**	**Medium**				
Stressor	**Impact**							**Phase**		
Name	**Nature**	**Frequency**	**Extent**	**Duration**	**Magnitude**	**Likelihood**	**Significance**	**C**	**O**	**D**
Noise & vibration	(-)	Rare	Local	Short	Low	Probable	Moderate	X		

6.5 CUMULATIVE EFFECTS

Cumulative effects involve several impacts, often caused by different activities/stressors, affecting the same receptor in combination (see chapter 6.2.3).

A potential cumulative impact at the Leisure Island Scenario, Gran Canaria, is generated by noise from frequent vessel traffic and from the leisure facilities, and by artificial lighting from the leisure facilities. Taken alone, all the effects are of major or even critical significance for fish and turtles, and marine mammals. In combination, these effects may sum up to an even more detrimental and critical effect. It is difficult to predict cumulative impacts and their consequences, but the additive effects of noise and light on the marine fauna, in particular marine mammals, fish and turtles need to be reduced as much as possible and they have to be subject to comprehensive monitoring.

For the Green & Blue Scenario off Crete, so far no cumulative effects are expected.

In the Green & Blue Scenario off Liuqiu Island, similar cumulative effects to Leisure Island may arise, in particular because this scenario involves additional leisure facilities. Noise is generated from vessel traffic and leisure facilities, affect in particular fish and turtles and marine mammals in combination with artificial lighting from the leisure facilities. As for the Leisure Island Scenario, a strict mitigation and monitoring is required. Another potential cumulative effect may come from solid and liquid wastes. Waste and wastewater are produced in larger amounts in this scenario due to presence of visitors and leisure facilities, but waste entering the water is also produced by the aquaculture farms. Release of any sewage from the central unit and associated leisure facilities should be avoided by all means to reduce the cumulative negative effect of waste and wastewater on water quality and the marine living community.

7 FRAMEWORK FOR MITIGATION, MANAGEMENT AND ENVIRONMENTAL MONITORING

7.1 MITIGATION MEASURES

To reduce or avoid potential negative impacts of the TROPOS elements on the environment, appropriate mitigation measures are required; in particular for impacts expected to be of major or critical significance for the ecosystem and its receptors. There are different strategies for mitigation, ranging from changes in design of structures to on-site reduction or avoidance of the impact. It is of major importance that the best available practice is always used.

Below are shown, negative impact mitigation measures for each element of the TROPOS case scenarios. Though platform construction and disassembly will take place in a shipyard (see Chapter 6.3.10 above), there are some important issues applying to the whole construction – the CU and all satellites – to consider:

- On-site, offshore, mooring installation as well as platform anchoring and decommissioning should be scheduled outside of phases with high abundances, seasonal migration and/or breeding seasons of fish, turtles, birds and marine mammals.
- Assuming enhanced benthic production on the artificial hard substrates during the platform operation, mooring and anchors should be removed carefully, and maybe even left on-site at decommissioning.
- Careful and economical use of goods, energy and (fresh) water are essential.
- Recycling and reusing of resources (e.g. water) wherever possible.

However, some of the negative impacts can be efficiently mitigated (e.g. disposal of waste into the sea), while others can possibly be reduced, but not avoided (e.g. artificial lighting or noise generation).

7.1.1 VESSEL TRAFFIC

Mitigation measures to reduce/avoid negative impact of vessel traffic on the environment are summarised in ANNEX, Table 11-1.

The **physical impact** of ships:

- Reduction/minimisation of ships traffic by joint logistics.

Risk of accidents & unplanned events and negative effects from **Harmful substances and materials** can be mitigated by:

- Reduction/minimisation of ships traffic by joint logistics.
- Use of the Traffic Monitoring System.
- Use of ships with double hulls.
- Regular careful inspection and maintenance of the machine.
- Emergency preparedness, prevention response.
- Use of nontoxic anti-fouling paint.

Noise & vibrations and **emissions to atmosphere** can be significantly reduced to acceptable levels by:

- Reduction/minimisation of ships traffic by joint logistics.

- Regular careful inspection and maintenance of the machine.
- Use of high-quality fuel.
- Regular state control of ships.

Solid and liquid wastes are reduced and best handled with:

- Efficient waste and wastewater treatment on board.
- Reduction of waste production.

The risk of **Introduction of alien species** can be reduced by:

- Ballast water control and management;

It is essential that the ships used for (tourist) shuttle, service and maintenance meet the highest standards concerning technology, equipment, operation and security.

7.1.2 CENTRAL UNIT

Mitigation measures to reduce/avoid negative impact on the environment arising from the Central Unit are summarised in ANNEX, Table 11-2.

Mitigation of negative **physical impacts** and increased **risk of accidents & unplanned events** involve:

- Selection of signals and indications that could avoid collision.
- Definition of protocols to follow in case of spillage and methodologies for quick treatment of pollutants.
- Ensure that the equipment used remains in optimum working conditions.
- Consider using elasticated mooring risers in sensitive areas or areas with strong tides.
- Increase time spacing between operations to allow for turbidity decrease.
- Simple model involving flight lines/densities recorded during boat survey.
- Study the habitats of the different marine mammals.
- Previous analysis of the placement of the structure.
- Pass bilge water through a bilge separator before being discharged to the sea.
- Protocol for depollution in case of spill.
- Brine water dilution with seawater or cooling water.
- Brine water collection.

Negative impacts of **solid and liquid wastes** and **harmful substances and materials** can be avoided/reduced by:

- Dilution of releases with marine water, secondary treatments implementation for bacterial decay and correct use of sanitation systems.
- Efficient waste and wastewater treatment and management.

- Sealed systems of storage and evacuation. Definition of protocols in case of spill.
- Oil discharge and monitoring system. Fuel and oil treatment and purification and reuse. Preparedness for and Response to pollution Incidents.
- Specific design of discharge outlets to the sea, to maximize dispersion and dilution

Introduction of alien species can be mitigated by:

- Biofouling treatment of ballast tanks/water.

7.1.3 MODULE LEISURE

Mitigation measures to reduce/avoid negative impact on the environment generated by the different Leisure facilities are summarised in ANNEX, Tables 11-3 and 11-4.

Potential measures to mitigate negative effects of **solid and liquid wastes** and **harmful substances and materials** include:

- Efficient waste and wastewater treatment and proper transportation.
- Emergency preparedness, prevention response.
- Using ecological material, design packages minimising the consumption of material.
- Recycle & reuse wherever possible.
- Proper planning and equipment.
- Efficient waste and wastewater treatment and proper transport.
- Composting food waste.
- Emergency preparedness, prevention response.
- Green restaurants: recycled materials, including low-flow fixtures, energy-efficient appliances.
- Use BAT for reducing water use such as vacuum toilets
- Improved technology to reduce water pollution.
- Avoiding the use of products that can be harmful to the natural populations.
- Special care in the storage and handling of all chemicals.
- Regular control of equipment.

Physical impacts, mainly due to diving activities, can be reduced by:

- Obligatory attendance of a pre-activity briefing.
- Use of proper equipment.
- Implementation of maximum feasible reduction measures.
- Promoting environmental awareness achieved through nautical activities.

Noise and vibration impacts may be reduced by:

- Noise measurement.

- Proper acoustic isolation of bars and other leisure facilities.
- Ecodesign of boats.
- Regular checking of boats machines
- Reduction of ships traffic by joint logistics.
- Using low-noise machines to reduce noise generation.

The negative impact of **artificial lighting** can be reduced by:

- Reducing the levels of light needed for a safe illumination.
- Minimise artificial lighting during the night.
- Ensuring that after sunset lights level in bars, restaurants, etc. are significantly reduced.
- Ensuring that after sunset light does not escape/exit from bars, restaurants, etc. (e.g. by lightproof curtains), in particular not from underwater bars.
- Use of suitable light with less-disturbing wavelengths.

7.1.4 MODULE AQUACULTURE

Mitigation measures to reduce/avoid negative impact on the environment generated by the Aquaculture Module on board the CU are summarised in ANNEX, Table 11-5.

Negative effects of **solid and liquid wastes** and **harmful substances and materials** can be mitigated by:

- Collection of intestines and other organic materials separately for processing into by-products.
- Designing the production line so that the cooling water, storm water and process effluents can be kept separate to permit appropriate treatment options.
- Conducting a dry pre-cleaning of equipment and production areas before wet cleaning.
- Fit and use floor drains and collection channels with girds and screens and/or traps, to reduce the amount of solids entering the waste water.
- Choosing cleaning agents that do not have adverse impacts on the environment in general.
- Optimising the use of the cleaning agents through correct dosage and application.
- Avoiding cleaners that contain active chlorine or restricted use chemicals.
- Appropriate residues management.
- Using ecological material.
- Designing packages minimising the consumption of material.
- Periodic checking and maintenance of the installation to ensure its efficiency.
- Monitoring of the efficiency of the use of the wastewater.
- Avoiding the use of products that can be harmful to the natural populations.
- Special care in the storage and handling of all chemicals and fuels.
- Avoiding the use of chemicals near the water.

Emissions to the atmosphere can be reduced by:

- Periodic checking and maintenance of the installation to ensure its efficiency and proper functioning.
- Using ecological cold storages.
- Operating the cold storages according to a schedule to reduce the activity of unnecessary units.

7.1.5 MODULE PV PLANT

Mitigation measures to reduce/avoid negative impact on the environment generated by the PV plant are summarised in ANNEX, Table 11-6.

Physical impacts and **noise & vibration** can be reduced by:

- Careful installation to reduce disturbance.
- Careful removal to reduce impact to a minimum.

Negative impacts due to **light reflections** and **heat energy** can be mitigated by:

- Use of appropriate material and technique that minimises light reflections of panels.
- Use prevention techniques to avoid birds landing on the panels, displace birds.
- Cleaning activity to happen close to sunrise to avoid any post-cleaning stain caused by birds landing on the panels.

The impact of **electromagnetic fields** and **physical impacts** of cable laying on the environment can be significantly reduced by:

- Pre-lay survey to minimise the impact of cable route.
- Careful installation.
- Ensuring appropriate isolation of cables.
- Installation of artificial structures after burying the subsea cable to re-build marine habitat.

7.1.6 SATELLITE UNIT ALGAE FARM

Mitigation measures to reduce/avoid negative impact of the Algae Farm on the environment are summarised in ANNEX, Table 11-7.

Potential **physical impacts of the structure** can be minimised by:

- Use of cage design, material and mesh size that minimises risk of entanglement.
- Regular control of the installations and maintenance of the components.
- Safety structures to avoid direct interactions between the paddlewheel and wild animals.
- Careful installation and decommission of parts.

Solid and liquid waste and **emissions to atmosphere** can be reduced by:

- Monitoring the composition of water and structure of the soil.
- Adjusting the addition of nutrients to growth of the microalgae.
- Analysing the water before release it to the sea water.
- Monitoring the level of CO_2 in the storage.
- Careful installation and decommission of parts.

Negative impacts of **noise and vibration** can be mitigated by:

- Regular checking and maintenance of harvester, centrifuge and thrusters.

7.1.7 SATELLITE UNIT FISH FARM

Mitigation measures to reduce/avoid negative impact of the Fish Farm Unit on the environment are summarised in ANNEX, Table 11-8.

Physical impacts of the structures on the living environment can be significantly reduced by:

- Using a cage design, material and mesh size that minimises risk of entanglement.
- Regular control of the installations.
- Study of the location of the cages.
- Careful choice of appropriate anchor.

Negative impacts of **harmful substances and materials** can be avoided by:

- Using recognised, environmentally safe and copper free anti-fouling agents to clean the nets.
- Avoiding the use of substances and products that can be harmful to the natural populations, and that can accumulate along the food chain.
- Special care in the storage and handling of all chemicals and fuels.
- Avoiding the use of chemicals near the water.
- If treatment with chemicals/pharmaceuticals is required it should be applied in a separated closed system to avoid release into environment.
- Emphasis should be placed on preventive measures so the use of chemicals would be the last resort.
- Keeping records of the treatments to evaluate them.

The negative effect of **solid (and liquid) waste** can be avoided by:

- Designing the feeding program considering feed, stage of growth, species, water quality, weather conditions and tide patterns.
- Using Integrated multitrophic aquaculture (IMTA).
- Adaptation of the diet.

- Elimination of dead fish.

The **escape of fish** can be mitigated by:

- Development of a safe mechanism for the maintenance of the cages to prevent escapes.
- Development of a safe mechanism for the seed.
- Development of a strategy for the harvest that reduces the risk of escape.
- Checking the installation before the seeding.
- Periodic checking and maintenance of the installations to avoid mass escapes.
- Maintenance of the equipment needed for harvesting.

The **attraction of wild animals** can be reduced by:

- Refraining from feeding wild animals.
- Adjusting the feed to the consumption by the cultured fish.
- Turning off the light when it is not needed to reduce attraction by light.
- Avoiding the escape of fish.

The **introduction of alien species** should be avoided by:

- Selection of native species.
- Careful checking of the health of the juveniles.
- Careful selection of high quality, healthy seed.
- Biology and ecology knowledge.

7.1.8 WIND ENERGY SATELLITE UNIT

Mitigation measures to reduce/avoid potential negative effects of the Wind Energy Satellite Units on the environment are summarised in ANNEX, Table 11-9.

Negative **physical impacts** and the **risk of accidents and unplanned events** due to the structures can be reduced by:

- Strict observance of tow, construction and operational phases, implementation of best management practices.
- All boat traffic will be prohibited during the construction and decommissioning phases.
- Human observers on vessels, especially during migration & breeding seasons of endangered species.
- Strict observance of boat safety rules and quarterly emergency management drills.
- Strict observance and practice of accident prevention and management for all employees.
- Selection of signals and indications that could avoid collision.
- For cable connection to shore, avoid sensitive, protected, or recreational areas along the coast.
- Schedule annual visit when no migration or presence of endangered species.
- Light signals to make birds aware of the structure.

The impact of **artificial lighting** on the environment can be minimised by:

- Limiting the number of lights and flashing lights.
- Finding the optimum balance between needs for artificial lights and protection of the marine environment.

Negative effects of **solid and liquid wastes** and **harmful substances and materials** can be mitigated by:

- Strict observance and implementation of operational best management practices may minimise potential negative consequences.
- If treatment with chemicals for bio-fouling is required it should be applied in a separated closed system to avoid release into environment.
- Avoiding the use of harmful substances and products that can be accumulated in the trophic chain; seek biodegradable substances wherever possible.
- Removal of any harmful substances and materials from turbines and/or cables on shore at shipyard minimises marine impacts.

Impacts of **heat energy** and **electromagnetic fields** coming from the undersea cables can be mitigated by:

- Pre-lay survey to minimise the impact of cable route.
- Careful installation, i.e., using best available techniques and materials.
- Ensure appropriate isolation of cables.
- Deeper trenching of cables to shore may reduce potential heat energy.

7.1.1 SATELLITE UNIT OTEC PLANT

Mitigation measures to reduce/avoid negative impact of OTEC on the environment are summarised in ANNEX, Table 11-10.

The **physical impact** and **noise and vibration** from an OTEC plant can be mitigated by:

- Careful installation and removal.
- Appropriate pre-monitoring and analysis of water column stratification and distribution of organisms.
- Screens on the intakes.
- Collect and release rare organisms in the cold water and warm water sumps.
- Avoid discharge to any sensitive layers.
- Discharge at sufficient depth, below main pycnocline.

Also, the negative impact from **heat energy**, can be reduced by:

- Appropriate pre-monitoring and analysis of water column stratification and distribution of organisms.
- Avoiding discharge to any sensitive layers.

The impact of **harmful substances and materials** from cleaning of the heat exchangers can be reduced by:

- Minimising the use of chlorination.
- Keeping concentrations below the maximum permitted.

7.2 MANAGEMENT PLAN

The operation of the different TROPOS scenarios will require appropriate management schemes to ensure best feasible protection of the environment. Best Available Practice (BAP) and Best Management Practice (BMP), respectively, should be applied in all cases. Best available material and up-to-date techniques should be used for construction, operation and decommissioning of the platforms and all their elements. Efficient safety and emergency response involving fast reaction for the platform including all elements, as well as for vessel traffic, are essential to avoid accidents and unplanned events and their impact on the environment. Comprehensive waste and wastewater management, including recycling, treatment, and safe transport to shore are of major importance. The light and noise regime will require appropriate management, in particular in the Leisure Island Scenario, but also in the Green & Blue Scenario in Taiwan which includes some leisure facilities. An optimum management plan has to be thoroughly developed and carefully prepared for each scenario, with sustainable use of resources, resource sharing and an efficient logistic management being important components.

7.3 MONITORING STRATEGY

An efficient and comprehensive monitoring strategy is required to test the correctness and efficiency of applied mitigation measures. In particular, stressors and receptors identified as being of major or of critical significance in the scope of the EIA need to be well monitored. Endangered species and key species of the particular ecosystem should be monitored in all of the cases to assure that no impact was missed or overlooked in the EIA. An appropriate monitoring programme for the TROPOS Scenarios is developed in deliverable D6.3.

8 CONCLUSIONS

For an EIA, there are general guidelines and defined contents that should be included, but there are no strict or fixed rules on how to perform the procedure exactly. The impact assessment, to a certain degree, is always influenced by the personal opinion of the person carrying out the assessment, thus, the assessment may be subjective. The evaluation of impacts and its consequences is often difficult and uncertain, in particular in such a virtual approach carried out here in the framework of TROPOS.
However, the methodology developed in the scope of this deliverable may provide a valuable guideline for future EIAs, and the virtual impact assessments carried out for the three considered scenarios represent a good approximation and a valuable basis to develop a monitoring strategy and to adapt design and management of the platforms to mitigate the identified negative impacts on the environment.

In total, a multitude of potential impacts were identified for each scenario, most of them of only minor or moderate significance. The Green & Blue Scenario off Crete is not expected to have very critical detrimental effects on the environment, because the existing environment is not of extremely high sensitivity and it is very deep there. However, the waters are phosphorous-limited and the deposits and remains from the fish aquaculture may result in a boost of local primary production due to phosphorous input. For the Leisure Island scenario off Gran Canaria, noise from vessel traffic and operation of leisure facilities, as well as artificial lighting from bars and restaurants have been identified as the most critical effects. The Green & Blue scenario in Taiwan involves aquaculture as well as some leisure facilities, i.e. noise and artificial lighting are impacts to consider here, as well. Additionally, solid and liquid wastes from leisure facilities and the fish aquaculture may in combination significantly affect water quality and the living community.

While some of the negative effects identified, such as impacts due to waste and wastewater, can be efficiently mitigated by an appropriate treatment and management, other negative effects, such as noise generated by mooring installation, vessel traffic and leisure facilities or artificial lighting are difficult or impossible to avoid. These impacts can be reduced using appropriate mitigation measures, but the reduction capabilities are limited. The effect of these stressors on the environment will need comprehensive monitoring and appropriate management. Accordingly, for those impacts which cannot be avoided, an appropriate monitoring strategy and efficient management plans are needed, to minimise long-term negative effects on the environment.

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10 ACRONYMS

AC	Alternating Current
AQ	Air Quality
BAP	Best Available Practice
BB	Birds and Bats
BFF	Benthic Flora and Fauna
BMP	Best Management Practice
CU	Central Unit
DC	Direct Current
EC	European Commission
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EU	European Union
FCR	Feed Conversion Ratio
FT	Fish and Turtles
H	Humans
IUCN	International Union for the Conservation of Nature
L/S	Landscape/Seascape
MAP	Modified Atmosphere Packaging
MI	Microorganisms
MM	Marine Mammals
OTEC	Ocean Thermal Energy Conversion
PFF	Pelagic Flora and Fauna
ROV	Remotely Operated Vehicle
SD	Sediment Dynamics
SQ	Sediment Quality
TEAL	Transport, Energy, Aquaculture, Leisure
UNEP	UN Environmental Programme
WT	Water Temperature

WQ	Water Quality

11 ANNEX PART A

11.1 ENVIRONMENTAL IMPACT ASSESSMENT & MITIGATION – SUMMARY TABLES

11.1.1 VESSEL TRAFFIC

Table 11-1: EIA summary of ***Vessel Traffic*** *(Transport, supply, service, maintenance, etc.).*

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

CONSTRUCTION, OPERATIONAL & DECOMMISSIONING PHASES					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	Physical Impact	Negative, direct	*Abiotic*: L/S *Biotic*: FT, MM, H	-Presence of ships affects seascape -Increased risk of collisions	(i) Reduction/minimisation of ships traffic by joint logistics; (ii) Use of Traffic Monitoring System; (iii) Regular careful inspection and maintenance of the machine; (iv) Use of high-quality fuel; (v) Regular Port State Control of ships; (vi) Use of ships with double hull; (vii) Emergency preparedness, prevention response; (viii) Ballast water control and management; (ix) Use of nontoxic anti-fouling paint; (x) Efficient waste and wastewater treatment on board
	Noise and vibration	Negative, direct	*Biotic*: FT, MM, BB, H	-Noise from ship's machine may disturb animals & humans	
	Solid and liquid wastes	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	-Pollution of water by sewage, and/or waste -Pollution due to accidents	
	Harmful substances and materials	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	-Release of harmful anti-fouling chemicals -Release of oil/oily waste	
	Emissions to atmosphere	Negative, direct	*Abiotic*: AQ *Biotic*: H	-Emissions to air (CO_2)	
	Risk of accidents and unplanned events	Negative, direct & indirect	*Abiotic*: WQ, SQ, L/S *Biotic*: MI, PFF, BFF, FT, BB, MM, H	-Increased risk of accidents due to increased amount of ships and traffic	
	Introduction of alien species	Negative, direct & indirect	*Biotic*: MI, PFF, BFF, FT, BB, MM	-Introduction of alien species in ballast water and/or ship's hull (bio-fouling)	

11.1.2 CENTRAL UNIT

*Table 11-2: EIA summary of the **central unit***

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

<table>
<tr><th colspan="6">CONSTRUCTION PHASE</th></tr>
<tr><th>ACTIVITY</th><th>STRESSORS</th><th>NATURE OF IMPACT</th><th>RECEPTORS</th><th>IMPACT DETAILS</th><th>MITIGATION OPTIONS</th></tr>
<tr><td>Vessel Traffic</td><td colspan="5">See Table 11-1</td></tr>
<tr><td rowspan="3">Positioning and installation of platform (including mooring)</td><td>Risk of Accidents and Unplanned Events</td><td>Negative, direct</td><td>Abiotic: WQ, SQ
Biotic: MI, PFF, BFF, FT, BB, MM, H</td><td>-Increased risk of accidents due to increased amount of machines used for installation</td><td rowspan="3">(i) Selection of signals and indications that could avoid collision
(ii) Definition of protocols to follow in case of spillage and methodologies for quick treatment of pollutants
(iii) Reduce to the minimum the installation machinery required and the time span for installation manoeuvres by selecting the correct weather window
(iv) Ensure that the equipment used remains in optimum working conditions</td></tr>
<tr><td>Harmful substances and materials</td><td>Negative, direct & indirect</td><td>Abiotic: WQ, SQ
Biotic: MI, PFF, BFF, FT, BB, MM, H</td><td>-Potential release of pollutants from construction plant such as accidental spillage of petroleum products and chemicals delivered to the site</td></tr>
<tr><td>Physical Impacts</td><td>Negative, direct & indirect</td><td>Abiotic: WQ, SQ, SD, L/S
Biotic: MI, BFF, PFF, FT, BB, MM</td><td>-Risk for collision of birds with the installation equipment
-Temporary increases in sediment deposition
-Turbidity, smothering of seabed sediment/rock, fine sediment deposition that may affect benthic & pelagic habitat and communities
-Loss of habitat</td></tr>
</table>

Positioning and installation of platform *(continued)*	Emissions to atmosphere	Negative, direct	*Abiotic*: AQ	-Air emissions generated to support the operation of heavy equipment	
	Noise and vibrations	Negative, direct	*Biotic*: FT, BB, MM	- Disturbance/displacement of fish, birds and mammals from construction noise	(i) When anchored or moored keep noise and disturbance to a minimum and take care when selecting landing sites (ii) Consider using elasticated mooring risers in sensitive areas or areas with strong tides (iii)Increase time spacing between operations to allow for turbidity decrease
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Presence of CU	Physical impact	Negative, direct	*Abiotic:* L/S *Biotic*: BB, MM	-Change of landscape/seascape -Alteration of habitat supporting birds species since the structure acts as barrier for migrating and foraging birds considering the upper part of the structure, and the submerged part acts as a barrier or disturbance for marine mammals that implies fragmentation of habitat	(i) Simple model involving flight lines/densities recorded during boat survey (ix) Study the habitats of the different marine mammals (ii) Previous analysis of the placement of the structure (iii) Pass bilge water through a bilge separator before being discharged to the sea (iv) Protocol for depollution in case of

Presence of CU (*continued*)		Positive, direct and indirect	*Biotic:* PFF, BFF, FT, MM	-The structure may serve as hard substrate for benthic organisms (artificial reef effect) -Structure may serve as refuge and nursery for plankton, turtles and fish -Aggregations of plankton and fish provide food for marine mammals	spill v) Brine water dilution with seawater or cooling water Brine water harvesting
	Shading	Negative, direct & indirect	*Abiotic:* WQ *Biotic:* PFF, BFF, FT	-Shading may affect water quality, primary production and vertical migration patterns	
		Positive, direct & indirect	*Biotic:* FT	-Shaded zone may serve as refuge for fish & turtles from predators	
Evacuation of accumulated water from bilge tanks	Harmful substances and materials	Negative, direct	*Abiotic*: WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM	-Bilge water pumped from the engine may be contaminated with fuel and oil	
Desalination (brine discharge)	Solid and liquid wastes	Negative, direct	*Abiotic:* WQ *Biotic*:MI, PFF, BFF, FT	-Salinity increase triggers chemical unbalance in microorganisms and flora habitat, changing species distribution. -Chemical products release such as surfactants and detergents used in the desalination process.	

	Harmful substances and materials	Negative, direct	*Abiotic:* WQ *Biotic*: MI, PFF, BFF, FT, BB, MM	-Release of antifouling products used in the desalination unit	
Release of CU's ballast water	Introduction of alien species	Negative, direct & indirect	*Abiotic:* WQ *Biotic:* MI, PFF, BFF, FT, MM, H	-Pathogens and toxic organisms such as harmful algae in ballast water. The transferred species may survive to establish a reproductive population in the host environment and may even become invasive out-competing native species and multiplying into pest proportions	(i) Bio-fouling treatment of ballast tanks/water
Accommodation and board for crew/staff	Solid and Liquid wastes	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic:* MI, PFF, BFF, FT, BB, MM	-Faecal bacterial contamination, uncontrolled chemicals and turbidity increase affecting microfauna and benthic flora and fauna	(i) Dilution of releases with marine water, secondary treatments implementation for bacterial decay and correct use of sanitation systems.
	Consumption of energy	Indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Crew/staff members consume energy	(i) Save energy wherever possible
	Consumption of freshwater	Indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Crew/staff members consume freshwater	(i) Avoid waste of freshwater, reuse
	Consumption of goods	Indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Crew/staff members consume goods	(i) Use ecological material (ii) Design packages minimising the consumption of material

	Artificial Lighting	Negative, direct & indirect	*Biotic:* PFF, FT, BB, MM	-Photopollution may affect life cycle patterns of local fauna, and alter daily vertical migration patterns, thereby disrupting trophic interactions	(i) Reduce artificial lighting as much as possible
Daily operations on board	Solid and Liquid wastes	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic:* MI, BFF, PFF, FT, BB, MM, H	-Accidental release of sewage and solid waste and leachates (plastics and other harmful elements) into the marine habitat affect water and sediment quality and organisms incl. humans, may strand on beaches	(i) Efficient waste and wastewater treatment and management (ii) Sealed systems of storage and evacuation. Definition of protocols in case of spill (iii) Oil discharge and monitoring system. Fuel and oil treatment and purification and reuse. Preparedness for and Response to pollution Incidents
	Harmful substances and materials	Negative, direct	*Abiotic*: WQ, SQ *Biotic:* MI, BFF, PFF, FT, BB, MM	-Incidents of fuel, oil and chemical pollution from storage and sedimentation tanks	
	Consumption of energy	Indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Daily operation requires energy	(i) Save energy wherever possible
	Consumption of freshwater	Indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Daily operation consume freshwater (cleaning, kitchen, etc.)	(i) Avoid waste of freshwater, reuse
	Consumption of goods	Indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	- Goods will be consumed during daily operation	(i) Use ecological material (ii) Design packages minimising the consumption of material

Exhaust gases from engines	Emissions to atmosphere	Negative, direct	*Abiotic*: AQ, *Biotic:* H	-Air pollutants contained in exhaust gas, including sulphur oxides (SO_X) and nitrous oxides (NO_X) and volatile organic compounds from tankers affect air quality leading to poor respiratory health and also affect natural environment, such as through acid rain	(i) Extension of designated emission control areas (ECAs) for more stringent control of the emission of SO_X to NO_X and particulate matter (PM) as well
DECOMMISSIONING PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel traffic	*See Table 11-1*				
De-installation of platform (including mooring)	Risk of Accidents and unplanned events	Negative, direct	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Increased risk of accidents due to increased amount of machines used for installation	(i) Selection of signals and indications that could avoid collision
	Physical impacts	Negative, direct	*Biotic*: BB	-Risk for collision of birds with the decommissioning equipment	
	Harmful substances and materials	Negative, direct	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	-Potential accidental spillage of petroleum products and chemicals delivered to the site	(i) Definition of protocols to follow in case of spillage and methodologies for quick treatment of pollutants
	Emissions to atmosphere	Negative, direct	*Abiotic*: AQ	-Air emissions from de-installation equipment	(i) Reduction of the installation machinery to a minimum
Elements left in situ (moorings'	Physical impact	Negative, direct	*Abiotic: SD* *Biotic*: MM	Moorings piles left in place triggers disturbance for marine mammals	(i) Study the habitats of the different marine mammals

piles)					

11.1.3 MODULES

Table 11-3: EIA summary of ***Leisure 1 – Leisure Island, Gran Canaria***

The part "Nautical Activities" includes reception, diving facilities & hyperbaric chamber, and repair and adaptation area for sailing activity. The marina still needs to be specified and is therefore not yet considered in this table. Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

CONSTRUCTION PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Visitors Center	Physical Impact	Negative, direct	*Biotic*: MI,BFF,PFF, FT,BB,MM,H	- Increased numbers of platform visitors	(i) Reduction/minimisation of ships traffic by joint logistics (ii) Efficient waste and wastewater treatment and proper transportation (iii) Reducing the levels of light needed for a safe illumination (iv) Emergency preparedness, prevention response; (v) More sustainable consumption (vi) Aligning mitigation and management strategies (vii) Avoid waste of freshwater, reuse (viii) Use ecological material, design packages minimising the
	Noise	Negative, direct	*Biotic*: FT, MM, BB,H	-Noise may disturb people and animals	
	Solid and liquid wastes	Negative, direct & indirect	*Abiotic*: WQ, SQ, L/S *Biotic*: MI, PFF, BFF, FT, BB, MM, H	-Pollution of water by sewage, and/or waste -Pollution due to accidents	
	Artificial lighting	Negative, direct	*Biotic*: PFF, BFF, FT, BB, MM,H	- The intensity, spectral quality, duration and periodicity of exposure to light affect the biochemistry, physiology and behavior of organisms - Negative health *i*mpacts	

Visitors Center *(continued)*	Emissions to atmosphere	Negative, direct & indirect	*Abiotic*: AQ *Biotic*: H	-Emissions to air (CO_2)	consumption of material (ix) Recycle (x) Save energy wherever possible
	Risk of accidents and unplanned events	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	-Increased risk of accidents due to increased amount of visitors and ferries transport	
	Consumption of energy	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Visitors and staff consume energy	
	Consumption of freshwater	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	- Visitors and staff consume freshwater	
	Consumption of goods	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	- Visitors and staff consume goods	
	Social impact	Negative, direct	*Biotic*: H	- Cost of goods and services - Crowding and congestion	
		Positive, direct & indirect	*Biotic*: H	- New leisure amenities - Improvements to local infrastructure - Promote conservation of wildlife and natural resources through Educational activities	
	Physical Impact	Negative, direct	*Biotic*: MI,BFF,PFF, FT,BB,MM,H	- Increased numbers of platform visitors	(i) Reduction/minimisation of ships traffic by joint logistics

Food & Beverage	Noise	Negative, direct	*Biotic*: FT, MM, BB,H	- Noise may disturb people and animals	(ii) Proper planning and equipment (iii) Efficient waste and wastewater treatment and proper transport (iv) Composting food waste (v) Reducing the levels of light needed for a safe illumination (vi) Emergency preparedness, prevention response (vii) More sustainable consumption (viii) Management strategies (xi) Green restaurants: recycled materials, including low-flow fixtures, energy-efficient appliances (xii) Avoid waste of freshwater, reuse (xiii) Use ecological material, design packages minimising the consumption of material (xiv) Recycle (xv) Save energy wherever possible
	Solid and liquid wastes	Negative, direct & indirect	*Abiotic*: WQ, SQ, L/S *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Pollution of water by sewage, and/or waste - Pollution of solid waste - Pollution due to accidents	
	Artificial lighting	Negative, direct	*Biotic*: PFF, BFF, FT, BB, MM,H	- The intensity, spectral quality, duration and periodicity of exposure to light affect the biochemistry, physiology and behavior of organisms - *Negative* health *impacts*	
	Emissions to atmosphere	Negative, direct & indirect	*Abiotic*: AQ *Biotic*: H	- Emissions to air from energy use for cooking and refrigeration	
	Risk of accidents and unplanned events	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Increased risk of accidents due to increased amount of visitors and ferries transport	
	Consumption of energy	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Visitors and staff consume energy	
	Consumption of freshwater	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	- Visitors and staff consume freshwater	
	Consumption of goods	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF,	- Visitors and staff consume goods	

Food & Beverage *(continued)*			PFF, FT, BB, MM, H		
	Social impact	Negative, direct	*Biotic*: H	- Cost of goods and services	
		Positive, direct & indirect	*Biotic*: H	- New offer - Bolstering the local economy offering local food	
Accommodation	Noise	Negative, direct	*Biotic*: FT, MM, BB,H	- Noise may disturb people and animals	(i) Adequate planning and equipment (ii) Efficient waste and wastewater treatment and proper transportation (iii) Reducing the levels of light needed for a safe illumination (iv) Emergency preparedness, prevention response (v) More sustainable consumption (vi) Recycling (vii) Management strategies (viii) Green hotel: recycled material, energy-efficient appliances Benefits: gaining competitive advantage by being a leader in the sector; customer loyalty; awards and recognition; increased brand value, regulatory compliance (ix) Avoid waste of freshwater, reuse (x) Use ecological material, design packages minimising the consumption of material (xi) Save energy wherever possible
	Solid and liquid wastes	Negative, direct & indirect	*Abiotic*: WQ, SQ, L/S *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Pollution of water by sewage, and/or waste - Pollution of solid waste - Pollution due to accidents	
	Artificial lighting	Negative, direct	*Biotic*: PFF, BFF, FT, BB, MM,H	- The intensity, spectral quality, duration and periodicity of exposure to light affect the biochemistry, physiology and behavior of organisms - *Negative* health *impacts*	
	Emissions to atmosphere	Negative, direct & indirect	*Abiotic*: AQ *Biotic*: H	- Emissions to air (CO_2)	
	Risk of accidents and unplanned events	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Increased risk of accidents due to increased amount of visitors and ferries transport	
	Consumption of energy	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Visitors and staff consume energy	
	Consumption of	Negative,	Abiotic: AQ, WQ,	- Visitors and staff consume	

Accommodation *(continued)*	freshwater	indirect	SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	freshwater	
	Consumption of goods	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	- Visitors and staff consume goods	
	Social impact	Negative, direct	*Biotic*: H	- Cost of goods and service	
		Positive, direct & indirect	*Biotic*: H	- New offer	
Nautical Activities	Physical Impacts	Negative, direct	*Abiotic*: WQ, SQ,SD,SQ *Biotic*: MI, PFF, BFF, FT, BB, MM	- Sailing maintenance activities - Physical impact on feature - Disturbance to wildlife caused by sailing craft & diving - Minimal Impact for erosion and turbidity. Low contact between divers and substrate - Depletion in fish stocks from recreational fishing and angling - Physical damage to the environment such as bad anchorage or wave generation	(i) Adequate planning and equipment (ii) Number of times divers damage decreases with increasing level of diving experience; attending a pre-activity briefing cause less physical damage (iii) Improved technology to reduce water pollution (iv) Noise measurement (v) Efficient waste and wastewater treatment and proper transportation (vi) Reducing the levels of light needed for a safe illumination (vii) High-quality equipment (viii) Implementation of maximum feasible reduction measures (ix) Emergency preparedness, prevention response (x) More sustainable consumption
	Noise	Negative, direct	*Biotic*: FT, MM, BB,H	- Noise from compressors and repair area may disturb people and animals - Noise disturbances from recreational engines - Sounds emitted above the surface of the water	

Nautical Activities *(continued)*				- Underwater sounds	(xi) Recycling (xii) Ecodesing of boats (xiii) Promoting environmental awareness achieved through nautical activities (xiv) Offering hyperbaric oxygen therapy, health and economic benefit (xv) Avoid waste of freshwater, reuse (xvi) Use ecological material, design packages minimising the consumption of material (xvii) Save energy wherever possible
	Solid and liquid wastes	Negative, direct & indirect	*Abiotic*: WQ, SQ, L/S *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Sewage discharge from craft - Pollution due to accidents - Contamination from antifouling paints	
	Artificial lighting	Negative, direct	*Biotic*: PFF, BFF, FT, BB, MM,H	- The intensity, spectral quality, duration and periodicity of exposure to light affect the biochemistry, physiology and behavior of organisms - Underwater lighting	
	Emissions to atmosphere	Negative, direct & indirect	*Abiotic*: AQ *Biotic*: H	- Hydrocarbons releases from recreational craft and private water craft engines	
	Risk of accidents and unplanned events	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Risk of diving accidents	
	Consumption of energy	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Visitors and staff consume energy	
	Consumption of freshwater	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	- Visitors and staff consume freshwater	
	Consumption of goods	Negative, indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	- Visitors and staff consume goods	

Nautical Activities *(continued)*	Social impact	Negative, direct	*Biotic*: H	- Disturbing local sailors	
		Positive, direct & indirect	*Biotic*: H	- New water-based recreation	
DECOMMISSIONING PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				

*Table 11-4: EIA summary of **Leisure 2 – Green & Blue Concept, Liuqiu Island***

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

CONSTRUCTION PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Leisure (Hotel)	Emissions to atmosphere	Negative, direct and cumulative	*Abiotic*: AQ	-Dust will be generated during the construction phase	(i) Use of dust networks to reduce the amount of fugitive dust
	Solid and liquid wastes	Negative, direct and cumulative	*Abiotic*: WQ	-Some wastes may accidentally enter into the sea	(i) Avoidance to discharge waste water and drop solid wastes into the sea during the construction phase
	Harmful substances and materials	Negative, direct, indirect and cumulative	*Abiotic*: WQ, SQ *Biotic:* BFF	- Some heavy metal materials from fuel may accidentally enter the sea and may be disposed in the sediment. - Heavy metals in the sediment may harm benthic organisms	(i) Regular control of equipment (ii) Avoid the use of products that can be harmful to the natural populations (iii) Special care in the storage and handling of all chemicals
	Noise and vibrations	Negative, direct	*Biotic:* FT, BB, MM, H	-Noise and vibrations will be generated during the construction phase and impact the quality of habitat and human life	(i) Using low-noise machines to reduce noise generation.
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Leisure	Solid and liquid	Negative, direct,	*Abiotic*: WQ, SQ	-Some domestic sewage and	(i) Use of an efficient waste

(Hotel)	wastes	indirect and cumulative	*Biotic:* MI, BFF, PFF, FT, MM, H	organic matter may enter the sea -Nutrients may enter the food chain and enhance growth of algae and microorganisms, thereby altering trophic structure and quality of water and sediment	management (ii) Use of efficient sewage treatment systems
	Harmful substances and materials	Negative, direct, indirect and cumulative	*Abiotic*: WQ, SQ *Biotic:* BFF	- Some heavy metal materials from fuel may accidentally enter the sea and may be disposed in the sediment - Heavy metals in the sediment may harm benthic organisms	(i) Regular control of equipment (ii) Avoid the use of products that can be harmful to the natural populations (iii) Special care in the storage and handling of all chemicals
	Consumption of energy	Indirect	*Abiotic*: AQ, WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	-Crew/staff members consume energy	(i) Save energy wherever possible
	Consumption of freshwater	Indirect	*Abiotic*: AQ, WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	-Crew/staff members consume freshwater	(i) Avoid waste of freshwater, reuse
	Consumption of goods	Indirect	*Abiotic*: AQ, WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	-Crew/staff members consume goods	(i) Use ecological material (ii) Design packages minimising the consumption of material
	Noise and vibrations	Negative, direct	*Biotic:* FT, BB, MM, H	-Noise will be generated during operation of accommodation by human activities and impact the quality of habitat and human	

				life	
	Artificial lighting	Negative, direct	*Biotic:* PFF, FT, BB, MM, H	-The light of hotel in the night may affect vertebrates -Light pollution my affect quality of human life	(i) Use of suitable LED lighting (ii) Minimise artificial lighting during the night
DECOMMISSIONING PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Leisure (Hotel)	Emissions to Atmosphere	Negative, direct and cumulative	*Abiotic*: AQ	-Dust will be generated during the decommissioning phase	(i) Use of dust networks to reduce the amount of fugitive dust
	Solid and Liquid Wastes	Negative, direct and cumulative	*Abiotic*: WQ	-Some wastes may accidentally enter into the sea	(i) Avoidance to discharge waste water and drop solid wastes into the sea during the construction phase
	Harmful Substances and Materials	Negative, direct, indirect and cumulative	*Abiotic*: WQ, SQ *Biotic:* BFF	- Some heavy metal materials from fuel may accidentally enter the sea and may be disposed in the sediment - Heavy metals in the sediment may harm benthic organisms	(i) Regular control of equipment (ii) Avoid the use of products that can be harmful to the natural populations (iii) Special care in the storage and handling of all chemicals
	Noise and Vibrations	Negative, direct	*Biotic:* FT, BB, MM, H	-Noise and vibrations will be generated during the decommissioning phase and impact the quality of habitat and human life	(i) Using low-noise machines to reduce noise generation

*Table 11-5: EIA summary of the **Aquaculture module** (on board the CU)*

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

CONSTRUCTION PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See extra table*				
Fish processing plant	Consumption of freshwater	Indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	- Fresh water (liquid or as ice) is used in the processing plant, increasing the consumption of energy and other impact derived from its production	(i) Minimise the use of ice to secure the product quality (ii) Efficiency in the organization of the production to adjust it to the fish collection period (iii) Optimise the process to facilitate cleaning and eliminate wet transport, minimising water consumption (iv) Dry cleaning and efficient cleaning process to reduce the use of water (v) Save energy wherever possible
	Consumption of energy	Indirect	Abiotic: AQ, WQ, SQ Biotic: MI, BFF, PFF, FT, BB, MM, H	-Operation of the fish processing plant needs energy	
	Consumption of goods	Direct & indirect	*Abiotic*: AQ, WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	- Reduction of the environment sustainability due to the consumption of no renewable resources	(i) Use ecological material (ii) Design packages minimizing the consumption of material
	Solid and liquid waste	Negative, direct &	*Abiotic*: WQ, SQ, L/S	- Residual packages parts that can cause injuries and transport harmful	(i) Appropriate residues management

Fish processing plant *(continued)*		indirect	*Biotic*: MI, PFF, BFF, FT, BB, MM, H	chemicals - Residual products that can affect to fisheries and tourism - Organic residues due to fish processing - Waste water due to processing fish and cleaning processes can carry inorganic and/or organic compounds that may accumulate through the food chain or be harmful to the environment	(ii) Formation and awareness of personal (iii) Collect internal organs and other organic materials separately for processing into by-products (iv) Design the production line so that the cooling water, storm water and process effluents can be kept separate to permit appropriate treatment options (v) Conduct a dry pre-cleaning of equipment and production areas before wet cleaning (vi) Fit and use floor drains and collection channels with girds and screens and/or traps, to reduce the amount of solids entering the waste water
	Harmful substances and materials	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	- Water contamination by cleaning agents used for disinfection can widespread in the environment or/and accumulate through the food chain if they are not managed correctly	(i) Choose cleaning agents that do not have adverse impacts on the environment in general (ii) Optimise the use of the cleaning agents through correct dosage and application (iii) Avoid cleaners that contain active chlorine or restricted use chemical (iv) Conduct a dry pre-cleaning of equipment and production areas before wet cleaning
Algae processing	Consumption of energy	Indirect	Abiotic: AQ, WQ, SQ	-Operation of the algae processing plant needs energy	(i) Save energy wherever possible

plant (incl. biorefinery)			Biotic: MI, BFF, PFF, FT, BB, MM, H		
	Consumption of goods	Direct & indirect	*Abiotic*: AQ, WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	- Reduction of the environment sustainability due to the consumption of no renewable resources	(i) Use ecological material (ii) Design packages minimizing the consumption of material
	Solid and liquid waste	Negative, direct & indirect	Abiotic: WQ, SQ, L/S Biotic: FT, BB, MM, H	- Residual packages parts that can cause injuries and transport harmful chemicals - Residual products that can affect to fisheries and tourism	(i) Appropriate residues management (ii) Formation and awareness of personal
		Positive, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	- The biorefinery use part of the fish aquaculture wastewater full of organic compounds for sustainable production	(i) Periodic checking and maintenance of the installation to ensure its efficiency (ii) Monitoring of the efficiency of the use of the wastewater
	Harmful substances and materials	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	- Water contamination by cleaning agents used for disinfection can widespread in the environment or/and accumulate through the food chain if they are not managed correctly	(i) Choose cleaning agents that do not have adverse impacts on the environment in general (ii) Optimise the use of the cleaning agents through correct dosage and application (iii) Avoid cleaners that contain active chlorine or restricted use chemical (iv) Conduct a dry pre-cleaning of equipment and production areas before wet cleaning
Storage	Emissions to atmosphere	Negative, direct &indirect	*Abiotic*: AQ *Biotic*: BB, MM, H	- Cold storages can be filled with gases that in case of release can contribute to climate change	(i) Periodic checking and maintenance of the installation to ensure its efficiency (ii) Use ecological cold storages (iii) Operate the cold storages
	Consumption of energy	Indirect	Abiotic: AQ, WQ, SQ		

Storage *(continued)*			Biotic: MI, BFF, PFF, FT, BB, MM, H		according to a schedule to reduce the activity of unnecessary units
Desalination	Solid and liquid wastes	Negative, direct	*Abiotic*: WQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	- The desalination of water generates a high salinity effluent that will be discharged in the water - It may affect to the distribution and ecology of organisms	(i) Periodic checking and maintenance of the installation to ensure its efficiency (ii) Monitoring of the composition of the water before release (iii) Periodic monitoring of the water composition and sediment structure
	Consumption of freshwater	Positive: direct	*Abiotic*: WQ, SQ, AQ, S/L *Biotic*: MI, BFF, PFF, FT, BB, MM, H	- Autonomous freshwater production, no freshwater import required	
Maintenance	Harmful substances and materials	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Chemicals used in maintenance activities may pose environmental threats such as toxic contamination, damage to the ecology, bioaccumulation, etc.	(i) Avoid the use of products that can be harmful to the natural populations (ii) Special care in the storage and handling of all chemicals and fuels (iii) Avoid the use of chemicals near the water
DECOMMISSIONING PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				

Table 11-6: EIA summary of the ***PV module***

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H); * only valid for the PV Plant of the Green & Blue Concept (Crete)

CONSTRUCTION PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Installation of panels	Physical impact	Negative, direct	*Biotic*: FT, BB, MM	- Physical disturbance due to panels structure and installation	(i) Careful installation to reduce disturbance (ii) Use material and technique that minimises light reflections of panels
	Noise and vibration	Negative, direct	*Biotic*: FT, BB, MM	- Noise generated during installation may disturb organisms	
	Light reflection	Negative, direct	*Abiotic*: L/S *Biotic*: BB, MM, H	-Visual disturbance due to light reflection, may affect seascape and organisms	
Installation of subsea cable*	Electromagnetic fields	Negative, direct	*Abiotic*: SQ *Biotic*: MI, BBF, PFF, FT, BB, MM, H	- Radiation caused by induction field created in cables due to electricity circulation	(i) Pre-lay survey to minimise the impact of cable route (ii) Careful installation (iii) Isolation of cables
	Physical impact	Negative, direct	*Abiotic*: SD, SQ *Biotic*: MI, BFF	- Changes in sediment dynamics, scouring	
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Presence of panels	Light reflection	Negative, direct	*Abiotic*: L/S *Biotic*: BB, MM, H	- Visual impact and birds disorientation due to panels' structure and light reflection, attraction or scare off of animals	(i) Develop appropriate monitoring strategy (ii) Use material and technique that minimises light reflections of panels

	Heat energy	Negative, direct	*Biotic*: BB	- Panel surface can become hot and harm birds landing on it	(i) Use prevention techniques to avoid birds landing on the panels
Electrical extraction	Electromagnetic fields	Negative, direct	*Biotic*: BB, H	- Radiation caused by induction field created in cables due to electricity circulation	(i) Electromagnetic isolation should be installed covering cables in order to reduce exposure
Transmission of electricity through subsea cable*	Electromagnetic fields	Negative, direct	*Abiotic*: SQ *Biotic*: MI, BBF, PFF, FT, BB, MM, H	- Radiation caused by induction field created in cables due to electricity circulation	(i) Ensure appropriate isolation of cables
DECOMMISSIONING PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Disassembly of pipes	Solid and liquid waste	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM	- Material left overs that may go into the water to the seabed	(i) Careful disassembly to avoid pollution
Removal of Subsea Cable*	Physical impact	Negative, direct	*Abiotic*: SD *Biotic*: BFF, MM	- Changes in sediment dynamics, scouring - Disturbance of benthic fauna and mammals due to unburying machinery	(i) Careful removal to reduce impact to a minimum

11.1.4 SATELLITES

Table 11-7: EIA summary of the ***Algae Aquaculture unit***

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

CONSTRUCTION PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Installation of the algae farm	Physical impact of structure	Negative, direct	*Biotic*: FT, BB, MM	-Animals might be entangled in the installations and be hurt or die	(i) Use of cage design, material and mesh size that minimises risk of entanglement (ii) Regular control of the installations
	Solid (and liquid) wastes	Negative, direct	*Biotic*: FT, BB, MM, H	-Pollution due to loss of material	
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Algae farm	Risk of accident and unplanned event	Negative, direct & indirect	Abiotic: WQ Biotic: MI, BFF, PFF, FT, BB, MM	- Accidental release of the algae culture and attraction of wild animals - Blooms	(i) Maintenance of the components (ii) Periodic checking of the installation
	Attraction of wild animals	Negative, direct	*Biotic*: FT, BB, MM	- Some animals can be attracted by the structure; components can be released leading to injuries to the animals and/or damage of the structure, with the possible release of the culture	(i) Maintenance of the components (ii) Periodic checking of the installation (iii) Avoid feeding wild animals
Addition of nutrients	Solid and liquid waste	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, BFF, PFF	- Accidental release of nutrients that can produce nitrification and eutrophication and blooms	(i) Maintenance of the components (ii) Periodic checking of the installation (iii) Adjust the addition

					of nutrients to growth of the microalgae (iv) Monitoring of the composition of water and structure of the soil
CO_2 injection	Emissions to atmosphere	Negative, direct & indirect	*Abiotic*: AQ, WQ Biotic: MI, BFF, PPF, FT, BB, MM, H.	- Residual/accidental emissions of CO2 to the atmosphere can lead to increase the climate change -Accidental injection in the water can lead to the acidification of the water	(i) Maintenance of components (ii) Periodic checking of the installation (iii) Monitoring of the level of CO_2 in the storage
Harvest (Pre-concentration and centrifugation)	Solid and liquid waste	Negative, direct & indirect	Abiotic: WQ Biotic: MI, BFF, PFF, FT, BB, MM	-The residual water from the centrifugation process can contain nitrate and phosphate causing a risk of nitrification and eutrophication and blooms	(i) Analyse the water before release it to the sea water (ii) Adjust the addition of nutrients to growth of the microalgae
	Noise and vibrations	Negative, direct	*Biotic:* FT, BB, MM, H	- Noise can disturb the activity and ecology of animals	(i) Harvester and centrifuge must be in good working order to prevent excessive noise
Thrusters	Physical impact of structure	Negative, direct	*Biotic:* FT, BB, MM	- Thusters can attract the attention of wild animals causing them injuries or death	(i) Safety structures to avoid direct interactions between the paddlewheel and wild animals. (ii) Maintenance of components (iii) Periodic checking of the installation
	Noise (and vibrations)	Negative, direct	*Biotic:* FT, BB, MM, H	- Noise can disturb the activity and ecology of animals	(i) Thrusters must be in good working order to prevent excessive noise
DECOMMISSIONING PHASE					

ACTIVITY	STRESSORS	NATURE OF IMPACT	RECEPTORS	IMPACT DETAILS	MITIGATION OPTIONS
Vessel Traffic	*See Table 11-1*				
Dismounting of algae farm	Solid (and liquid) wastes	Negative, direct	*Abiotic:* L/S *Biotic*: PFF, BFF, FT, BB, MM, H	- Pollution by solid waste due to loss of material (nets); animals might entangle in waste and/or die after consumption of waste parts - Lost installation material may pollute beaches	(i) Careful decommission (ii) Removal of any solid waste parts

Table 11-8: EIA summary of the ***Fish Aquaculture unit***

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

CONSTRUCTION PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Installation of Mooring	Physical impact of structures	Negative, direct	*Abiotic*: SD *Biotic*: BFF	-Changes in sediment dynamics, scouring -Where the mooring is placed benthic flora & fauna will be temporarily destroyed	(i) Careful installation (ii) Reduced mass of anchor (iii) Study of the location
	Noise and vibration	Negative, direct	*Biotic*: BFF, PFF, FT, BB, MM, H	-Noise development during mooring installation may disturb animals (and humans)	
Installation of Cages	Physical impact of structures	Negative, direct	*Biotic*: FT, BB, MM	-Animals might be entangled in the installations and be hurt or die	(i) Use of cage design, material and mesh size that minimises risk of entanglement; (ii) Regular control of the installations (iii) Study of the location of the cages
	Solid (and liquid) wastes	Negative, direct	*Biotic*: FT, BB, MM, H	-Pollution due to loss of material (nets)	
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Presence of Mooring	Physical impact of structures	Negative, direct	*Abiotic*: SD	-Sediment dynamics altered around anchor due to changes in current, underwashing	(i) Careful choice of appropriate anchor with reduced mass
		Positive, direct	*Biotic*: BB	-Provides new hard substrate for	

				settlement	
Presence of Net cages	Physical impact of structures	Negative, direct & indirect	*Biotic*: PFF, FT, BB, MM	-Changes in small-scale current pattern -Animals might be entangled in the installations and die	(i) Use of cage design, material and mesh size that minimises risk of entanglement; (ii) Regular control of the installations
Net cleaning	Escape of fish	Negative, direct & indirect	*Biotic*: PFF, BFF, FT, BB, MM	- To avoid algal growth and any damage that could led to the escape of fish or the penetration of predators; during cleaning fish can escape	
	Solid and liquid wastes	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Chemicals used for net cleaning may pose environmental threats such as toxic contamination, damage to the ecology, bioaccumulation, etc.	(i) Recognised, environmentally safe and copper free anti-fouling agents should be used to clean the nets (i) Avoid the use of products that can be harmful to the natural populations (ii) Special care in the storage and handling of all chemicals
Maintenance	Escape of fish	Negative, direct & indirect	*Biotic*: PFF, BFF, FT, BB, MM	- Introduction of pathogens, parasites into the system - Replacement of wild for domestic fish	(i) Development of a safe mechanism for the maintenance of the cages to prevent the escape
	Solid and liquid wastes (organic)	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Chemicals used in maintenance activities may pose environmental threats such as toxic contamination, damage to the ecology, bioaccumulation, etc.	(i) Avoid the use of products that can be harmful to the natural populations (ii) Special care in the storage and handling of all chemicals and fuels (iii) Avoid the use of chemicals near the water
Stocking of fry	Escape of fish	Negative, direct &	*Biotic*: PFF, BFF, FT, BB, MM	- Introduction of pathogens, parasites into the system	(i) Development of a safe mechanism for the seed

		indirect		- Replacement of wild for domestic fish	(ii) Checking the installation before the seeding
	Attraction of wild animals	Negative, direct & indirect	*Biotic*: FT, BB, MM	- Cultured fish and their wastes can attract birds, seals, piscivorous and detritivorous fish	(i) Avoid feeding wild animals
	Introduction of alien species	Negative, direct & indirect	*Biotic*: PFF, BFF, FT, BB, MM	- Introduction of pathogens, parasites into the ecosystem - Change the distribution of local species	(i) Selection of native species (ii) Checking the health of the juvenile fish (ii) Biology and ecology knowledge
Feed of cultured fish	Solid and liquid wastes (organic)	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	-Organic residues, Nitrification and eutrophication due to feed	(i) Design the feeding program considering feed, stage of growth, species, water quality, weather conditions and tide patterns (ii) Use of Integrated multitrophic aquaculture (IMTA)
	Attraction of wild animals	Negative, direct & indirect	*Biotic*: PFF, BFF, FT, BB, MM	- Cultured fish and their wastes can attract birds, seals, piscivorous and detritivorous fish	(i) Avoid feeding wild animals (ii) Adjust the feed to the consumption by the cultured fish
Presence of cultured fish	Solid and liquid wastes (organic)	Negative, direct & indirect	*Abiotic*: WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM, H	- Organic residues, nitrification and eutrophication due to faeces and decomposition of dead fish	(i) Adaptation of the diet (ii) Elimination of dead fish
	Attraction of wild animals	Negative, direct & indirect	*Biotic*: FT, BB, MM	- Cultured fish and their wastes can attract birds, seals, piscivorous and detritivorous fish	(i) Avoid feeding wild animals
	Escape of fish	Negative, direct & indirect	*Biotic*: PFF, BFF, FT, BB, MM	- Introduction of pathogens, parasites into the system - Replacement of wild for domestic fish	(i) Periodic checking and maintenance of the installations to avoid mass escapes
Treatment of	Harmful	Negative,	*Abiotic*: WQ, SQ	-Water and soil contamination by	(i) Avoid the use of harmful substances

cultured Fish	substances and materials	direct & indirect	*Biotic*: MI, PFF, BFF, FT, BB, MM, H	inorganic chemicals or pharmaceuticals, such as antibiotics, used for disinfection and to treat diseases that can widespread in the marine environment or/and accumulate through the food chain	and products that can be accumulated in the trophic chain (ii) If treatment with chemicals/pharmaceuticals is required it should be applied in a separated closed system to avoid release into environment (iii) Care in the storage and handling of chemicals (Iv) Emphasis should be placed on preventive measures so the use of chemicals would be the last resort (v) Keep records of the treatments to evaluate them
Monitoring (Lighting)	Attraction of wild animals	Negative, direct & indirect	*Biotic*: FT, BB, MM	- Attracted animals may alter behaviour of naturally occurring community	(i) Adaptation of the light to the ambient circumstances (ii) Turn off the light when it is not needed
	Artificial Lighting	Negative, direct	*Biotic*: FT, BB, MM	- Some animals can be attracted/repelled by the light	
Fish harvest	Noise	Negative: direct	*Biotic:* FT, BB, MM, H	- Noise can disturb the activity and ecology of animals	(i) Pump must be in good working order to prevent excessive noise (ii) Perform the harvest in an adequate time frame to reduce the impact of the noise
	Escape of fish	Negative, direct & indirect	*Biotic*: PFF, BFF, FT, BB, MM	- Introduction of pathogens, parasites into the system - Replacement of wild fish for domestic fish	(i) Development of an strategy for the harvest that reduces the risk of escape (ii) Formation of the personal (iii) Right maintenance of the equipment needed in the harvest
DECOMMISSIONING PHASE					

ACTIVITY	STRESSORS	NATURE OF IMPACT	RECEPTORS	IMPACT DETAILS	MITIGATION OPTIONS
Vessel Traffic	*See Table 11-1*				
Removal of Mooring	Physical impact of structures	Negative, direct	*Abiotic*: SD *Biotic*: BFF	- Changes in sediment dynamics, scouring - Removal of habitat (hard substrate)	(i) Careful removal to reduce scouring on seafloor
Dismounting of cages	Solid (and liquid) wastes	Negative, direct	*Biotic*: PFF, BFF, FT, BB, MM, H	(i) Pollution by solid waste due to loss of material (nets); animals might entangle in waste and/or die after consumption of waste parts (ii) Lost installation material may pollute beaches	(i) Careful decommission (ii) Removal of any solid waste parts

*Table 11-9: EIA summary of the **Wind Energy unit***

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

CONSTRUCTION PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Tow and Installation of assembled turbines and mooring lines and installation of the substation on the CU	Physical impact	Negative & positive, direct & indirect	*Abiotic*: AQ, WQ, WT, SD, SQ *Biotic*: MI, BFF, PFF, FT, BB, MM, H	- Traffic and mooring lines related to construction activities might entangle or disturb wildlife & may result in injury or mortality -Create habitat fragmentation from turbine hub height & mooring lines - Changes in sediment dynamics, scouring -Potential limitation of fishing (trawling) in the project area could have benefits to flora & fauna but negative impacts to fishing community -Exclusion of fishing activities provide opportunities for fish aggregation, diversity of microorganisms, plants, and fish species	(i) Strict observance of tow and construction best management practices may minimise potential accidents and negative consequences from this phase (ii) All boat traffic will be prohibited during the construction phase (iii) Human observers on vessels, especially during migration & breeding seasons (iii) Strict observance of boat safety rules and quarterly emergency management drills
	Artificial Lighting	Negative & positive, direct &	*Biotic*: MI, PFF, FT, BB, MM, H	Lighting at the construction site may create temporal impacts to micro-organisms and species in the marine	(i) A balance between needs for artificial lights for construction and protection of the marine environment would help

		indirect		habitat, but could also reduce risks of collisions and other worker related incidents (see accidents below)	mitigate potential negative impacts
	Heat Energy	Negative, direct & indirect	*Biotic*: MI, PFF, FT, MM	-Marine activity over long periods of time may generate heat energy and affect water temperatures and surrounding habitat, benthic resources, and wildlife (directly or indirectly); the actual levels of heat energy are not known so the potential impacts are uncertain	(i) Monitoring of temporal heat energy related to construction may reduce potential impacts to surrounding biotic resources
	Noise & Vibration	Negative, direct	*Biotic*: PFF, FT, BB, MM, H	-Impacts related to installation of equipment could generate noise and vibrations from installing 60 turbines and 30 floating units	(i) Implement noise reduction procedures wherever possible with bubble curtains or available new technologies for anchor systems
	Solid & Liquid Wastes	Negative, direct & indirect	*Abiotic*: AQ, WQ, SQ *Biotic*: MI, PFF, BFF, FT, BB, MM,H	-Management, presence, and potential release of wastes and/or other materials could increase air & water pollution from normal operations and effect FT; Indirect effects could impact MI & BFF	
	Harmful substances & materials	Negative, direct & indirect	*Abiotic*: AQ, WQ, SQ *Biotic*: MI, PFF, BFF, FT,BB, MM, H	-Management, presence, and potential release of wastes and/or other materials could increase air & water pollution from normal operations and effect FT; Indirect effects could impact MI & BFF	(i) Strict observance and practice of management procedures from all equipment and human presence that generates wastes
	Risk of accidents and unplanned	Negative, direct &	*Abiotic*: AQ, WQ, WT, SD, SQ	-Hazards could affect worker health and safety	(i) Strict observance and practice of accident prevention and management

	events	indirect	*Biotic*: MI, BFF, PFF, FT, BB, MM, H	-Release of wastes and/or other hazardous materials could increase air & water pollution & have widespread impacts depending on the nature of the accident and/ releases	for all employees
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Presence of Mooring lines, anchors, 30 floating platforms, and 60 3.3 MW turbines in the marine environment	Physical impact	Negative, direct, indirect Positive, direct	*Abiotic*: WT, SD L/S *Biotic*: MI, BFF, PFF, FT, BB, MM, H,	-Physical impacts above & below the waterline include, habitat fragmentation from turbine hub height & anchors/mooring lines -Potential limitation of fishing (trawling) in the project area could have benefits but negative impacts on the fishing community (see socio-economic section) - Changes in sediment dynamics & quality due to artificial hard substructures- negative or positive -Benthic flora & fauna will be temporarily impacted & potential long term effects may introduce new invasive species or new benthic habitats -Release of ballast waters could affect immediate marine environment	(i) Strict observance and implementation of operational best management practices may minimise potential negative consequences (ii) Minimise risk of entanglement & strikes of marine mammals & endangered or listed species with human observers on vessels, especially during migration & breeding seasons (iii) Strict observance of boat safety rules and quarterly emergency management drills (iv) Control and testing of ballast water tanks for each unit

				-Wind structures are fish aggregation devices that may protect fish species & lead to greater diversity -Potential for entangling or disturbing wildlife during routine or accidental processes may result in injury or death -Visual impacts from the project are expected from recreational and tourist activities near the project site (see D6.4)	
	Shading	Negative, direct, indirect	*Biotic:* MI, PFF, BFF, FT, H	-Shading from turbines & platforms could also affect marine life, e.g., algae production, within a relatively shallow water column	
	Artificial Lighting	Negative, direct, indirect	*Biotic*: MI, PFF, FT, BB, MM, H	-Turbine safety lights and from the substation could affect marine life & recreational boaters, but most likely not coastal communities 45 km away	(i) Lighting needed for safety procedures to protect workers, fishing community, and recreational boaters; limit number of lights & flashing lights to reduce avian impacts
	Heat Energy	Negative, direct & indirect	*Abiotic:* WQ, WT *Biotic:*MI, PFF, BFF, FT	-Heat from spinning turbines, the substation on the CU, and cables could affect the marine ecology, behaviors of some species, and foraging ability	(i) Monitor heat emissions and reduce with sheathing and protective equipment
	Noise & Vibration	Negative, direct, indirect	*Biotic:*FT, MM, H	-Affects workers as well as marine mammals; the area of influence for these effects are largely unknown and dependent on the type of species in the area	(i) Investigation of new methods that reduce noise and vibrational effects from cable trenching

	Solid & liquid wastes Harmful substances & materials	Negative, direct	*Abiotic:* AQ, L/S, WQ, SQ *Biotic:* MI, BFF, PFF, FT, BB, MM, H	-Normal operations of the transformer & other fluids from the turbines or more likely the substation could leak into the ocean & cause a variety of effects on the flora & fauna depending on the level of releases (see accidents below)	(i) Strict observance and implementation of operational best management practices may minimise potential negative consequences
	Risk of accidents and unplanned events	Negative, direct, indirect	*Abiotic:*AQ, WQ, WT, SD, SQ, *L/S* *Biotic:* MI, BFF, PFF, FT, BB, MM, H	-This new floating technology will have accident risks and uncertainties throughout the operational life of the turbines and the substations	(i) Strict observance and implementation of operational best management practices may minimise potential negative consequences
Installation & presence of high voltage transformer/substation on the CU, installation of inter-array cables between 30 floating Satellite Units, and one cable from CU to shore	Physical impact	Negative, direct & indirect	*Abiotic*: WQ, WT, SD, SQ, L/S *Biotic*: MI, BFF, PFF, FT, H	-Installation of substation on the CU, trenching of seabed for cable laying & associated impacts to the benthic communities along its pathway -Buried inter-array cables will have direct and indirect impacts associated with habitat disruptions on the seabed & connection to shoreline & coastal ecology - The height of the CU and substation impact the habitat both above and below the waterline -High voltage has potential to create worker safety risks	(i) Implement best management practices for substation and cable installations and shoreline connectors (ii) Avoid installations during wildlife migrations and sensitive seasonal periods (iii) For cable connect to shore, avoid sensitive or recreational areas along the coast
	Heat Energy	Negative, direct and indirect	*Abiotic:* WT *Biotic:* MI, PFF, BFF, FT, H	-Generated at the substation & through the cable lines may affect the water temperature & indirectly influence the surrounding habitat &	(i) Deeper trenching of cables to shore may reduce potential heat energy

				marine life	
	EMFs	Negative, direct and indirect	*Biotic:* BFF, PFF, FT	-EMFs from high voltage cables may effect already endangered species of rays and sharks	(i) Deeper burial of cables may mitigate potential EMF and heat releases
	Solid & liquid wastes	Negative, direct and indirect	*Abiotic: WQ, SQ* *Biotic: MI, PFF, BFF, FT, BB, H*	-Potential leakage of liquid wastes from the transformer could have serious consequences above and below the water line	(i) Strict observance of best management practices could prevent potential leakages & emergency management procedures could limit the extent of the damage
	Harmful substances & materials	Negative, direct and indirect	*Abiotic: WQ, SQ* *Biotic: MI,PFF, BFF, FT, BB, H*	-Potential leakage of harmful substances from the transformer could have serious consequences above and below the water line	(i) Strict observance of best management practices & emergency management procedures could limit the extent of the damage
	Risk of accidents and unplanned events	Negative, direct and indirect	*Abiotic:* WQ, WT, SD, SQ, *Biotic:* MI, PFF, BFF, FT, H	-Increasing water pollution & hazardous substances from vessel collisions, equipment malfunctions, substation explosions would impact water quality and these disturbances would also impact area marine wildlife	(i) Strict observance and implementation of operational best management practices may minimise potential negative consequences
Annual Maintenance & inspection	Physical impacts	Negative, direct & indirect	*Abiotic*: WQ *Biotic*: FT, MM	-Inspection & maintenance leads to the presence of divers, ROVs, vessels, and equipment in the marine environment	(i) Schedule annual visit when no migration or presence of endangered species, e.g., FT, MM
	Solid & Liquid wastes	Negative, direct & indirect	*Abiotic:* WQ *Biotic:* FT, MM	-Potential waste flows into the sea from routine maintenance activities	
	Harmful substances and materials	Negative, direct & indirect	*Abiotic:* WQ *Biotic:* FT, MM	-Potential for water contamination by inorganic chemicals or hazardous substances used at the wind satellite	(i) If treatment with chemicals or bio-fouling is required it should be applied in a separated closed system to avoid

				site	release into environment (ii) Avoid the use of harmful substances and products that can be accumulated in the trophic chain; seek biodegradable substances wherever possible
	Risk of accidents and unplanned events	Negative, direct & indirect	*Abiotic:* WQ *Biotic:* FT, MM	-Conducting maintenance introduces potential for accident risks and release of substances related to turbines, components, & platforms	(i) Strict observance and practice of emergency management procedures
DECOMMISSIONING PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Removal of 60 3.3 MW Turbines & cables to shore; Mooring lines are removed and anchors are left on the seabed; Turbines towed to shipyard for decommissioning	Physical impact	Positive & Negative, direct, & indirect	*Abiotic: AQ, WQ, SD, SQ,* L/S *Biotic*: MI, PFF, BFF, FT, BB, MM, H	-Decommissioning of the turbines is done at the shipyard so activities will generate some potential air & water emissions on the sea as well as safety hazards for workers -Keeping anchors in seabed does not disturb potential new habitat (hard substrate) may present direct or indirect benefits -The wind satellites are towed to the shipyard while the anchors are left on the seabed -Boating traffic would be prohibited during decommissioning	(i) Assuming production of benthic habitat, the marine ecology may have benefited from presence of mooring (and anchors) so removal only of moorings is recommended (ii) Scheduling decommissioning when no large presence or seasonal migrations of PFF, FT, BB, MM (iii) Decommissioning policies would minimise marine impacts as well as impacts at shipyard when managing potential solid & liquid wastes (iv) All metal (steel and copper) and liquid materials (lubricants) are recycled. Assume the wind turbine blades can be recycled. Virtually all materials can be recycled

	Noise & vibrations	Negative, direct, & indirect	*Biotic:* PFF, FT, BB, MM, H	-Decommissioning vessels' engines and related activities for removing turbines, units, & mooring lines cause noise impacts that could affect humans, marine life, and disturb recreational activities in the area	(i) Scheduling decommissioning when no large presence or seasonal migrations of PFF, FT, BB, MM (ii) Practice strict worker safety policies with proper safety gear to reduce noise effects
	Solid and liquidwastes	Negative, direct, & indirect	*Abiotic:* WQ *Biotic*: FT, MM, H	-Decommissioning activities & moving equipment may cause some unintended leakage from the equipment and/or storage containers	(i) Removal of any harmful substances and materials from turbines and/or cables on shore at shipyard minimises marine impacts
	Hazardous substances	Negative, direct, & indirect	*Abiotic:* WQ *Biotic*: PFF, BFF,FT, MM, H	-Decommissioning activities & moving equipment may cause some unintended leakage from the equipment and/or storage containers	(i) Removal of any harmful substances and materials from turbines and/or cables on shore at shipyard minimises marine impacts
	Risk of accidents and unplanned events	Negative, direct, & indirect	*Abiotic:* AQ, WQ, SQ, L/S *Biotic:* MI, PFF, BFF, FT, BB, MM, H	-Accidents from routine decommissioning activities, malfunctioning equipment, or hazardous weather conditions could cause serious impacts to the marine environment from unplanned hazardous liquid discharges. Worker injury or death may results depending on level of risk	(i) Strict observance and implementation of best management practices may minimise potential negative consequences. Also avoiding decommissioning activities during severe weather events would prevent some severe accident

Table 11-10: EIA summary of the ***OTEC Plant***

Acronyms – abiotic: Air Quality (AQ), Water Quality (WQ), Water Temperature (WT), Sediment Dynamics (SD), Sediment Quality (SQ), Landscape/Seascape (LS); biotic: Microorganisms (MI), Benthic Flora & Fauna (BFF), Pelagic Flora & Fauna (PFF), Fish & Turtles (FT), Birds & Bats (BB), Marine Mammals (MM), Humans (H)

CONSTRUCTION PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Installation of Mooring	Physical impact of structures	Negative, direct	*Abiotic*: SD *Biotic*: BFF	-Changes in sediment dynamics, scouring -Where the mooring is placed benthic flora & fauna will be temporarily destroyed	(i) Careful installation (ii) Reduced mass of anchor (iii) Study of the location
	Noise and vibration	Negative, direct	*Biotic*: BFF, PFF, FT, BB, MM, H	-Noise development during mooring installation may disturb animals (and humans)	
OPERATIONAL PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Take up of Water	Physical impacts	Negative, direct	*Biotic*: PFF, FT	-Entrainment of organisms into warm water and cold water intakes, pelagic organisms can be diverted with large water flows into the pipe intakes	(i) Screens on the intakes (ii) Collect and release rare organisms in the cold water and warm water sumps
Discharge of used Water	Physical impacts	Negative, direct & indirect	*Abiotic*: WQ *Biotic*: PFF, FT, MM	-Salinity increase at discharge depth and deeper due to higher salinity in return flow -Change in local stratification due to different density of return flow,	(i) Avoid discharge to any sensitive layers (ii) Discharge at sufficient depth, below main pycnocline

Discharge of used Water *(continued)*				change in stratification may affect local convection and diurnal cycle -Discharged water may be enriched in nutrients, which may cause local eutrophication and algae blooms when discharged in upper layers	
	Heat Energy	Negative, direct & indirect	*Abiotic*: WT *Biotic*: PFF, FT	- Temperature increase at discharge depth and deeper due to waste heat in return flow -Thermal disturbance in a certain mid-depth layer	(i) Avoid discharge to any sensitive layers
Cleaning of Heat Exchangers	Harmful substances and materials	Negative, direct	*Abiotic*: WQ *Biotic*: MI, PFF, FT	-Heat exchangers need to be cleaned for protection from bio-fouling, residuals from chlorination in high concentrations may harm organisms	(i) Minimise use of chlorination (ii) Keep concentrations below the max. permitted
DECOMMISSIONING PHASE					
ACTIVITY	**STRESSORS**	**NATURE OF IMPACT**	**RECEPTORS**	**IMPACT DETAILS**	**MITIGATION OPTIONS**
Vessel Traffic	*See Table 11-1*				
Removal of Mooring	Physical impact of structures	Negative, direct	*Abiotic*: SD *Biotic*: BFF	-Changes in sediment dynamics, scouring -Removal of habitat (hard substrate)	(i) Careful removal to reduce scouring on seafloor

11.2 THE SERVICE HUB CONCEPT ON THE DOGGER BANK

11.2.1 BACKGROUND

The Dogger Bank is located in the central North Sea, 100 km (62 miles) off the east coast of England, and crosses the offshore waters of the UK, the Netherlands, and Germany. Due to high wind speeds of over 10 m/s on average, the Dogger Bank area is of high interest to the offshore wind industry. In 2010 *Forewind Ltd* obtained the license to develop a wind farm on the Dogger Bank. *Forewind Ltd* is a consortium comprising four leading

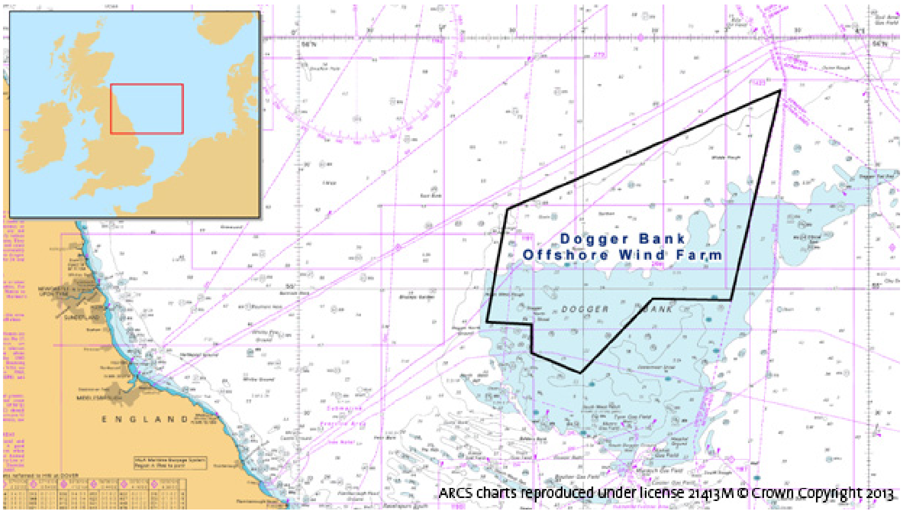

Figure 11-1: Location of the *Forewind* Dogger Bank Offshore Wind Farm (source: Royal Haskoning 2012)

international energy companies, namely RWE, SSE, Statkraft, and Statoil, which joined forces to bid for the Dogger Bank Zone Development Agreement as part of The Crown Estate's third license round for UK offshore wind farms. The Dogger Bank wind farm zone, located in the North Sea off the coast of East Yorkshire, is potentially the world's largest offshore wind project, in 125 km to 290 km distance from shore (Figure 11-1). If fully developed, the 8,660 km^2 area could contain more than 2,000 wind turbine generators. Target capacity is 7.2 GW by 2020. Planning approval for the first development at Dogger Bank Creyke Beck is anticipated around late 2014. The Dogger Bank development will consist of a number of offshore wind farms, each with an onshore grid connection and a capacity of up to 1.2 GW. These wind farms will individually comprise some hundreds of wind turbines (depending on the size of turbines selected). Beside the offshore installations including substations, considerable onshore infrastructure, including converter stations, and hundreds of kilometers of undersea and underground cables will be required to export the electricity to the National Grid (for more details see Forewind 2011-2014).

Dogger Bank Creyke Beck will be the first stage of development in the Dogger Bank zone, and will comprise two offshore wind farms, *Dogger Bank Creyke Beck A* and *Dogger Bank Creyke Beck B*. *Dogger Bank Teesside* was named as Forewind's second stage of development of the Dogger Bank Zone. Originally planned to be four separate wind farms this stage has now been divided into two separate applications – *Dogger Bank Teesside A & B* and *Dogger Bank Teesside C & D* (see more at Forewind 2011-2014).

11.2.2 SUSTAINABLE SERVICE HUB CONCEPT

The *Sustainable Service Hub* (Figure 11-2) is one of the TROPOS ICS concepts based on the TEAL components (Transport, Energy, Aquaculture and Leisure) defined in the scope of the TROPOS project. This concept consists of an offshore structure which is focusing on transport and energy related aspects while it still has some leisure related aspects. The platform is composed of 5 modules, the first two modules (Quick Reaction Maintenance Base and Substation) are related to energy aspects, the third and the fourth modules (Auxiliary Module and Helipad) are related to transport aspects and the fifth module (Accommodation) is related to Leisure aspects. The concept mainly serves as an Offshore Wind Hub to a wind farm assembled around the platform, leaving enough clearance for a safe access of large ships to the platform. The electrical energy generated by the wind turbines directly supplies the electrical power consumers of the entire facility. Due to the accommodation infrastructure for the workforces, this concept has capacity to host a large number of people. The infrastructure is also ready for external visits (controlled and following strict security measures). Offshore R&D related accommodation can be offered. The waste heat of the electricity generation is used for heating purposes.

When located in the centre or vicinity of an offshore wind farm, such as the Dogger Bank Wind Farm, the *Sustainable Service Hub* will significantly contribute to a reduction of the carbon footprint of the offshore farm, as the presence of the service hub allow for the reduction of vessel traffic between the offshore installation and the shore. Service and maintenance operations can be carried out directly from the service hub. The decrease in shipping traffic goes along with reduced fuel consumption and emissions to the atmosphere, and reduced risk of accidents and/or unplanned events. Moreover, the service hub will allow for a much faster reaction in case of emergency or malfunction.

Figure 11-2: Sustainable Service Hub Conceptual Design (to be reviewed once the concept is fully designed)

11.2.3 ENVIRONMENTAL ASPECTS

The Dogger Bank is a large shallow sandbank of about 260 km (160 miles) length and 97 km (60 miles) width, covering more than 17,000 km^2 (Stride 1959). The structure is elevated compared to the surrounding sea floor by about 20 m; water depths range from 15 m to 35 m (see Figure 11-3). The Dogger Bank is a huge moraine,

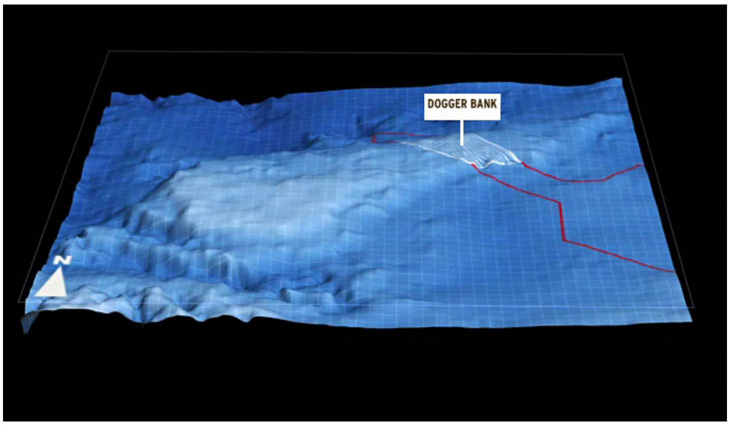

Figure 11-3: Seafloor topography of the Dogger Bank (source: BfN 2012)

deposited at the southern limit of the last glaciation. The sandy bottom habitat is characterised by high species richness (polychaete worms, snails, amphipods, clamps, crabs, starfish, fish, etc.), and is an important fishing ground for cod, herring, plaice, haddock, turbot, and dabs. Different species of sandeels, which are an important component of the food web as a source of prey for many fish, seabirds and marine mammals, are found in high abundances on top and at the borders of the sandbank (Brown and May Marine Ltd 2013). The entire site is nominated as a Special Area of Conservation (SAC) under the Habitats Directive due to the sandbank habitat listed in Annex I of the Directive. It is a characteristic sandbank with mostly fine sands containing many shell fragments and is representative of the open offshore sublittoral zone (BfN 2012). Different water masses are converging on the Dogger Bank, resulting in the dominance of rather cold-adapted species in the northern part and of more temperate species in the southern part. High primary and secondary production in this area support the diverse fish, bird and marine mammal communities (BfN 2008).

Each of the *Forewind* Dogger Bank wind farm projects undergoes an Environmental Impact Assessment (EIA) as well as specific stakeholder and community consultation activities. The Environmental Impact Statements (reports) are already available for Dogger Bank Creyke Beck (completed in August 2013), and Dogger Bank Teesside A & B (completed in March 2014). To investigate and assess the potential impact of an offshore wind farm on the Dogger Bank Creyke Beck and Teesside, comprehensive onshore and offshore baseline studies were carried out. The studies included seabed surveys, ground investigation, wave, current and tidal data collection, vessel movements, marine and intertidal ecology, fish and shellfish, birds, marine mammals, landscape walkover, archaeology, contaminated land walkover, flood risk assessment, topographical surveys and watercourse walkover, background noise monitoring, onshore habitats & protected species, and traffic counts. The following assessment of environmental impacts is taken from the Non-technical summaries of the Dogger Bank Environmental Statements (Forewind 2013, 2014):

A wide range of marine and terrestrial designated sites and protected species are present within the study area, but construction, operation, and decommissioning phases of Dogger Bank Creyke Beck and Teesside projects are not expected to have significant impacts on the designated sites and species. Only if all projects currently planned in the area are going to commence at the same time, short-term negative effects on harbour porpoise and some bird species are expected.

Suspended sediment concentrations will temporarily increase during the construction and operation phases and additional sediment will be deposited on the seabed. Sediment deposited on the seabed from suspension will be continuously re-suspended until its thickness is spread to effectively zero. Operation of the wind farm will cause small but permanent changes to wave heights and tidal current velocities, but the magnitude of change will be within what would be expected through existing levels of natural variation. Coarser sediment that is not dispersed as part of the construction plume will be deposited on the seabed at its source position. This deposited sediment is assumed to be sculpted into a sand wave through reworking by tidal currents and waves.

No negative impact on water quality is expected. Potential impacts such as deterioration of water quality due to re-suspension of sediments are not anticipated to be significant. The risk of deterioration in water quality as a result of accidental spillage of material or discharges of waste water is assessed as low due to environmental protection and control measures which will be implemented.

The impact on birds during construction (and decommissioning) is predominantly short-term and reversible disturbance and displacement impacts, which are not considered to be significant, either for Dogger Bank Creyke Beck alone, or when the cumulative effects with Dogger Bank Teesside A & B are considered. During operation there is likely to be disturbance and displacement effects due to habitat loss or alteration, a barrier effect on many of the breeding seabird and migratory wintering or passage bird populations, and collision effects could arise on seabird and migratory birds' national populations. As with the construction phase, none of these effects are predicted to be significant. Potentially significant cumulative impacts have been predicted for some bird species, but it would be present only if the cumulative impact of all other projects for which there is available information is considered.

Key potential impacts on marine plants and animals have been assessed for all stages of the development. Temporary disturbance of existing habitats and increases in suspended sediment levels will occur during the construction phase, with some permanent loss of habitat where infrastructure is fixed in place during operation. The impact assessment has established that these impacts will not be significant. This is based on the fact that the areas of existing seabed habitats that will be subject to temporary disturbance and/or permanent loss represent only a small proportion of similar seabed habitats in the wider region. In addition, the areas affected are generally considered to be of low sensitivity and high recoverability. The impact assessment also concluded no significant impacts on the *Dogger Bank candidate Special Area of Conservation* and/or Flamborough Head Special Area of Conservation.

Fish and shellfish species may be impacted by the development in a number of ways, including habitat disturbance or loss, increased suspended sediment concentrations and sediment deposition, underwater noise, and electric and magnetic field emissions from subsea cables. The impact assessment has established that none of the identified effects will result in a significant impact. This conclusion is based on a number of factors, namely the following: the available habitats for breeding species are large relative to the development footprint; noise mitigation measures will be used during piling operations enabling fish to swim away from the noise source (pile driver) thus reducing their exposure; the effects of increased suspended sediment concentration and deposition will be temporary, localised and with minimal deposition due to tidal movements; and electromagnetic field emissions from cables are limited to the immediate vicinity of the cable.

Marine mammals found in the Dogger Bank zone and wider region include harbour porpoise, minke whale, white-beaked dolphin, grey seal, harbor seal. All cetaceans are listed as European Protected Species under Annex IV of the Habitats Directive, as they are classified as being endangered, vulnerable or rare. Both grey seal and harbour seal are protected under Annex II of the Habitats Directive which requires Member States of the European Union to designate areas essential to their life and reproduction as Special Areas of Conservation. The key impacts for marine mammals relate to the potential for auditory injury and/or behavioral disturbance (such as displacement from a feeding area) during construction. However, the risk of causing auditory injury to marine mammals will be minimised through the use of a Marine Mammal Mitigation Protocol. The protocol will aim to reduce the exposure of marine mammals to sources of noise. During construction there is the potential for behavioural disturbance, as a result of underwater noise from pile driving, to occur for up to six years per project. However, due to the relatively small proportion of the population of each species that may be temporarily displaced, the impacts are not considered to be significant. No other impacts are considered to be significant in the assessment of Dogger Bank Creyke Beck A and/or B, or cumulatively with Dogger Bank Teesside A & B. The impact of collision risk in harbour seal due to propellers is considered significant when taking into account cumulative impacts from projects outside of the Dogger Bank Zone. However this assessment is highly conservative as the actual contribution of the Dogger Bank projects to this cumulative impact is only small.

The only significant impact on commercial fishing interests is the potential loss of fishing area for crab and lobster during construction as a result of the installation of the export cables. This impact will be restricted to the duration of the installation works. The majority of potential cumulative impacts are identified as being not significant, during all phases. An exception to this is a potential significant impact on the seine net fishery during construction and operation, due to the extensive nature of the nets.

Navigation Risk Assessment was undertaken, which describes the existing hazards within the development area and the navigation routes commonly used by vessels. Common vessel types include commercial fishermen, recreational boats and commercial operators. Very few vessels transit through the site and given its location, relatively small changes in a vessel's course are necessary to avoid the development.

Other activities in this area include other renewable energy projects, carbon capture and storage, oil and gas activity, underground coal gasification, aggregate extraction, and subsea cables and pipelines. Other marine users may be disrupted if activities overlap (primarily carbon capture and storage, oil and gas and aggregates activity). However it is anticipated that, through engagement with the potentially affected parties, significant residual impacts will be avoided.

The assessment has identified a number of potential impacts on archaeological resources, both direct (from the physical footprint of the development) and indirect (arising from changes to marine physical processes such as scour effects), but no designated (protected) archaeological sites were found to lie within or around the development footprint. Mitigation proposals recommend the avoidance of any identified archaeology, therefore a series of Archaeological Exclusion Zones around identified archaeological features is recommended. As a result, no significant residual impacts on marine and coastal archaeology are anticipated.

Given its distance offshore, there will be no significant impacts on the seascape and coastal character (at the landfall and inshore areas) as a result of the construction and operation of the offshore development. During construction there will be disturbance to the local landscape from construction activity at the landfall, along the cable route, and at the site of the converter stations, resulting in a limited number of temporary landscape and visual impacts. These will be short-term at any one location, and following construction each affected area will be reinstated back to its pre-construction condition, with the exception of the converter stations site. Overall, landscape impacts during construction are not considered to be significant. Impacts are likely to occur at the site of the converter stations, and to the agricultural farmland to the south and southwest of the converter stations. The converter stations will have a significant effect on views within 1 km. The converter stations will be designed to reduce significant impacts, and will be integrated into the landscape. Overall, the proposed development will have some significant impacts on landscape and visual receptors, but these will be localized, and set in the context of a landscape where built development is already characteristic.

The EIA information above refers to offshore wind farms and associated infrastructure. However, the general effects to consider for the deployment of the floating *TROPOS Service Hub* platform are similar, but the impact of the floating service hub can be expected to be much less.

11.2.4 JUSTIFICATION FOR SITE SELECTION

According to the project title, the TROPOS Project aims at developing a floating modular multi-use platform system for use in deep waters, with an initial geographic focus on the Mediterranean, Tropical and Sub-Tropical regions. The Dogger Bank is neither a deep water habitat, nor it is located in a sub-tropical or tropical region. Nevertheless, the TROPOS platforms are designed to be flexible enough so as to not be limited in geographic scope, and the Dogger Bank Zone with its huge wind farm developments is the perfect site for the first *Sustainable Service Hub* for several reasons:

(i) The concept was developed to serve as an Offshore Wind Service Hub, and the North Sea is the among the world's oceans with the highest wind park density. So far, there are no wind farms in deep waters, but they will be for certain developed in the future. The current development of the huge Dogger Bank wind farm provides the perfect opportunity to specify and adapt the TROPOS *Service Hub concept* in shallow waters before moving to deep waters;

(ii) The environment in the Dogger Bank Zone is well studied, and Environmental Impact Assessments (EIAs) are already available for some areas. These available baseline studies can be used to assess the impact of the *Sustainable Service Hub*, i.e. no further extensive invasive sampling will be required (or it can be drastically limited);

(iii) According to the *Forewind* Dogger Bank EIAs above, the major significant impact on the marine fauna, in particular on marine mammals such as cetaceans, are noise, collisions with ships and injuries by ships' propellers. The significance of these impacts will be extremely reduced by the presence of the *Service Hub*, because vessel traffic between offshore wind farms and shore will be much less.

However, when considering the Dogger Bank as site for the TROPOS *Sustainable Service Hub Concept*, it has to be taken into account that parts of the Dogger Bank Zone are considered for becoming a Special Area of Conservation, i.e. a protected site. And apparently several environmental protection organisations and agencies (at least in the German part) are asking for more area of the Dogger Bank to become a marine protected area. Moreover, the Dogger Bank is an important fishing ground; therefore, offshore developments such as wind farms and service hubs on the Dogger Bank are not very welcome among fishers because these developments will go along with the loss of major fishing ground. Accordingly, efficient mitigation strategies to avoid negative effects particularly on marine mammals are essential, and if possible the main productive fishery zones on the Dogger Bank should be maintained.

For optimum political support of the Service Hub Concept and the selected site in the North Sea it might be useful to go for an integrated approach, i.e. to ensure that the TROPOS Service Hub is an international/European facility serving for the support of all Wind Farms in the neighborhood (and not only for support and maintenance of a single wind farm project).

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12 ANNEX PART B

Descriptions of Existing Environments

D6.2 Report on Environmental Impact Assessment and Mitigation Strategies

ANNEX PART B

DESCRIPTIONS OF EXISTING ENVIRONMENTS

University Bremen/MARUM

The TROPOS Project —— Modular Multi-use Deep Water Offshore Platform Harnessing and Servicing Mediterranean, Subtropical and Tropical Marine and Maritime Resources, has received funding from the European Union's Seventh Framework programme for research, technological development and demonstration under grant agreement number 288192 (Call Ocean of Tomorrow).

Deliverable 6.2 Report on Environmental Impact Assessment and Mitigation Strategies, ANNEX PART B: Descriptions of Existing Environments

Programme: The Ocean of Tomorrow

Project: Modular multi-use deep water offshore platform harnessing and servicing Mediterranean, subtropical and tropical marine and maritime resources

Code: TRP_WP6_ECD_D6.2 ANNEX PART B

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Abstract

This document presents the ANNEX Part B of Deliverable 6.2 – Descriptions of Existing Environments.

TABLE OF CONTENTS

Chapter *Description* *Page*

TABLE OF CONTENTS

Chapter *Description* *Page*

TABLE OF CONTENTS

TABLE OF CONTENTS

Chapter *Description* *Page*

TABLES INDEX

Description *Page*

FIGURES INDEX

Description *Page*

1 EXISTING ENVIRONMENT GRAN CANARIA, SPAIN (EXTENDED VERSION)

1.1 OVERVIEW

The TROPOS project selected three 'target regions' to study multi-use platforms installation. Gran Canaria in Spain, Crete in Greece, and Taiwan are the areas chosen for platforms deployment.

The Canary Archipelago, comprising seven main islands and several minor ones, is located in the northeast Atlantic Ocean between latitude 27.61 and 29.51N and longitude 18.21 and 14.51W. It is only 100 km from the north western edge of the African continent. The islands are the emergent parts of an important volcanic formation on the oceanic continental transit of the Afro-Atlantic plate, forming an independent set of islands with a water depth of 2000 m between them (Perez *et al.*, 2005).

In Gran Canaria the TROPOS platform will follow the Leisure Island Concept defined by the ICS in the Deliverable 3.1 and will comprehend a floating hotel which will provide additional services to the services provided by onshore hotels. The location selected to install the Leisure module is on the southwest side of the Gran Canaria and is well aligned with the leisure component since it is a typical location for leisure activities in Gran Canaria. The location is at a distance of 1.5 NM (nautical miles) from the southwest coast of Gran Canaria and has the central point coordinates 27º 45' 37"N and 15º 43' 40"W (see Figure 1-1).

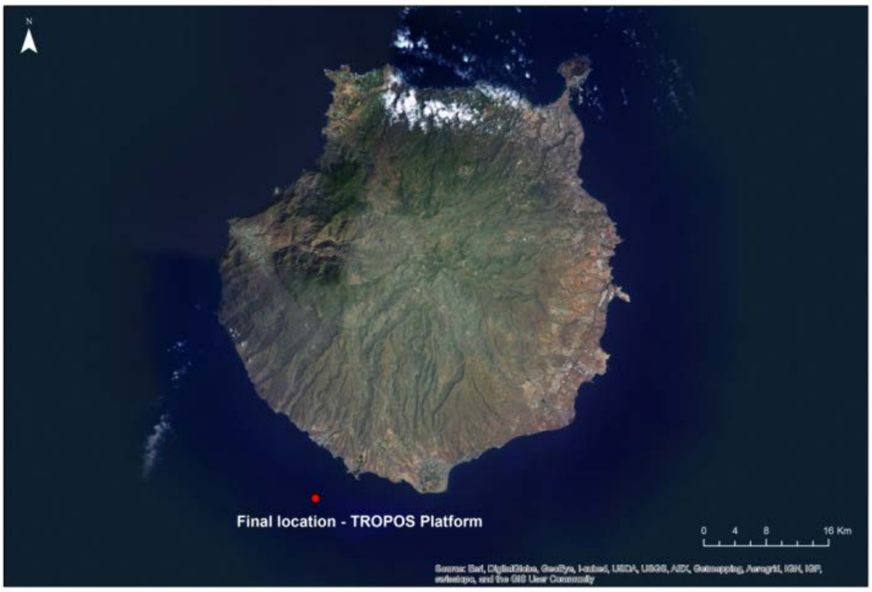

Figure 1-1: Leisure Island location in Gran Canaria Island (Source: WavEC)

1.2 PHYSICAL ENVIRONMENT

1.2.1 INTRODUCTION

The Canary Islands consist of seven major volcanic islands located in the northeast Atlantic margin, a few hundreds of km from the northwestern coast of Africa (Morocco). The islands roughly form a west-southwest to east-northeast trending archipelago confined between latitudes 27° 37' N and 29° 25' N, and longitudes 13° 20' W and 18° 10' W. Volcanism in this belt decreases in age from the northeast (about 70 million years) to the southwest (about 1 million years). The volcanic province lies over (older) Jurassic ocean crust (approximately 150 to 180 million years old) and it is believed that it was generated by the Canary hotspot. Except for Lanzarote and Fuerteventura, which are not geologically different and are only separated by a narrow and shallow portion of sea, all the islands of the archipelago were formed by individual processes. The 1,950 m high central volcano of Gran Canaria, in particular, which is approximately 15 million years old, shows signs that it is well into its destructive phase of evolution, with erosion and mass wasting outpacing growth through magmatic activity. In fact, although it is roughly round in its outline, it no longer presents a conical shape and is characterised by deeply incised canyons. Erosion has exposed intrusive complexes and dike swarms on the island.

The diversity of ecosystems in the Canary Islands, which include a variety of species characterised by their uniqueness and exclusivity, is a consequence of the peculiar geomorphologic, oceanographic and climatologic features of the archipelago. Due to its geographical location and configuration, it is an important obstacle in the North Atlantic circulation, which, in turn, plays a key role in the global circulation and in the ocean-atmosphere interaction dynamics.

The Canary Islands climate is determined by several factors: the trade winds, damp winds which combined with the orography of the islands produce climatic stability all year round, the cold current of the Canary Islands which keeps the water temperature lower than expected, their geographical latitude, close to the tropic of Cancer. All this together with their proximity to Africa, and their condition as islands give them a subtropical climate.

1.2.2 CLIMATE AND ATMOSPHERE

Climate in the Canary archipelago is the result of the joint influence of geographic latitude (it is roughly located 4º north to the Tropic of Cancer), wind systems and ocean currents. In general, Canary Islands present a subtropical climate, with long, warm and dry summer seasons, and moderately warm winter seasons. However, the complexity of the factors affecting the climate in the region is translated in the occurrence of relevant phenomena which disturb this average pattern.

The trade winds, associated to the eastern branch of the Azores High, are prevailing in the Canary Islands, predominantly blowing from the northeast. They consistently blow during the whole year, but more intensively during the summer season (mostly from April to September). Although this pattern is dominant in the archipelago, the seasonality of the Azores High allows for the occasional arrival of polar air masses. On the other hand, due to the proximity to Africa (and, in particular, Sahara), dry and warm continental tropical air masses sporadically surge into the archipelago. The occurrence of these events results in a sudden change of the weather conditions, otherwise influenced by the dampening effect of the ocean. In these occasions, southeasterly/easterly winds may carry small particles of dust or sand from the desert into the islands. This phenomenon is called Calima and, during severe events, it decreases visibility. In Gran Canaria, in particular, Calimas typically occur 5 to 7 times a year, lasting between 2 and 7 days until the direction of the wind changes or it starts raining.

Topography plays an important role in the local variations to the broad climatologic pattern on the islands. Due to their low relief, the eastern islands (namely Lanzarote and Fuerteventura) present an arid climate with very little rainfall throughout the year. The high mountains in the remaining islands of the archipelago present a barrier to the trades' circulation, so that clouds accumulate in the windward slopes generating high rainfall rates and Foehn winds prevail in the leeward slopes. Averaged annual precipitation in the Canary Islands varies between 8.5 mm in Fuerteventura and 557 mm in Tenerife. In Gran Canaria, in particular, annual precipitation is 134 mm. Rainfall in the island is mostly concentrated in the winter months, i.e. from November to March (the highest precipitation rate is reached in December– 27 mm), and from June to August there is virtually no precipitation.

The Canary Current also plays an essential role in the archipelago's climate. The system is a wide (approximately, 1,000 km) and slow flowing (0.1–0.3 m/s, with seasonal fluctuations) wind-driven surface current (extending about 500 m down into the ocean) (Wooster et al. 1976). It branches south from the North Atlantic Current, flowing along the African coast from north to south between 30°N and 10°N and offshore to 20°W, where it joins the Atlantic North Equatorial Current (Fedoseev, 1970). The Canary Islands partially block the flow of the current. The presence of the Canary Current is responsible for an important regulating or damping effect which prevents significant temperature variations in the region. In fact, the moderate temperatures along the year, with no significant seasonal variability, are a particular feature of the climate in the Canary archipelago. Yearly average temperatures in the eastern islands (Lanzarote and Fuerteventura) are around 21°C, with an average maximum of 28.8°C in August for Lanzarote and of 27.2°C in September for Fuerteventura, and average minimums of around 14°C in January for both islands (AEMET, 2012). In the western islands, average minimum temperatures range between 10.5°C in La Gomera (January) and 15.6°C in El Hierro (February), and average maximum temperatures range between 26.1°C in La Palma and El Hierro (September) and 28.8°C in Tenerife (August). In Gran Canary, the average minimum temperature of 14.7°C occurs in January and the average maximum temperature of 27.1°C is registered in both August and September.

1.2.3 OCEANOGRAPHIC CONDITIONS

In terms of wave climate, conditions north and south to the archipelago differ significantly. The wave climate off the north coast of Gran Canaria, concretely, is dominated by the swell systems generated in the North Atlantic. This means that longer and more energetic waves prevail in the sea states in this part of the island. In fact, monthly average significant wave heights H_s vary between values superior do 1 m and values superior to 3 m, with predominance in the range 1.5–2 m, and monthly average peak periods T_p vary between ~7 s and close to 15 s, with predominance in the range 7–9 s (data from the SIMAR-44 catalogue, Puertos del Estado[1]). The predominant wave direction in the northern part of Gran Canaria is from the North. The south sector of Gran Canaria is less exposed to the North Atlantic swell systems, which are partially blocked by the islands. As a consequence, there is a higher predominance of wind sea systems in the sea states, which in general present shorter wave periods and lower wave heights. Monthly average H_s values vary between around 0.7 m and 2 m, with

[1] www.puertos.es

predominance in the range 1–1.5 m, and monthly average T_p varies between values inferior to 6 s and 14 s, with predominance in the range 5–6 s. A larger directional dispersion can be observed in this part of the island compared to the northern part, with different predominant directions of the waves depending on the location, its distance from the coast and its sheltering conditions.

The current systems in the Canary Islands are quite complex, involving a Gulf Stream branch, the Canary Current and upwelling phenomena due to the trade winds action close to the west coast of Africa. The Canary Current (see section 5.2.2), which is associated to this coastal upwelling, contains filaments, and eddies with length scales of 100–300 km which form along the coastal boundary of the current. As a consequence of highly variable upwelling events, sea surface temperature (SST) in the Canary archipelago presents significant variations in both time and space. This is particularly valid for the eastern islands, since they are closer to the African coast. SST in the Canary Islands is in the range 16–18°C in the winter months and 23–25°C in the summer months. Seasonal variations in the current systems may affect these ranges. In general, SST of the Atlantic waters surrounding the archipelago is relatively low due to the Canary Current, which brings colder water form high latitudes, and the upwelling of deep, cold water.

Salinity of surface water in the Canary Islands oscillates between 36.7 g/kg and 36.9 g/kg. Current systems variability, variations in precipitation and evaporation levels may also produce noticeable variations in space and time of the salinity values.

The western and eastern parts of the archipelago are well distinguishable when it comes to water productivity. While the zone covering the western islands is predominantly oligotrophic, the zone covering the eastern islands is affected by the upwelling processes taking place along the western coast of Africa and, consequently, presents high levels of primary productivity.

1.2.4 BATHYMETRY AND SEABED FEATURES

The bathymetry and seabed features of the Canary archipelago differ considerably, even between islands, due to their volcanic origin. The islands emerge from a seabed with east-west increasing depth, from around 4,000 m close to La Palma and El Hierro to around 3,000 m close to Lanzarote and Fuerteventura. Between Lanzarote/Fuerteventura and the African continent the depth is inferior to 1,400 m.

Since it is located on a volcanically active zone, the continental shelf in the Canary Islands is narrow and steep. In Tenerife, La Palma and El Hierro the continental shelf is practically inexistent. In Gran Canaria, Fuerteventura, Lanzarote and La Gomera the continental shelf is wider. In general, 200 m depth can be found at a relatively short distance from the shore (typically 1–8.7 km).

The channel between Gran Canaria and Tenerife presents some relevant geologic features. Though there is no evidence of giant landslides (typically associated with the construction of volcanic islands) in this part of the archipelago, numerous submarine canyons may be found in the flanks of both islands. Such canyons extend from close to the coast to water depth superior to 3,000 m. Several volcanic cones may be identified in the submarine island flanks, reflecting ongoing submarine volcanic activity.

1.2.5 SEDIMENT QUALITY

Oceanic islands are continuously subjected to erosive processes, which are an important source for sediment. Giant landslides and avalanches are among the most essential processes contributing to the erosion of islands, both of which are predominant in the Canary Islands. Sediments in the archipelago are dominated by volcaniclastic rocks generated by eruptions, erosion, and flank collapse of the volcanoes.

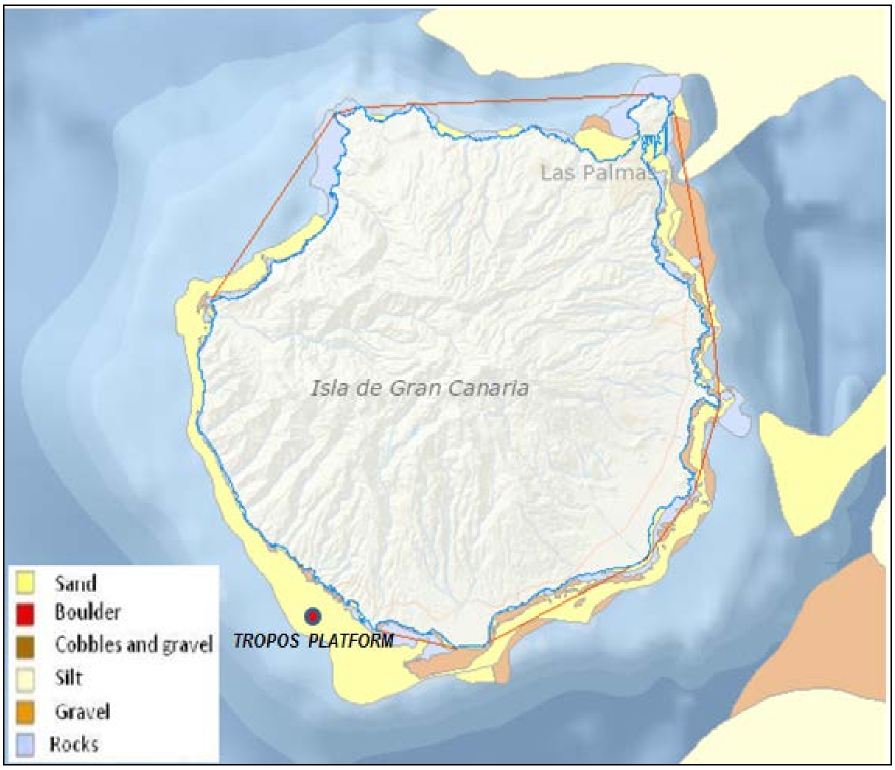

Figure 1-2: Seabed geology of the Canary Islands (Source: GIS application of the Spanish Institute of the Oceanography (IEO) at http://www.ideobase.ieo.es/)

1.2.6 WATER QUALITY

Canary region is affected by several human activities that represent a source of chemical contaminations and that can lower the quality of coastal waters. Contaminants concentration in coastal waters is very variable in time since they depend on tides, currents, wind and of the irregularity of the spilling. Consequently, water analysis is not the most common method of surveillance used to define water quality as it only reflects the quality in that exact moment. Instead, to evaluate the marine environment contamination two other matrices of study are preferred: sediments and biota (mostly limpets and fishes). Nevertheless, since the Water Framework Directive (WFD) compels it, it's required to perform the analyses of water contaminant to evaluate coastal waters quality (MARGRAMA, 2012e).

The Canary Government develops a control plan of discharges of into the sea through the "Census of discharges from land to sea," available on the web (www.gobcan.es/cmayot/medioambiente/calidadambiental/vertidos/index.html), see Figure 1-3 below.

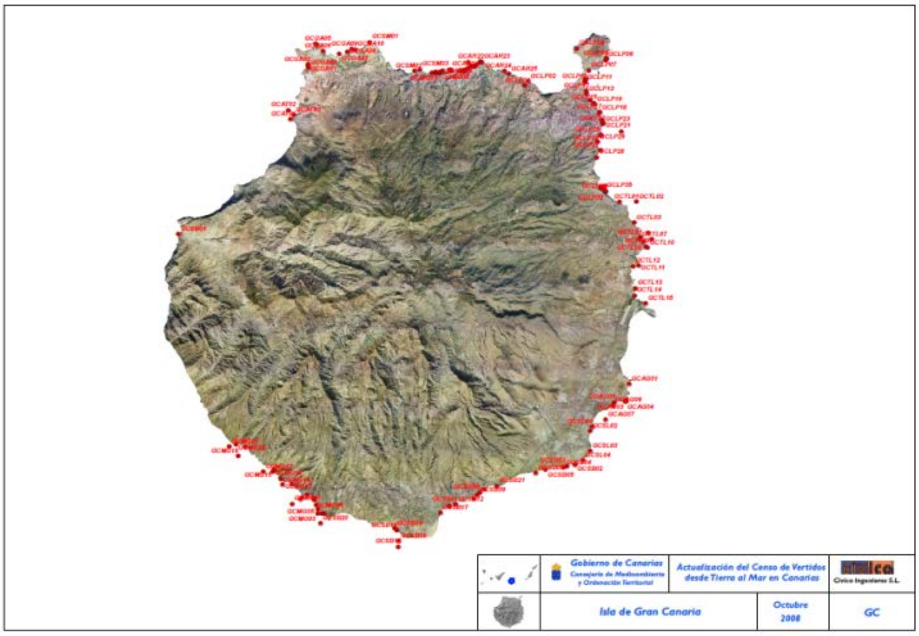

Figure 1-3: Census of discharges from land to sea in Gran Canary Island. (Source:MARGRAMA, 2012e)

The census showed that discharges are more abundant in urban areas, since there has been an evident reduction of industrial residues. Therefore, since the land-based sources of pollutants are known, it is possible to analyse the effects of the substances that reach marine waters (MARGRAMA, 2012e).

In the context of the Water Framework Directive (WFD) Canary Islands Government published in 2005 a report on the studies undertaken for the implementation of the WFD where the typology of coastal waters of the Canary Islands (Gobierno de Canarias, 2005) are specified. In Figure 5.3 the distribution of coastal water masses is shown.

Several reports as the "Caracterización y análisis de la calidad de las aguas costeras de Canarias" conducted in 2007 indicate that, in general, the quality of the coastal waters in the islands is very good, due to the absence of significant concentration of contaminants (Riera et al. 2007a, b). These works included the collection and subsequent analysis of a large amount of samples along the entire coastline of Gran Canaria, with the ultimate goal of characterising the water and sediment quality and assess both the chemical and ecological status of coastal water masses. Punctually, slight deviations of good status level were found in areas with localised pollution sources, such as submarine discharges, however they had scarce spatial importance.

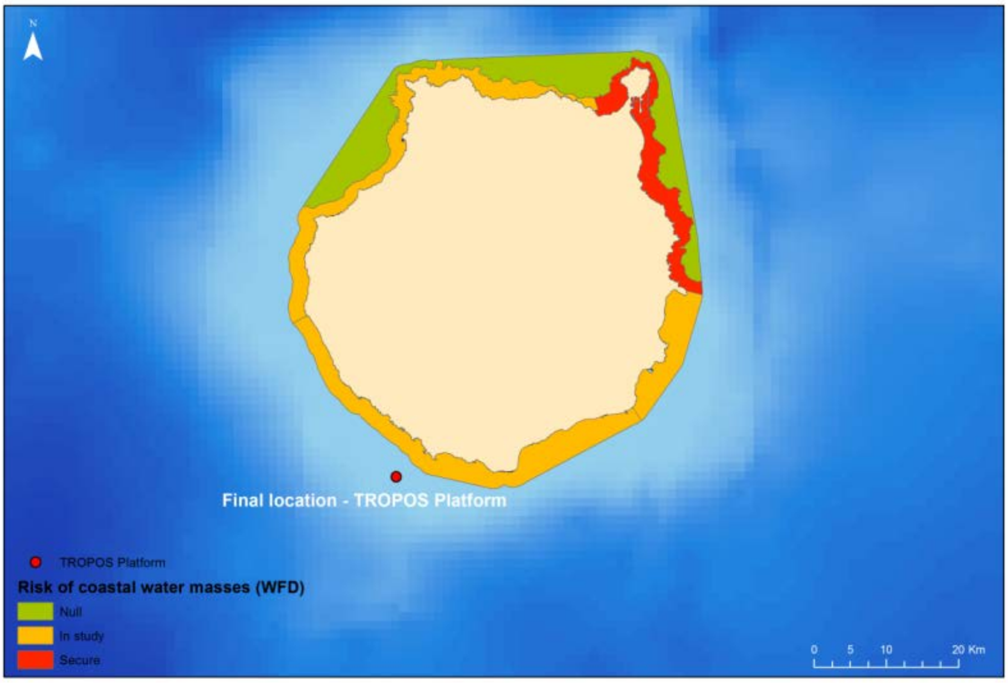

Figure 1-4: Distribution of coastal water masses at risk according to the distribution of the points of discharge inventoried in Gran Canaria (Source: Riera et al. 2007; Gobierno de Canarias, 2005)

1.2.7 NATURAL HAZARDS

Since it is located on volcanic soil, the Canary archipelago is naturally subject to volcanic and seismic activity. The last known eruption in Gran Canaria was around 40 AD. Main areas of hazard have been identified in the northeast part of the island (see below). However, geological hazards in the Canary Islands in general are moderate compared with other volcanic regions with equivalent demographic features (e.g. the Hawaiian Islands).

The occurrence of clouds of dust from the Sahara Desert (Calimas – see chapter 1.2.2 above) is another potential natural hazard in the archipelago. These severe events significantly decrease visibility. Calimas typically occur in Gran Canaria 5 to 7 times a year and last between 2 and 7 days.

Large storms are extremely rare in the Canary Islands. The first time that a tropical storm was recorded in the archipelago was in November 2005, causing considerable damage, including the destruction of the Dedo de Dios (God's Finger) natural rock structure that had stood for thousands of years in Gran Canaria.

Volcanism events

Nearly twenty eruptions have been reported through written chronicles in the last 600 years giving an average of an eruption every 25–30 years and suggesting the probability of having new eruption in subsequent years (Sobradelo, *et al*. 2011). This information enhances the importance of assessing and monitoring the volcanic hazard of the region in order to reduce and manage its potential volcanic risk, and ultimately contribute to the design of appropriate preparedness plans.

The Canary Islands (Spain) are located off the NW African coast, developing over Jurassic oceanic lithosphere as a result of the eastward movement of the African plate over a mantle hotspot (Holik *et al*., 1991; Carracedo *et al.*, 1998). Although all islands except for La Gomera show Holocene volcanic activity, historical volcanism has been restricted to the La Palma, Lanzarote and Tenerife islands (see figure 5.4). In all cases, historical eruptive activity has been related to basic magmas ranging in intensity from strombolian to violent strombolian, originating scoria cones and lavas. In most cases, historical eruptions occurred on the active rift zones along eruptive fissures occasionally generating alignments of cones. The eruption sequences that may be deduced from the successions of deposits differ from one eruption to another and reveal that eruptions did not follow a common pattern. In all cases, the resulting volcanic cones were constructed during single eruptive episodes (i.e. they must be referred to as monogenetic), commonly including several distinctive phases that do not show significant temporal separations between them (Acosta *et al*., 2003). These natural events are mapped on Figure 1-5.

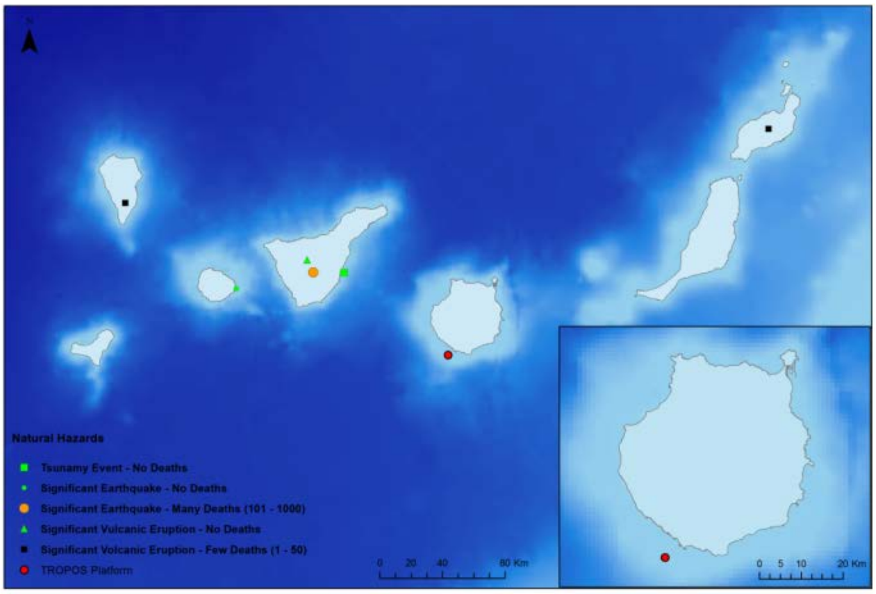

Figure 1-5: Natural hazards registered in the Canary Islands Region (Source: NOAA – National Geophysic Data Center, Natural hazards)

Concerning volcanic hazards assessment in Gran Canaria, the main question relates to the evaluation of the most predictable location and time of occurrence of the next event. Regarding the most probable site, the existing data show that Holocene eruptions are predominantly located around large landslide forming bays in two sectors on the northern flank of Gran Canaria. This setting has been maintained since about 1.9 Ma, and therefore it is highly likely to continue in the future, with basaltic fissure eruptions most probably taking place around the old landslide scars. This information has been used to draw up the volcanic hazards map Figure 1-6, which shows the two sectors on the northeast side of Gran Canaria where future eruptions would pose a considerable risk for densely populated areas. The most dangerous areas in these sectors will be the network of "barrancos", since lava flows will follow the pre-existing valleys. The most likely eruption type produces small amounts of ashes and ash fallout dispersion will be driven by the predominant north/northeast trade winds. More difficult is the prediction of the time of occurrence of the next eruptive event. Existing data refute that volcanic events of the last 11,000 years have a random time distribution. On the contrary, they suggest a pattern in which the present period is an interval of quiescence with duration of 1.9 ka, although longer phases of rest have been observed in the past. Available data does not provide more precision on this aspect. The duration of each eruption will probably be more than 1 week and not longer than 12 weeks, as suggested by comparison with the observations of the historical eruptions of other Canary Islands (Rodriguez-Gonzalez *et al.,* 2009). This risk has been estimated to have a moderate probability and immense magnitude (Gesplan – Gobierno de Canarias, 2010).

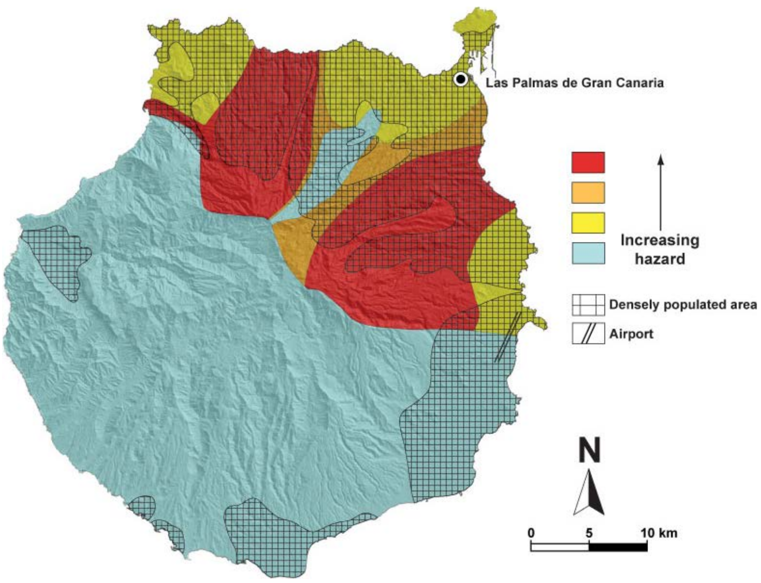

Figure 1-6: Volcanic hazards map of Gran Canaria (Source: Rodriguez-Gonzalez et al., 2009)

Rock detachments and landslides

Pronounced escarpments induce risks of rock detachments and landslides, either by gravity or arising from the combination of gravity and adverse climatic factors. In Gran Canaria, more precisely in an area called Teror, there is a high probability of rock fall by gravity. This hazard may affect populations living on the edges of the main ravines and buildings close to the slopes. However, competent authorities have classified this hazard to be negligible and to have low probability and magnitude (Gesplan – Gobierno de Canarias, 2010).

Risks of wave and wind

The risks of wind and waves have gained increasing importance in recent years due to the rapid and uncontrolled occupation of the coastline due to the tourism boom from the '70s. Touristic areas are located close to the sea and therefore on the ocean foreshore, in areas highly exposed to wave and tidal extreme events. This represents a high risk to the population who inhabits these areas.

Regarding the wind, it can affect power lines, antennas, buildings, either telephone or television. This risk is estimated to have a moderate probability and magnitude (Gesplan – Gobierno de Canarias, 2010).

Erosion Risk

Erosion hazards are common in exposed areas, with high slopes and rare vegetation. In these locations extreme events can be very harmful, as extraordinary rainfalls. These are rare, but when they occur they are characterised by a rapid discharge, with development of torrential floods.

There is also a risk of coastal erosion with widespread incidence along the coast, produced by the erosive activity of the sea, continuously undermining the base of the cliffs, thus promoting instability, resulting in falling blocks sporadically. Marine storms can promote the disappearance of shoreline units as a consequence of strong wave regimes. This risk can affect the eastern side of the island from Las Palmas until Arinaga and in the Southwest side from Arguineguín until Amadores. This risk is estimated to have low probability and insignificant magnitude (Gesplan – Gobierno de Canarias, 2010).

As the Leisure Island deployment location is offshore some of the natural hazards described as land erosion, rock detachment and landslides are not expected to occur. Nevertheless, these risks are considered highly relevant for the island and their occurrence may indirectly affect the normal functioning of the platform. In general, it can be concluded that in Gran Canaria there isn't a large possibility of natural hazards with the exception of the permanent risk of being caused by seismicity or volcanism events (Gesplan – Gobierno de Canarias, 2010)

1.2.8 NOISE CONDITIONS

At the present moment, there is no information available to characterise and evaluate of the state of the submarine noise conditions in Gran Canaria. However, recent efforts to compile information for the Marine Strategy Framework Directive (MSFD) made it possible to perform an inventory considering all the activities that potentially generate noise in the marine environment. To assess the exiting noise pressure, all high and low frequencies noise impulses were considered. Data available made it possible to evaluate the main sources of noise and the potential pressure that can be occurring in the marine environment. In spite of not consisting in actual maps of noise this information was considered a good approach to the marine environment noise problem, identifying areas were the known sources of noise are located. The spatial analyse of accumulated noise pressure was based on shipping traffic made by mercantile ships and fishing vessels. Results shown on Figure 1-7represent an index calculated from the values of marine traffic intensity measured from the accumulated density of AIS signals ("Automatic Identification System", for mercantile boats) and VMS ("Vessel Monitoring System", for fishing vessels) (MAGRAMA. 2012e). The values obtained range between 0 and 2.1 with the following level classification: Very High: 1.6– 2.1, High: 1.2– 1.6, Average: 0.8– 1.2, Low: 0.4– 0.8, Very Low: below 0.4 (MAGRAMA. 2012f).

In Canary archipelago, three locations with potentially high levels of noise were identified (La Gomera, Tenerife, northeast of Tenerife and northeast of Gran Canaria) and two areas with potentially moderated submarine noise (south of Lanzarote and South of Fuerteventura) (see Figure 1-7). The main pressures that characterise these areas with high accumulated potential for acoustic contamination are marine traffic, mostly including ferries between the Islands, and fishing vessels concentration.

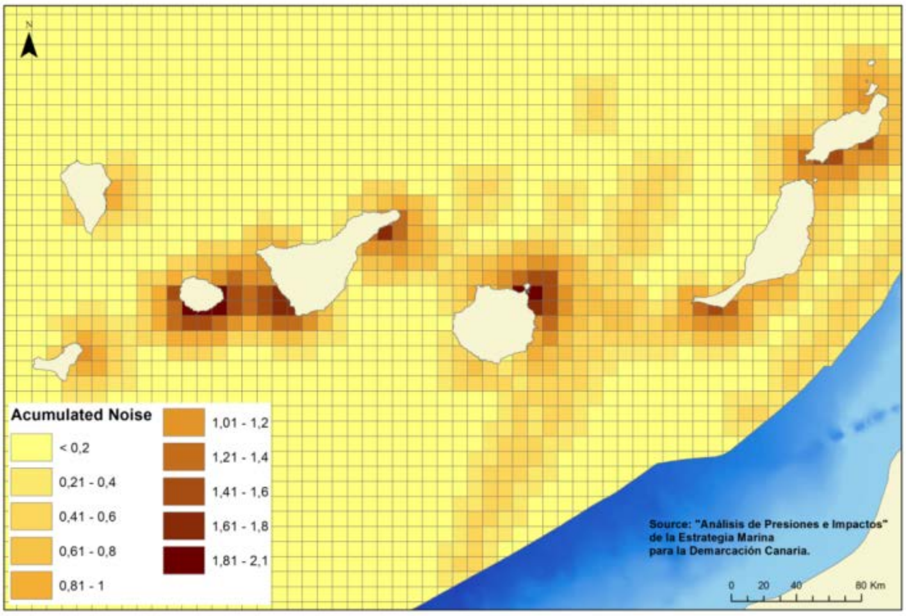

Figure 1-7: Potential levels of underwater noise in Canary Archipelago (Source: MAGRAMA. 2012f)

In the area chosen for the TROPOS platform installation the potential accumulated acoustic contamination appears to be low and the existing semi-quantitative noise index is of 0.60 (see Figure 1-8)(MAGRAMA. 2012f).

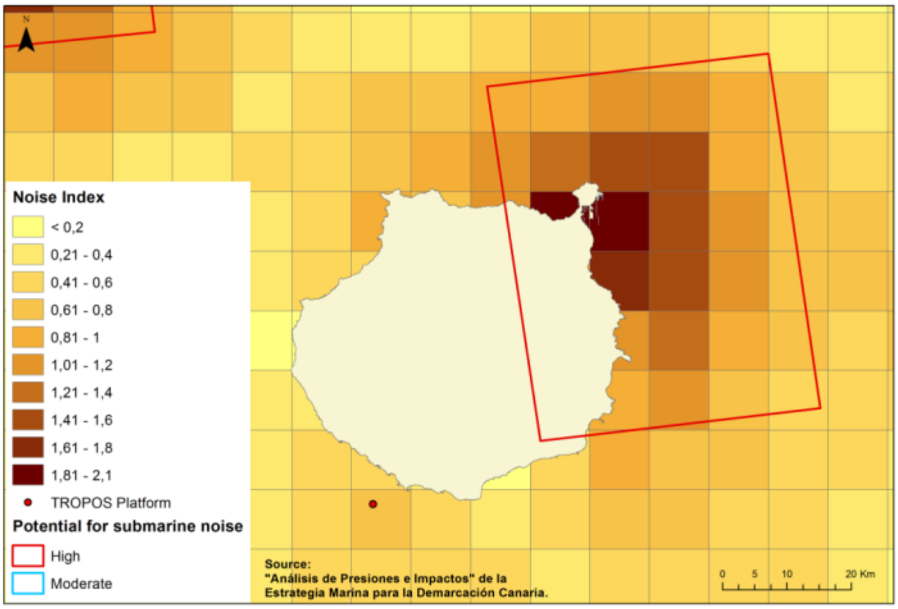

Figure 1-8: Potential levels of underwater noise in Gran Canaria (Source: MAGRAMA. 2012f)

No information was found concerning the routes of the recreational fleet; nevertheless, their impacts should not be neglected but should be addressed. Moreover, to complete the analysis of pressures of accumulated noise, the noise generated by exploitation platforms, hydrocarbons storage, areas of seismic research, etc. should also be taken into account.

As for environmental noise, its actual state is currently unknown, only existing punctual measurements made by national or European projects. To evaluate the actual levels and trends of environmental noise it would be necessary to have temporal series of direct measurements with hydrophones and with sufficient spatial coverage. Afterwards, it would be possible to infer the environmental noise in the entire region by means of modelling that interpolate and extrapolate from the measurements taken from the hydrophones.

1.3 ECOSYSTEMS, HABITATS AND SPECIES COMPOSITION

1.3.1 INTRODUCTION

Canary Islands have a marine area 60 times larger than its land area. With 7,500 km^2 of land and 500,000 km^2 of marine area, the emerged part of this archipelago occupies 1.6% of the total area of Canary Islands. Therefore, 98.4% of the Canarias archipelago is submerged with an average depth of around 3,500 meters, reaching in some areas almost 5,000 meters of depth. This indicates that the vast majorities of the marine ecosystems in this region are characterised by great depths and consequently are partially unknown and highly vulnerable (MARGRAMA, 2012a).

Currently, only 0.15% of the 200 maritime miles are under legal protection and only 0.2% of the existing species are under any protection, since, from all the existing marine species only 12 are in the Catálogo Canario de Especies Protegidas (Canary Catalogue of Protected Species). The general lack of knowledge of the deep ocean and of the distribution of marine species together with the lack of legal protection makes it more difficult to promote the conservation of habitats, marine flora and fauna. The very short coastal area and sub littoral of the Canary Islands are very important for several species of fish, including pelagic species that during parts of their life cycle use this area as a feeding ground and especially as nursery area given to the large abundance of food for larvae and juveniles. This is the case of some species with commercial interest as the anchovy (*Engraulis encrasicolus*), the sardine (*Sardina pilchardus*), the round sardinella (*Sardinella aurita*) and chub mackerel (*Scomber japonicus*) (MARGRAMA, 2012a).

1.3.1 PELAGIC COMMUNITIES

On a global scale, the pelagic environment presents a much larger uniformity than the benthic environment and species that inhabit it have much larger distribution areas. Nevertheless, factors such as light gradient, temperature, salinity, pressure and nutrients availability in the water column determine the structure of the pelagic species and their depth fluctuation between time and space. On the other hand, eddies, upwelling and ocean fronts also determine local differences in nutrient availability and, therefore, spatial heterogeneity, which affects the degree of concentration of plankton biomass and species diversity. In the pelagic sphere the plankton dominates, both in biomass and biodiversity of organisms (Templado *et al.*, 2012).

In Canary Islands a gradient is observed between the oligotrophic waters of the western islands and the most productive in the eastern, due to its proximity to the Saharan outcrop. In a study developed from the east of Fuerteventura to the north of Gran Canaria and La Palma Davenport *et al*. (2002) has concluded that annual productivity diminishes progressively towards the west (237 g C m^{-2} $year^{-1}$, 164 g C m^{-2} $year^{-1}$ and 145 g C m^{-2} $year^{-1}$) (MAGRAMA, 2012a).

1.3.1.1 Phytoplankton

In general, species diversity of the phytoplankton community of the Canary archipelago is dominated by small flagellates, dinoflagellates and diatoms. Other species of underrepresented groups also appear such as cyanobacteria, prasinophytes cryptophytes, and silicoflagellates euglenophytes. According to Ojeda (1986), the most abundant organisms around the Canary Islands are *Katodinium rotundatum*, *Amphidinium acutissimum*, *Gymnodinium simplex* and *Prorocentrum balticum*. Less often are larger dinoflagellates of the genus *Protoperidinium* (*P. bispinum, P. brevipes, P. cerasus, P. ovum, P. curtipes, P. depressum, P. divergens, P. minutum, P. Pyrum appear and P. steinii*), *Prorocentrum* (*P. balticum, P. compressum, P. dentatum, P. gracile, P. lima, P. rostratum, P. triestinum*), *Gonyaulax* (*G. polyedra, G. polygrarmma, G. sousae) , Oxytoxum (O. laticeps, O. mediterraneum, O. scolopax, O. turbo*), *Ceratium* (*C. azoricum, C. extensum, C. fusus, C. kofoidii, C. macroceros, C. pentagonum, C. teres, C. tripos, C. symmetricum*) and *Corythodinium* (*C. tessellatum*), and isolated forms with major sizes of genus *Hitioneis* (*H. cymbalata*) *Ornithocercus* (*O. magnificus*) and *Dinophysis* (*Dinophysis sp.).* It also appears diatoms of the genera *Amphora* (*A. angularis, A. ocellata, A. ostrearia, A. proteus*) *Diploneis* (*D.Bombus, D. chersonensis, D. didyma, D. fusca, D. rouchalensis*), *Coscinodiscus* (*C. radiatus, C. eccentricus*) *Pleurosigma* (*P. rigidum*) *Thalassionema* (*T. nitzschioides, T. patella*), *Navicula* (*N. abrupt, N. cancellata, N. digitodariata, N. lira, N. palpebralis, ramosissima*) and *Nitzschia* (*N. angularis*) among others. There are also coccolithophores (*Emiliania huxleyi, Coccolithus pelagicus, cf Syracosphaera pulchra, Thoracosphaera sp.),* and a unique representative of the silicoflagellates (*Dictyocha fibula*) (MAGRAMA, 2012a).

García-Rojas (2011), in a study focused on the Gran Canaria coastline, concluded that the majority of groups of the phytoplankton community are diatoms and dinoflagellates, and highlights that there are also cyanobacteria species (*Aphanocapsa sp., Arthrospira sp., Calothrix sp., Chrococcus turgidus, Lyngbya aestuarii, Microcoleus sp., Oscillatoria princeps, laetevirens Phormidium, Spirulina subsalsa*) prasinophytes, cryptophytes, euglenophytes (*Eutreptiella sp.)* and silicoflagellates (*Octactis octonaria*). Although diatoms and dinoflagellates are the groups with the greatest number of species, prasinophytes and cryptophyceae are those with the most abundant phytoplankton groups in relation to the total of organisms in the water column.

1.3.1.2 Zooplankton

In Canary Islands, the most important group of zooplankton are the copepods followed by the amphipods, siphonophores appendicularians, ostracods, pteropods and heteropods mollusks, Euphausiacea, Chaetognatha and cladocerans, among others (Hernández, 2001). Considering biomass, copepods are also the most important group (with a total percent of 60–75 %) followed by appendicularians, cladocerans, ostracods, chaetognaths and others. It should also be noted that approximately 70% of the benthic animal species have some plank tonic larval stage, so they are temporary inhabitants of the water column (Templado *et al*., 2012).

As for the ictioplankton, Moyano & Hernández-León (2009) have identified a total of 156 taxa in Gran Canaria Island. The Myctophidae family (*Lampanyctus sp., Ceratoscopelus warmingii, Diaphus holti, Diogenichthys atlanticus, Hygophum benoiti*) was the most abundant (30%), followed by the Sparidae (11%), the Clupeidae (*Sardina pilchardus, Sardinella aurita*) (9%) and the Gonostomatidae (*Cyclothone braueri, Gonostoma elongatum*) (7%). The neritic and oceanic taxa contribute in similar proportions what is characteristic of an oceanic island. Two seasonal patterns of larvae distribution were observed in the water column: a mixture period (winter) and a stratification period (summer). Moreover, it was also found that a significant relationship between moonlight and the small sized zooplankton biomass exists. The most abundant neritic larvae (Sparidae) showed a relationship with the lunar cycle, partially supporting a recent hypothesis about the effect of lunar illumination on larval survival and development in subtropical waters (Bécognée *et al.*, 2006). These authors showed through the study of an annual cycle that the abundance of larval round sardinella (*Sardinella aurita*) in the island of Gran Canaria during the full moon was 38% of that found during the new moon (MAGRAMA, 2012b).

1.3.1.3 Nekton

Although the number of nektonic species is not very high, these species are present in large quantities and consist in important fisheries resources.

The nekton populations exhibit strong natural fluctuations due to zooplankton annual variations and the randomness of recruitment in the water column. Some carangids and larger size scombrids are considered small pelagic, which feed primarily on the previous species, although they can also consume zooplankton. The most widespread are the atlantic chub mackerel (*Scomber colias*), the sardine (*Sardina pilchardus*), the Madeiran sardinella (*Sardinella maderensis*), the horse mackerel (*Trachurus trachurus, T. picturatus*), the sand smelt (*Atherina presbyter*), the European anchovy (*Engraulis encrasicolus*) and the bogue (*Boops boops*). The pompano (*Trachinotus ovatus*), the garfish (*Belone belone*), the leerfish (*Lichia amia*), the bluefish (*Pomatomus saltatrix*) and the barracudas *(Sphyraena* spp.) are also typical of the littoral waters. The barracudas and the amberjacks can be found in rock outcrops, where they can predate smaller benthonic fishes (Brito*,* 1984).

Considering large pelagic, there are several species of scombroid that are highly relevant for the fisheries sector, such as the bluefin tuna (*Thunnus thynnus*), the yellowfin tuna (*Thunnus albacares*), the albacore tuna (*Thunnus alalunga*), the bigeye tuna (*Thunnus obesus*) and the Skipjack tuna (*Katsuwonus pelamis*). Other tunas can also appear in the islands, although in smaller numbers. These are the bullet tuna (*Auxis* rochei), the Atlantic bonito (*Sarda sarda*), the Wahoo (*Acanthocybium solandri*) or the plain bonito *(Orcynopsis unicolor).*

The swordfish or emperor (*Xiphias gladius*), the blue and white marlins (*Makaira nigricans* and *Tetrapturus albidus*) and the atlantic sailfish (*Istiophorus albicans*), also close to the oceanic tuna species, are caught sporadically in Canarian waters. To this group also belong the Greater Amberjack (*Seriola dumerilii*) of the Carangidae family. Both swordfish and amberjacks are very voracious carnivorous fish, with gregarious and erratic habits, typical of the warm and temperate seas. They gather in larger or smaller banks and perform important trophic and reproductive migrations (MAGRAMA, 2012a; Templado *et al*., 2012).

There are also sharks like hammerhead sharks (*Sphyrna spp.),* blue sharks (*Prionace glauca*) and mako sharks (*Isurus oxyrinchus*). Other pelagic sharks of the *Carcharinidae* and *Lamnidae* families are also present in the archipelago waters, although their populations are very scarce and their artisanal fisheries landings are very low in number. Other representative of the large pelagic species are the manta rays (*Mobula mobular* and *M. tarapacana*), that are frequent in the coastal and oceanic waters that surround the islands. In contrast to these large pelagic swimmers there is also the sunfish (*Mola mola*), a slow-moving and low hydrodynamic morphology specie, that feeds mainly on gelatinous plankton at sea, but can also approach the coast to feed on some species of benthic ascidians. In Spanish waters there are also about 70–80 species of pelagic cephalopods, some of which also are of a great commercial interest (Templado *et al.*, 2012).

1.3.1.4 Marine Mammals

In Canary Islands, about 27 species of cetaceans[2] (22 baleen whales (mysticetes) and 5 toothed whales (odontocetes)) have been recorded. The most characteristic are the short-finned pilot whale (*Globicephala macrorhynchus),* the common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*), Atlantic spotted dolphin (*Stenella frontalis*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), sperm whale (*Physeter macrocephalus*) and Cuvier's beaked whale (*Ziphius cavirostris*).

Some of these species are present throughout the year, with permanent populations, as the short-finned pilot whales, the bottlenose and Risso's dolphins and the sperm whales. Other species are seasonal and their presence in the Canary Islands is probably associated with a migratory movement. Dolphins feed (stripped, common and bottlenose dolphins) on several species of fish and cephalopods. Other cetaceans such as pilot whales, beaked whales and sperm whales are exclusively teuthophageous (MARGRAMA, 2012a).

It is possible to observe from the Figure 1-9 and Figure 1-10 that the largest number of marine mammal sightings occurs on the southwest of the islands of La Gomera, Tenerife and Gran Canaria. Although this data reflects the effort of the boats that work with commercial and scientific purposes on the area, the cartographic representation of the sightings does not include sufficient information of the areas of major importance for these species.

The existence of stable populations in the Canary Islands has allowed a major development of whale watching industry. The main threats to the conservation of some species (particularly sperm whales) are the risk of collisions with ships, due to the heavy traffic of fast ferries between the islands, and the long-term impact of cruise ships especially on the pilot whales (MARGRAMA, 2012b).

[2] The order Cetacea includes whales, dolphins and porpoises

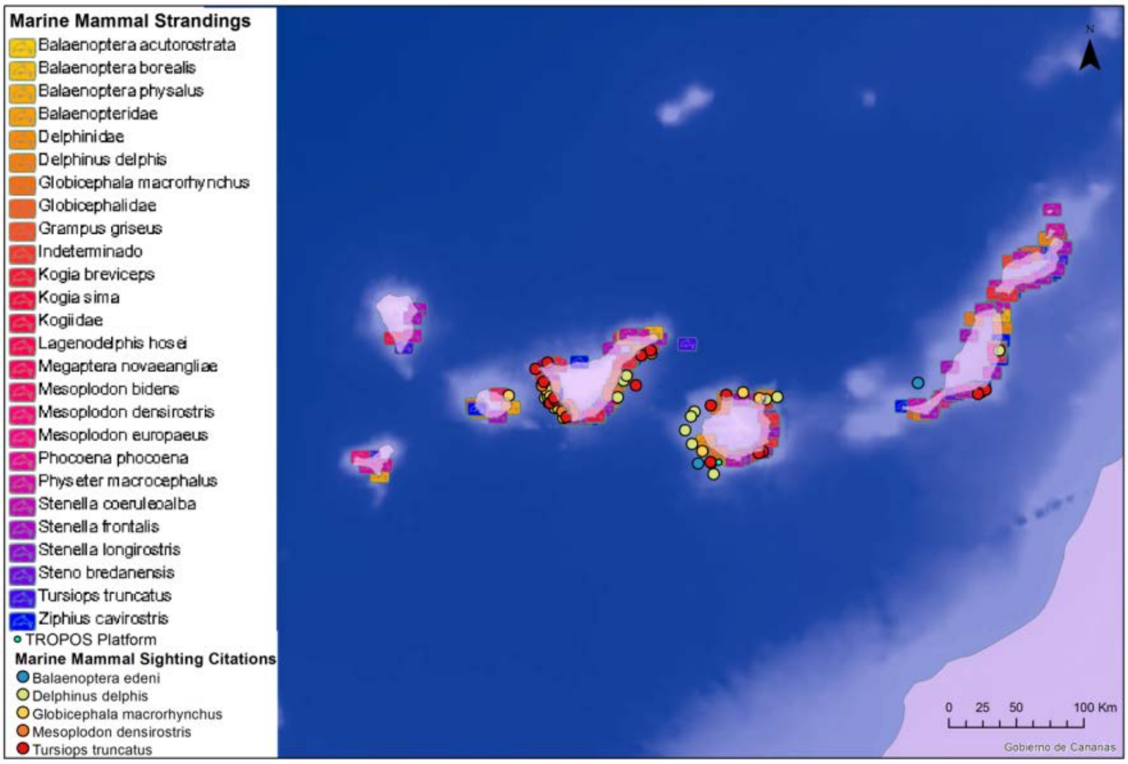

Figure 1-9: Marine mammal sightings and strandings in the Canary Islands. Source: REDMIC – Repositorios de Datos Marinos Integrados de Canarias

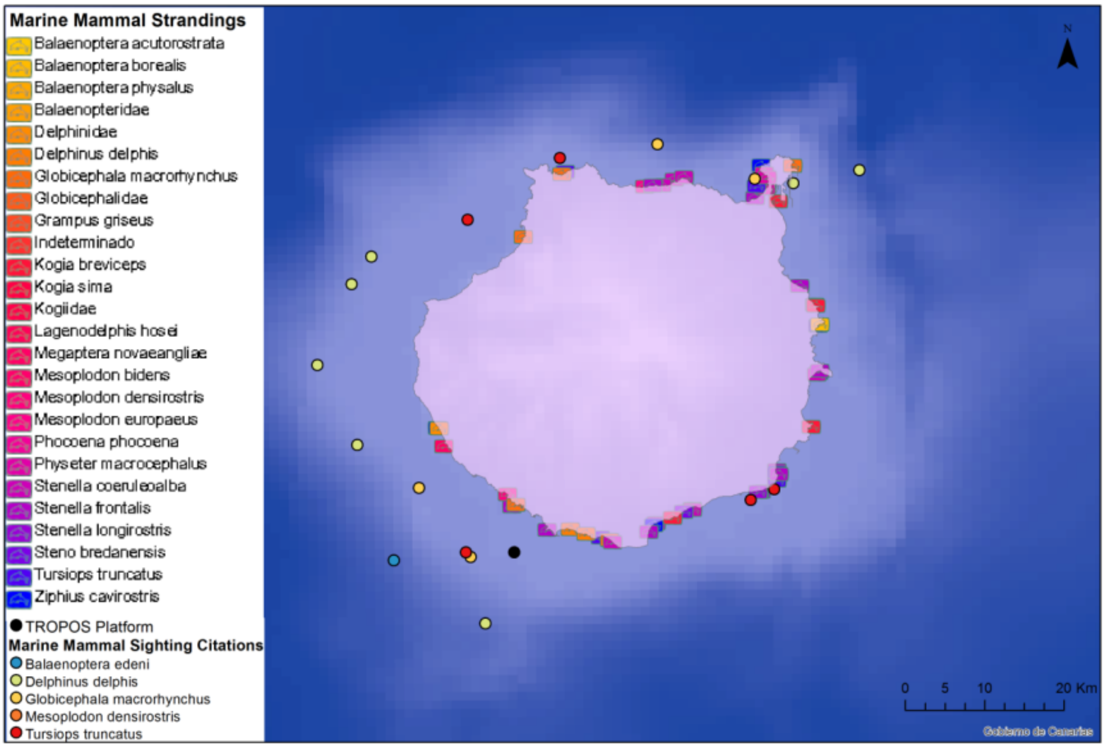

Figure 1-10: Marine mammal sightings and strandings in Gran Canaria Island. Source: REDMIC – Repositorios de Datos Marinos Integrados de Canarias

1.3.1.5 Marine Reptiles

In Canary Islands, the reptiles' group is represented by five of the eight currently recognised species of sea turtles: the loggerhead turtle (*Caretta caretta*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), green turtle (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*) and the olive ridley (*Lepidochelys olivacea)*. These animals feed on jellyfish, siphonophores and other oceanic elements on pelagic waters, and of benthic fauna and flora (crabs, urchins, mollusks, algae, etc.) in coastal waters (MARGRAMA, 2012b).

The movement of loggerhead sea turtles in Canary Islands was radio- tracked and mapped within the framework of different national and international project. The results of these projects are shown in Figure 1-11.

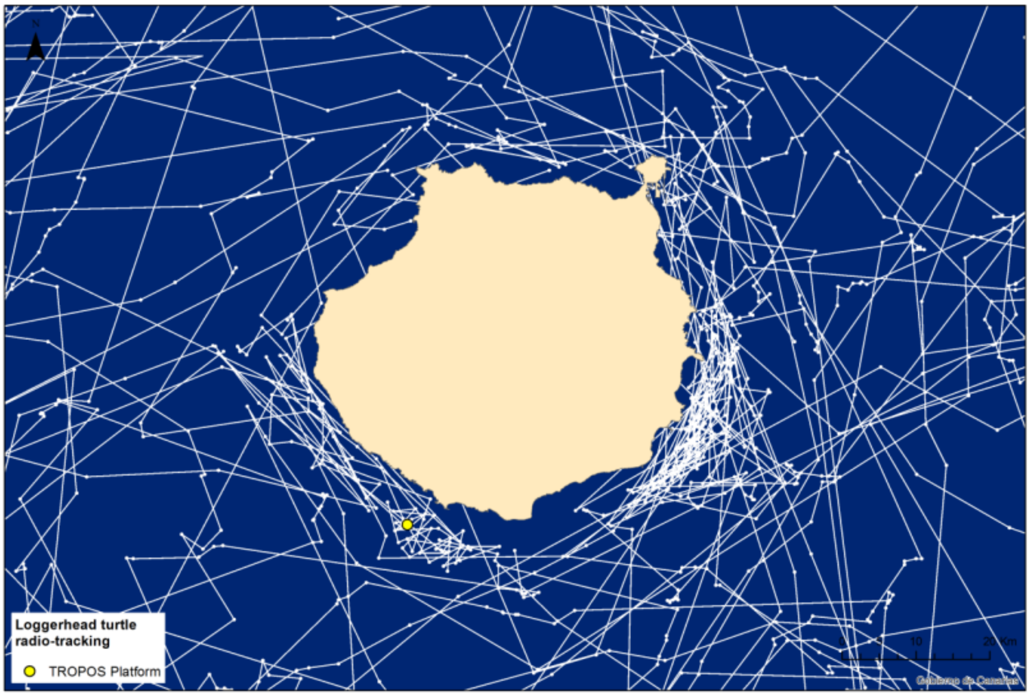

Figure 1-11: Analysis of distribution of the Loggerhead sea turtle (Caretta caretta) followed by radio-tracking in Gran Canaria Island. Source: REDMIC – Repositorios de Datos Marinos Integrados de Canarias (Data obtained from Observatorio Ambiental Granadilla; Project AEGINA; Project LIFE)

1.3.2 BENTHIC COMMUNITIES

In Canary archipelago benthic communities can be associated with both soft and hard substrate. The communities found on these two types of sediment are very distinct and therefore they are described separately.

1.3.2.1 Infralitoral soft bottom seabed

In the Canary archipelago, soft bottom seabeds are mostly shallow sand banks and sand seabeds permanently submerged and covered by marine phanerogams and seaweeds, until a depth of approximately 40 m (approximated lower limit depth, characterised by the paddle grass *Halophila decipiens)*.

The most extensive soft bottom infralittoral habitat in Canary Islands is dominated by algae of the genus *Caulerpa.* This habitat is unevenly distributed regionally, covering approximately 216 km^2 in three eastern islands and 12 km^2 in four western Isles (MARGRAMA, 2012b). *Caulerpa* grows in sandy, muddy or mixed sea beds at depths from approximately 10 m until a maximum of 50 to 60 m (Barquín-Diez *et al.* 2005). It can coexist with representatives of other typical communities of sandy bottoms as the seagrass *Cymodocea nodosa, Halophila decipiens*, the *Heteroconger longissimus* or the polychaete *Bispira viola* (MARGRAMA, 2012a).

Subsequently, the most extensive habitat is the community of sand eel (*Heteroconger longissimus*) covering 143.3 km^2 (Barquín *et al.*, 2005).

The two habitats described represent more than 65% of the extent of the sedimentary soft bottom seabed.

The most widespread habitat is the infralitoral soft bottom are the maerl beds that cover 90.5 km^2 of the soft seabed and are present in almost all islands, except for Fuerteventura and La Palma. This habitat is largely protected and is included in four habitat types considered in Annex I of the EC Habitats Directive: 'Sandbanks which are slightly covered by seawater at all times'; 'large shallow bays and inlets'; 'estuaries' and the priority habitat 'lagoons'. According to Falcon and Carrillo (2005) in Canary Islands these communities are located in the deeper subtidal zone, and although they can be found at shallow sites, most of its development takes place at 40–60 m and can occupy large areas (MAGRAMA, 2012a; MAGRAMA, 2012d).

Cymodocea seagrass meadows occupy 82.6 km^2 and exist in Lanzarote, Fuerteventura, Gran Canaria, Tenerife and La Gomera. Meadows of the seagrass *Cymodocea nodosa* are the most dominant vegetative communities in shallow soft substrates, forming extensive subtidal meadows. Most of these meadows are located in the eastern and southern coasts of the islands, in sheltered areas, protected from the trade winds and at depths ranging between 2 m and 35 m (Pavón-Salas *et al.,* 2000). *Cymodocea* are most abundant in the eastern and central islands, as they are the oldest and more eroded islands, with a larger submerged platform and sediment (Brito, 1984, Haroun *et al,* 2003.). In some locations, *Cymodocea nodosa* meadows are mixed with species of the green alga *Caulerpa* (Pavón-Salas *et al.* 2000). Seagrass meadows are considered as a habitat in decline throughout the Canarian coastal areas, and hence *Cymodocea nodosa* is legislated as an endangered species (Barberá *et al*., 2005).

The less extensive habitat is the Halophila meadow and the *Bispira violates* communities, and both represent 1.4% of the seabed (MAGRAMA, 2012b). Seagrass meadows of *Halophila* occupy only 2.48 km^2 in Tenerife and La Palma, although *Halophila decipiens* as already been documented in Gran Canaria.

1.3.2.2 Infralitoral hard bottom seabed

The specific composition of this ecosystem varies greatly depending on the prevailing environmental factors found on the archipelago and island. As a result, the existing biocenoses are different in the north or south of the islands. In addition, the biocenosis, both sessile and mobile, is diverse and varied also existing differences between the eastern and western islands (MAGRAMA, 2012a). In the Canary Islands the hard substrates are more extensive than the soft ones as a consequence of the island's short geologic age, with just 20 million years (González *et al.* 1986).

In general, the dominant benthic community in the infralittoral hard bottom is produced by the sea urchin *Diadema aff. antillarum*, covering 68% of the areas currently mapped. In these benthic communities, plant biomass production and its extension on the substrate is affected by the grazing activity of the lime sea urchin (*Diadema aff. Antillarum*) that is very abundant on the rocky hard bottoms. These herbivore populations are so abundant, that when they are present the bedrock has no vegetation cover. These areas without algal cover are called *blanquizal*, as a consequence of the whitish appearance of the bedrock. This colour is due to the presence of calcareous algae, corals and sponges that cover it and resist to the continuous grazing of these urchins (MAGRAMA, 2012a, MAGRAMA, 2012b).

Next in order of importance are the rocky bottoms dominated by algae. This habitat has a global surface of 211 km^2, represents approximately 30% of the entire infrallitoral hard substrate seabed and is present in all islands.

Facies of *Leptogorgia* spp. are registered in all islands with exception of Fuerteventura and El Hierro, occupying an area of 10.2 km^2.

The community of black coral (*Antiphatella wollastoni*) is distributed in several bathymetric strata though it presents further developments at depths beyond the circalittoral. This community covers an area of 3.9 km^2 in the Canary Islands (MAGRAMA, 2012b).

According to the Marine Strategy Framework Directive, currently, the major threat to the benthic communities is the fishery activity and other anthropogenic activities such as the deployment of artificial reefs, cables and tubes, dredging, coastal erosion, anchorages, infrastructures for ports and discharges of dredged (MARGRAMA, 2012d).

1.3.3 SEABIRDS

Canary Islands are very important for seabirds, as these Atlantic islands are home for several breeding populations. These islands include several Important Bird Areas (IBA's) that are in their vast majority marine extensions of coastal colonies, although some are areas of concentration in the sea (Figure 1-12). These islands are characterised by a high number of reproductive species of Procellariformes. Currently, seven species of this group use these islands for reproductive purposes and at least three other extinct species also did. For several of these colonies Canary Islands represent the only breeding site in Spain: Bulwer's petrel (*Bulweria bulwerii*), the Manx shearwater (*Puffinus puffinus*), the little shearwater (*Puffinos assimilis)* the white-faced storm petrel (*Pelagodroma marina*) and the Madeiran storm petrel (*Oceanodroma castro*). The majority of the reproductive birds feed on exclusively pelagic waters or in areas of high productivity in the African continental shelf.

All of these species are vulnerable to several threats as the loss of habitat, introduced land mammals, artificial lights, etc. Consequently, all of them, with the exception of the Manx Shearwater, are included in Annex I of the Birds Directive. Due to its geographical location, the Canary Islands are also crossed by numerous European species during migration (Arcos *et al.,* 2009).

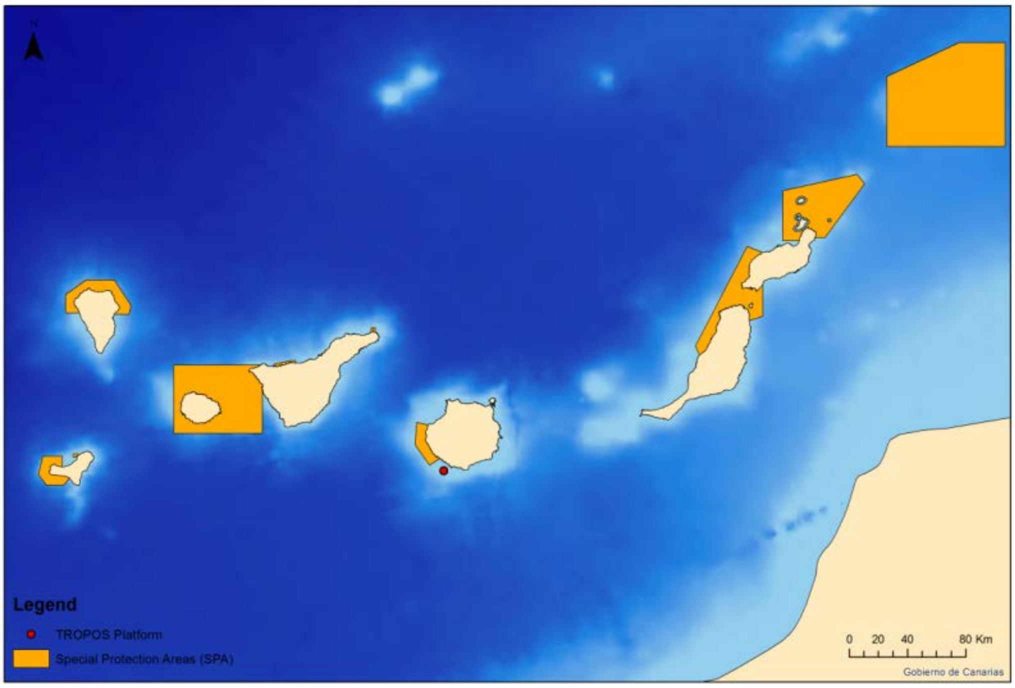

Figure 1-12: Special Protection Areas (SPA) in Canary Islands

On the cliffs, islets and rocks of the other ten species of marine birds archipelago regularly reproduce: the common tern (*Sterna hirundo*), the yellow-legged gull (*Larus argentatus*), the dark gull (*Larus fuscus*), the Madeiran storm petrel (*Oceanodroma castro*), the European storm petrel (*Hydrobates pelagicus*), the white-faced storm petrel (*Pelagodroma marina*), Cory's shearwater (*Calonectris diomedea*) the little shearwater (*Puffinus assimilis*), the Manx shearwater (*Puffinus Puffinus*) and the Bulwer's petrel (*Bulweria bulwerii*) (MAGRAMA, 2012a).

The TROPOS platform is installed 8 km south of an IBA and/or Special Protection Area (SPA), under the Birds Directive of the Natura 2000 Network. This IBA/SPA (ES395 Coasts and waters of Mogán/ ES0000530 Marine Space of Mogán – La Aldea), represents a seaward extension of the land colonies of Cory's Shearwater (*Calonectris diomedea*) and Bulwer's Petrel (*Bulweria bulwerii*) that nest on the sea cliffs of the IBAs coastline. This protected coastline extends from Punta de La Aldea until Mogán's harbour and is characterised by cliffs, ravines and at a lesser extent by beaches, rocks and debris. This stretch of coast is protected of the dominant trade winds during most part of the year and consequently is characterised by pleasant and tranquil sea conditions (Figure 1-13).

The IBAs several colonies of Bulwer's Petrel and Cory's shearwater are difficult to quantify due to the slope of the area and difficulties in accessing the nest holes. These species use near waters during the day and move to their breeding colonies during the night. Consequently, during the summer months it is very frequent to encounter groups of shearwaters floating at dawn and night. The area is also used as a feeding area. Other species of interest in this IBA are the Manx shearwater and the yellow legged gull that present several colonies on the littoral of the IBA (Arcos *et al.,* 2009).

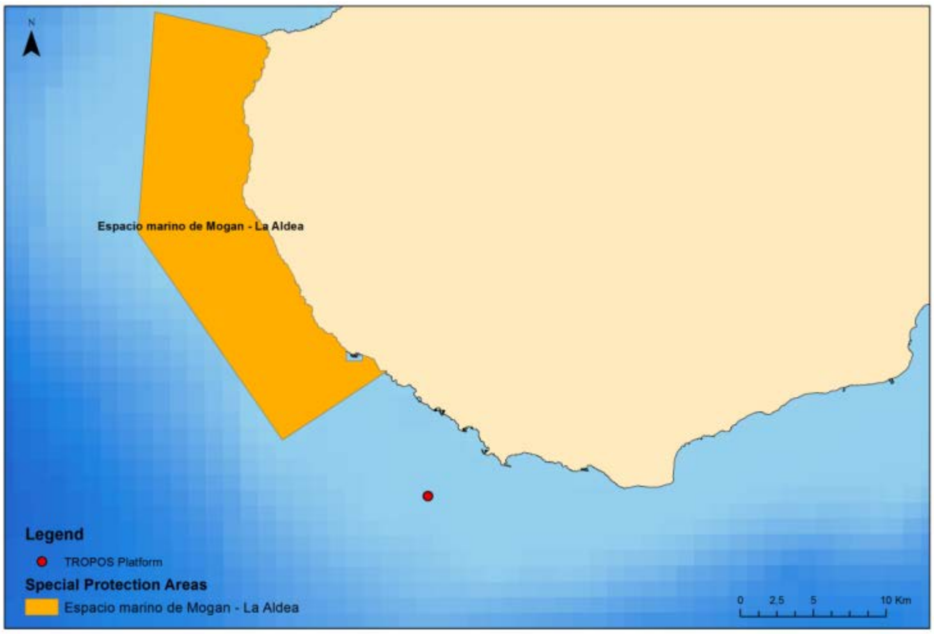

Figure 1-13: Special Protection Area – Espacio Marino de Mogán – La Aldea

1.3.4 SPECIAL HABITATS

The habitats designated in Gran Canaria are based on the EUNIS classification (Davies and Moss, 1997, 1999, Connor et al, 2004; RAC / SPA, 2006) and use a ranking system accepted in the EU context, with a hierarchical ranking allowing to go through the classification in an orderly manner, beginning with the abiotic characteristics (bathymetry layer and substrate type) and ending with the biological (facies, communities, etc.). Most of these habitats are also under the Annex I habitats directive classification (Habitat 1110: Sandbanks which are slightly covered by sea water all the time and Habitat 1170: Reefs).

The special habitats encountered in Canary archipelago are the following:

- Sublitoral rocky seabeds dominated by algae

- Facies de *Leptogorgia* spp.

- *Cymodocea* seagrass meadows

- *Diadema aff. Antillarum* communities

- *Halophila* seagrass meadows

- Infralitoral soft bottom maerl beds

1.3.4.1 Sublitoral rocky seabeds dominated by algae

In the Canary coastlines, the rocky substrate is more common than the soft substrate, as a consequence of the short geologic age of the archipelago. The rocky seabed in Canary Islands is abrupt, with frequent walls, trenches, cornices, wells, caves and underwater tunnels. In the rocky shoreline the upper infralitoral zone is markedly colonised by a dense algal coverage, forming a zonation that reaches variable depths up to 15 meters of depth, under which algae only develop forming patches in very specific locations. The algae specific composition is highly variable, changing in accordance with the occurring ecologic conditions. According to the degree of the prevailing hydrodynamism two types of communities can be distinguished, one in open areas with strong hydrodynamism and the other one in protected areas with low hydrodynamism. (Gonzalez *et al.,* 1986).

In the lower limit of the eulittoral and infralittoral rocky shores, a dense algal settlement develops characterised by the phaeophyta *Cystoseira abies-marina* (usually the most abundant) and other genres such as *Gelidium*, *Corallina*, *Zonaria*, *Padina*, *Sargassum*, etc.

A rich sessile fauna, with sponges as *Ircinia* spp and *Aplysina aerophoba* lives in this dense algal settlement known as a " biocenosis of photophilic algal". On the *Aplysina aerophoba* the opisthobranchia *Tylodina perverse* lives that feeds on it and has the same yellow colour. Anemones *Anemonia sulcata* and *Aiptasia mutabilis* are also frequent there. In these habitats, some slow motion organisms, as the sea stars *Marthasterias glacialis* and *Coscinasterias tenuispina* are also present. Herbivorous invertebrates such as limpets (*Patella spp*), gastropods (*Luria lurida* and *Erosaria spurca*), sea urchins (*Paracentrotus lividus, Arbacia lixula* or *Diadema antillarum aff*) and crustaceans (genera

Plagusia, Grapsus, Maja, Percnon, Pachigrapsus, etc.) intensively graze the different species of algae in these shallow waters. In these complex food webs characteristic fish species coated with algae are also involved suc as the parrotfish (*Sparisoma cretense*), salema porgy (*Salpa salpa*), blennies (*Ophioblennius atlanticus atlanticus; Scartella cristata; Parablennius pilicornis*) the wrasses (*Symphodus spp*) or the ornate wrasse (*Thalassoma pavo*) among others. Moreover, these habitats serve as breeding ground and refuge for offspring and many species of coastal juvenile fish (Fernández-Palacios et al., 2001). For some of the species such as wrasses (*Symphodus* spp. and *Labrus* spp.) these algal seabeds are critical to the preservation of their populations, since these are the only locations where they can lay their eggs in the form of nests. These fish build nests with branches, small piles of seaweed, pebbles and sand intertwined. For the distribution of this habitat in Gran Canaria see Figure 1-14.

No species of the infralitoral rocky seabed dominated algae is classified as endangered or vulnerable in the Spanish Catalogue of Endangered Species. The white limpet (*Patella aspera ulyssiponensis)* is in the List of Wildlife Species in a Regime of Special Protection. Additionally, in the Canary Catalogue of Protected Species, the algae *Cystoseira mauritanica* is considered as vulnerable.

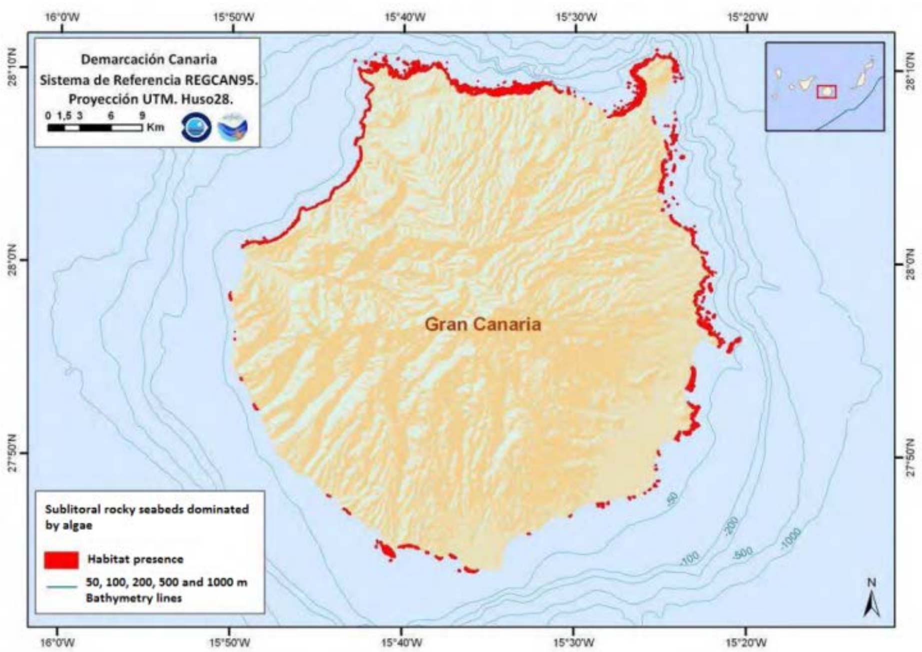

Figure 1-14: Spatial distribution of sublitoral rocky seabeds dominated by algae around Gran Canaria Island (MAGRAMA, 2012b)

1.3.4.2 Cymodocea seagrass meadows

In the Canarian Archipelago, the seagrass *Cymodocea nodosa* forms meadows known as *sebadales* or *manchones*. This species is considered to be endangered as a result of the regression in many coastal areas. Most of the *sebadales* are located in the eastern and southern coasts of the islands, always in sheltered areas, protected from the trade winds, at depths ranging between 2 m and 35 m (Pavón-Salas *et al.,* 2000). They are most abundant in the eastern and central islands, as these are the oldest and most eroded, with a larger submerged island platform and amount of sediment (Brito, 1984, Haroun et al, 2003.) (MARGRAMA, 2012a).

The phanerogam *Cymodocea nodosa*, has a size considerably smaller than *Posidonia oceanic* and presents a markedly seasonal development, where growth can occur between May and October, being very pronounced in the summer months. During winter, leaves can lose their colour and the rhizomes persist. It is a typical coloniser or pioneer plant, with a wide environmental tolerance. It grows from surface waters to about 30 m depth. It is very widespread and generally occupies small areas, usually on sandy or sandy-muddy substrates and more rarely, rock or "maerl" seabed. Frequently, these meadows are monospecific, although they can also form mixed meadows with the green algae *Caulerpa prolifera* or with another marine phanerogam. In shallow areas with muddy sediments, rich in organic matter, they can be found alongside *Zostera nolitii*, a smaller plant size.

In open water, Cymodocea can colonise clear areas of *P. oceanic* meadows. In places of *Posidonia* they often present a discontinuous depth distribution, forming a band above them and another below. Canarian *sebadales* can develop a mosaic of patches varying in size, or forming meadows with a more or less continuous distribution, generally between about 2 m and 25 m deep. Communities hosting *Cymodocea* are simpler and less diverse than that of *Posidonia*, but some invertebrate species are unique to this habitat. Variations depend on the geographical location or the environment in which are observed. The algal community that inhabit the leaves of *Cymodocea nodosa* is poor when compared to *Posidonia oceanica* leaves, however, the meadows have already been cited to have more than 50 species of epiphytic algae on the Canarian seagrass. There is a general predominance of small coralline algae (*Pneophyllum fragile*, *Hydrolithon farinosum*, *H. cruciatum*) and various filamentous algae such as *Ectocarpus siliculosus var. confervoides*, *Ceramium spp*., *Aglaothamnion tenuissimum*, *Acrochaetium daviesii* or *Anotrichium barbatum*. Among the epiphytic fauna, some hydroids (usually gender *Plumularia* and *Aglaophenia*) and small anemones are included, such as

Bunodeopsis strumosa and *Paranemonia cinerea*.

In the foliage stratum it is possible to identify typical seagrass species such as *Gibbula leucophaea*, *Rissoa monodonta*, *Tricolia tenuis* or *Smaragdia viridis*. The common shrimp of the genus *Hippolyte* and a small Gobiesocidae fish of the genus *Opeatogenys* (*O. cadenati*) are also frequent. Other characteristic fish are the syngnathids and wrasses.

The sediments colonised by this seagrass are occupied by numerous gastropod species (mostly by the families *Nassaridae, Marginellidae, Cystiscidae, Conidae and Turridae*) and some echinoderms, as the sea cucumber *Holothuria tubulosa* and *H. polii* and sea stars of the genera *Astropecten*. Partially buried in the sediment are common some anemones (*Condylactis aurantiaca*) and Ceriantharia (*Arachnanthus nocturnus*, *maderensis Isarachnanthus* and *Pachycerianthus dorhni*, the latter two species are found in the Canary Islands) and gastropods of the families Bullidae (*Bulla striata*) and Haminoeidae (*Haminoea hydatis*).

In the Canarian Islands, sebadales stand out the gastropod species *Conus pulcher*, *Marginella glabella*, *Bulla mabillei* and *Hydatina physis*. Additionally, there are many species that live completely buried in the substrate occupied by this plant among which is abundant the bivalves *Loripes lacteus*, *Spisula subtruncata* or *Venerupis geographica* or the irregular sea urchin *Echinocardium mediterraneum*. The sandy bottoms adjacent to the *sebadeles* are usually inhabited by dense populations of the sand eel *Heteroconger longissimus* (Templado *et al*., 2012). The distribution of this habitat in Gran Canaria is shown in Figure 1-15.

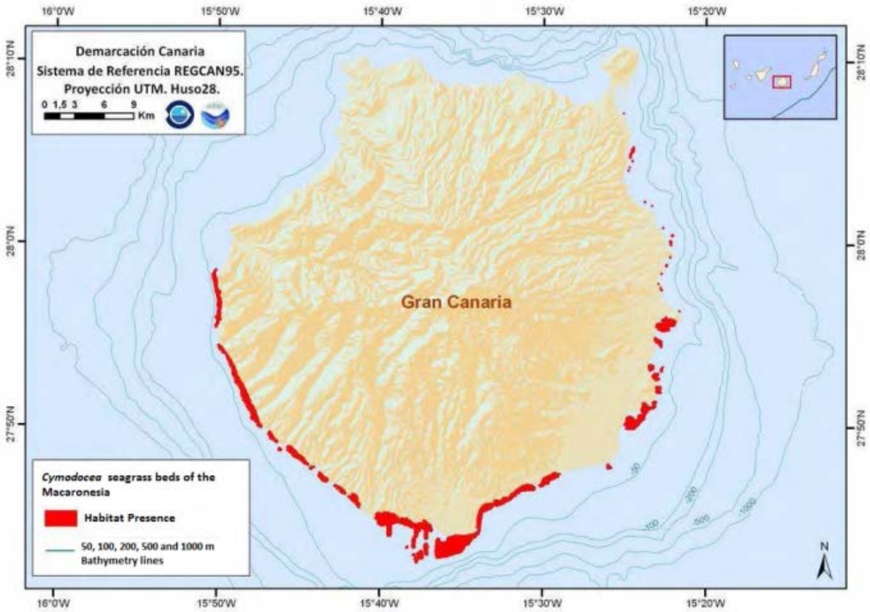

Figure 1-15: Spatial distribution Cymodocea seagrass meadows around Gran Canaria Island (MARGRAMA, 2012b)

1.3.4.3 Facies of *Leptogorgia* spp. In Gran Canaria Island

The gorgonia of the Leptogorgia genera grow in general in rocky surfaces with intense sedimentation. This substrate is usually clear of coral, although in some specific shallow areas it may appear as the *Dendrophyllia laboreli*. When occupying the same substrate, the yellow gorgonian *L. viminalis* presents a larger size and on its basal structures appear small colonies of *L. ruberrima.* On these colonies, it is possible to encounter specimens of the gastropod predator *Simnia spelta* and the crustacean *Balssia gasti*, which camouflage in the gorgonian branches and are frequent visitors of these colonies. Sometimes, the polychaete *Hermodice carunculata* predating on samples of these gorgonians is also observed. The gastropod *Pseudosimnia carnea* has been observed on the red gorgonian colonies as well as specimens of the bivalve *Pteria hirundo* and cephalopods eggs are occasionally seen growing on branches of algal specie (Brito and Ocana, 2004).

Species that are characteristic to this habitat have adapted to rocky and sandy mixed substrata. Among the most characteristic species of invertebrates there are the irregular urchin *Brissus unicolor*, the starfish *Astropecten aranciacus* and *Narcissia canariensis* and the crustacean *Cryptosoma cristatum* in this habitat. The ichthyologic community is composed of typical species of the rocky substratum such as the mullet (*Mullus surmuletus*), the greater weever (*Trachinus draco*), the scorpion fish or stargazer (*Scorpaena scrofa, Uranoscopus scaber*) and sparidaes such as the common pandora (*Pagellus erythrinus*), the common two-banded seabream (*Diplodus vulgaris*) and others (*Pagrus auriga, Dentex dentex, D. gibbosus*). Small serranids such as combers (*Serranus atricuada, Serranus cabrilla* and *Serranus scriba*) are usually also present in this type of habitat. Some *benthic chondrichthyans* such as stingrays (*Dasyatis stingray* and *Taeniura grabata*) and angel shark (*Squatina squatina*) are frequent in this type of seabed (MARGRAMA, 2012b). The distribution of this habitat in Gran Canaria is shown in Figure 1-16.

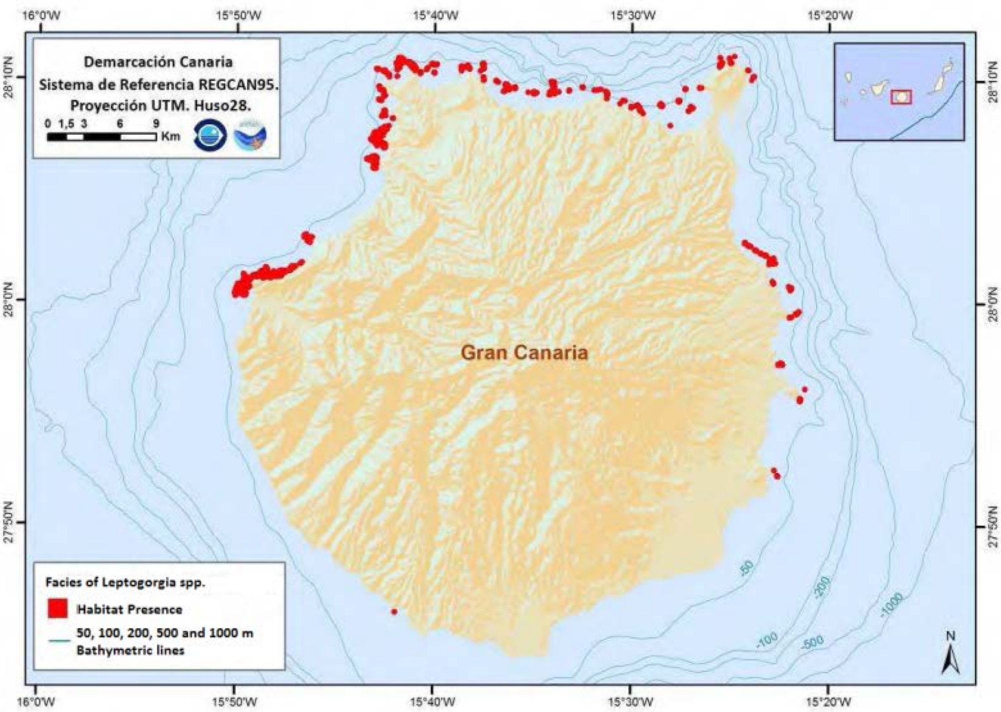

Figure 1-16: Distribution of the Leptogorgia spp. facies in Gran Canaria Island (MARGRAMA, 2012b)

1.3.4.4 Infralitoral rocky seabeds with moderate energy dominated by the sea urchin *Diadema antillarum*: Blanquizales

Diadema aff. antillarum, also know as lime urchin, black sea urchin or long-spined urchin is an avid consumer of algae. This urchin is at the base of the food chain of many coastal ecosystems in the archipelago. In a vast area of the infralitoral seabed of the archipelago, the grazing action of *Diadema* *antillarum* has created completely naked areas of any type of vegetal and animal coverage, commonly known as *blanquizales*. The urchin avoids the high turbulence of the first few meters of water from the surface, what enables the algal fringe to survive and benefit from the high light available. However, from the first few meters to the lower limit of the infralittoral (60–80 meters, but can also be found up to 400 m) high densities of urchins produce imbalances in the structure of rocky environments. Its causes are not totally clear, although most studies point out the overexploitation of the littoral fishery resources, specially the sea urchin common predators (Duggins, 1980, Tegner & Dayton, 1981, Breen *et al.*, 1982, Tegner & Levin, 1983, Hay, 1984, McClanahan & Muthiga, 1988 McClanahan & Shafir, 1990, McClanahan, 1992, McClanahan *et al*., 1994, Sala & Zabala, 1996, Babcock *et al*., 1999, Shears & Babcock, 2003).

D. antillarum morphology (color and long-spined black, black and thin) makes it easily distinguishable from any other species of sea urchin observable in Canary. *D. antillarum* is a gregarious species, forming large groups on rocky bottoms in shallow or shallow water, mainly in order to seek refuge in the caves and crevices for protection from predators (Tuya *et al.,* 2004). The distribution of this habitat in Gran Canaria is shown in Figure 1-17.

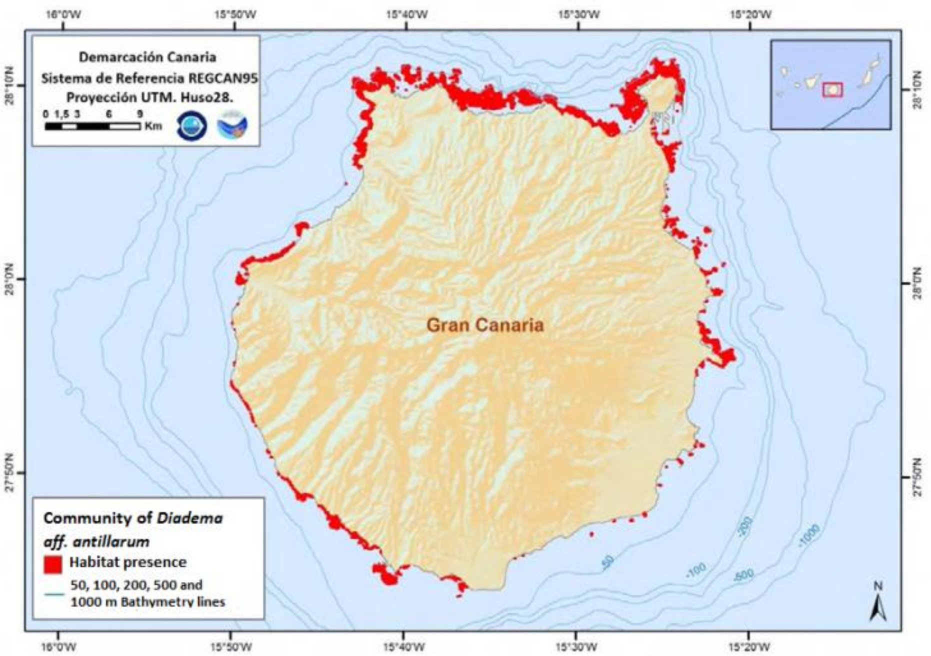

Figure 1-17: Distribution of the community of Diadema antillarum around Gran Canaria Island (MARGRAMA, 2012b)

1.3.4.5 Seagrass meadows of Halophila – EUNIS Code A5.5321

In Canarian waters, there are three species of marine phanerogams: *Cymodocea nodosa, Halophila decipiens* and *Nanozostera noltii*. The prairies of *H. decipiens* are included in the EUNIS code A5.5321 (designated by "Halophila seagrass meadows in the Canary Islands").

H. decipiens is a marine phanerogam that belongs to the family *Hydrocharitaceae*, characterised by delicate appearance and small size (up to 3 cm high). In the Canary archipelago, these meadows are present in all islands, except for Lanzarote and Fuerteventura in depths from 12 m to 40 m and on soft bottoms with a slope less than 14 º (off the coast of the island of Tenerife). It is the second most abundant seagrass in the Canary Islands after *Cymodocea nodosa*.

Their populations are distributed over sandy and sandy-muddy bottoms, forming small spots or patches (Barquin-Diez *et al.,* 2005), in waters west and south of Tenerife, not located any spot whose area exceeded 1 Ha, in relatively sheltered environments from prevailing winds and currents, and require a certain amount of organic matter in the sediment environments.

H. decipiens has the capability of inhabiting deep waters with low levels of solar radiation or waters with high turbidity levels; their short life cycle (comparing with other *phanerogamous*), their high fecundity rates and their rhizomes elongation rate allow them to colonise altered substrates or to easily recover from impacts. Moreover, its characteristics allow *H. decipiens* to occupy an ecologic niche that other phanergamous of larger life cycle and slow growth hardly could occupy (Kenworthy *et al.,* 1989). *Halophiletum decipientis* is considered a habitat of community interest by the European Commission DG Environment, 1999, "Habitat of Community Interest" (nº 111022). The Canary legislation considered this species of "Interest for Canaries Ecosystems," according to the Law nº4/2010 of June 4, of the Canarian Catalogue Protected Species.

Although the presence of this phanerogam is confirmed in all the islands except in Lanzarote and Fuerteventura, its meadows or patches are only mapped in Tenerife and La Palma, so the knowledge of the extent of this habitat in the Canary is very incomplete. Consequently, currently it's not possible to know its distribution around Gran Canaria Island.

1.3.4.6 Infralitoral soft bottom Maërl seabeds – EUNIS Code A5.51

Maërl is a term applied to several species of non-articulated coralline red algae (family Corallinaceae) who live free (Hall-Spencer *et al*., 2010). They can have large extensions, mostly in seabeds of coarse gravel, sand or mixed substrates, both in exposed intertidal or in protected areas (Peña and Barbara, 2007).

Maërl or rhodolite layers (as they can also be called) are composed of living algae, dead algae, or a mixture of both in different proportions. The living part of the maërl requires light for photosynthesis; therefore, the depth at which they can live is a function of water turbidity. In the oligotrophic waters of Canary Islands that present clear and transparent waters, this benthic community can live from the infralitoral until 70–80 meters of depth, being occasionally encountered at depths of 120 meters, at very low densities.

In Canary Islands, this habitat is distributed throughout the entire coastline and offshore bays (see Figure 1-18 for the distribution around Gran Canaria). Considering its extremely low growth, ecologic importance and high floristic and faunal diversity, that include a large number of ecologic niches, it is not difficult to understand the existing broad regulations for the conservation of this resource. This is the case of *Lithothamnion corallioides*, included in the Annex V of the Habitats Directive of the Natura 2000 network.

This habitat is also included in the Annex I of the Habitats Directive, on the EUNIS network (Peña and Barbara, 2007) and in the initial OSPAR list of threatened species or declining habitats, although Canary Islands do not belong to the OSPAR Commission. Nevertheless, it is important to highlight that this habitat is not highly impacted since there is no extractive industry and no harmful fishing methods as hauling are permitted in Canary Islands. The only threat that may impact this community is the habitat disturbance by different human activities (MARGRAMA, 2012b).

Each of algae or individual elements that constitute this substrate is called "rodolito" and its shape may vary from highly branched to more or less spherical, depending on the hydrodynamic conditions. Its size ranges typically from 1 cm to 6–7 cm. On the rhodolite layers, several algae can be installed, preferably rodophytas, and many sessile animals, especially, small encrusting sponges. All this contributes to creating a microcosm with a high diversity of species (in the rhodolite layers of the Spanish coasts more than 1,000 species, about 30% of algae and 70% of animal species have been cited).

The main species of maërl forming in the European seas are *Phymatolithon calcareum* and *Lithothamnion corallioides* (the first one dominates better structured substrates and the second one is found in more altered substrate), but they can also be formed by other coralinaceas and by some species of the genus *Peyssonnelia*. On the *calcareous* structure of these rhodolite beds lay another series of algae and invertebrates that increase their spatial complexity.

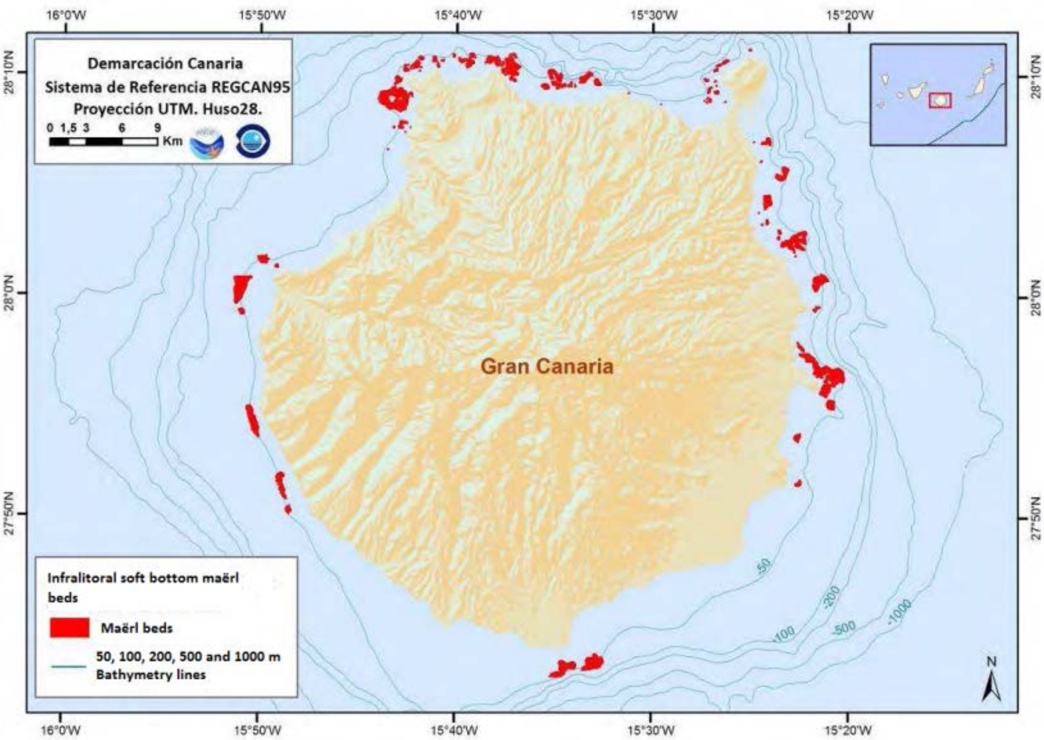

Figure 1-18: Distribution of the infralitoral soft bottom maerl beds around Gran Canaria Island (MARGRAMA, 2012b)

1.4 ENVIRONMENTALLY PROTECTED AREAS AND SPECIES

Several protection categories defend the Macaronesian ecosystems and habitats of Canary Islands. The existing protection can have a regional, national, European or international level.

On a regional level, the Canary network of protected natural areas (Red Canaria de Espacios Naturales Protegidos (RCENP)) includes different categories such as National Parks, Country Parks, Integral Nature Reserves, Special Nature Reserves, Natural Monuments, Protected Landscapes and Sites of Scientific Interest. This network encompasses 146 total spaces of different categories, but only considers terrestrial environment and excludes all marine areas. On a National level, the Spanish legislation includes three Marine Protected Areas (Graciosa Island and North of Lanzarote Islets, La Palma and Punta de la Restinga-Mar de las Calmas) and six Artificial Reefs areas in the Canarian fishing marine reserves.

On European level, the Natura 2000 network as proven to be the most efficient instrument, with 177 Special Areas of Conservation (SACs) and 43 Special Protection Areas for Birds (SPAs). There are also 10 Important Bird Areas (IBA) and 1 RAMSAR area.

It is also noteworthy that six of the seven Canary Islands are part of the World Network of Biosphere Reserves: La Palma, Lanzarote, El Hierro, Gran Canaria, Fuerteventura and La Gomera (Alenta, 2013).

1.4.1 NATURA 2000 NETWORK – HABITAT DIRECTIVE

In the Canary archipelago the Habitats Directive 92/43/EEC35 covers about 1,800 km^2 of the marine surface (although, it also includes some coastal areas). In the Habitats Directive, the area is classified as Special Areas of Conservation (SAC). Figure 1-19 shows the Special Areas of Conservation designated in the Archipelago.

The location selected for the TROPOS platform deployment is within a Special Area of conservation (SAC) – "Franja Marina of Mogán". The classification of the area was performed based on the existence of two classified habitats and three species. The Special Area of Conservation "Franja Marina of Mogán" is described in more detail below.

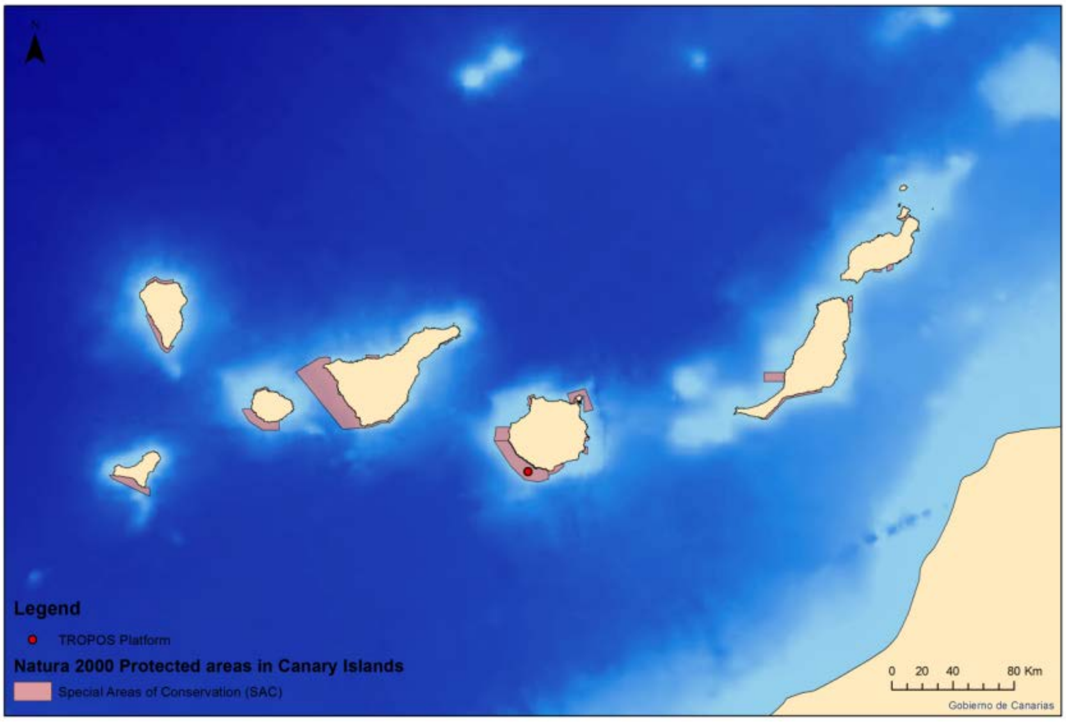

Figure 1.19: Special areas of conservation in Canary Islands

Special Area of Conservation (SAC) – ES7010017 Franja marina de Mogán

The Special Area of conservation (SAC) "Franja Marina de Mogán" is located on the south-southwest coast of Gran Canaria. It includes 29,993.09 hectares and is contiguous to 35,520 meters of the shoreline of San Nicolas de Tolentino, Mogán and San Bartolomé de Tirajana. This legal protection was declared in September 2011 with the purpose of ensuring the long time survival of threatened natural species and habitats, contributing to stop the loss of biodiversity caused by the adverse impact of human activities. This SAC is the most extensive in the Island and is sided by two others: "IS7011005 Sebadales de Güigüi" to the north and "ES7010056 Sebadales de Playa del Inglés" to the east. The SAC's area and location is shown in Figure 1-20.

Its extensive shallow marine shelf and sandy bottoms together with its location sheltered from the prevailing wind and sea, has led to the establishment of wide-ranging seagrass meadows, commonly known as *sebadales*, and populations of green algae. For its abundance and ecological role, the most representative marine phanerogams in Canary Islands meadows is *Cymodocea nodosa* that form meadows that provide key areas of refuge, breeding and feeding for invertebrates and fish.

In this area, a large abundance and diversity of rocky substrates (volcanic rocks, pebbles and rocks laying on sandy substrate) can also be found; typical benthic reef communities settle on them. Since they are of a volcanic origin, Canary Islands are dominated abrupt rocky seabeds, with many submarine canyons and valleys. The reefs habitats are compact and hard substrates of biogenic or geological origin can extend from the shoreline (intertidal) to the deep sea (bathyal depths). This type of habitat can host a complete benthic zonation of species of animals and algae, distributed along the bathymetry gradient, as well as other abiotic factors. Algae often dominate more illuminated areas, with the genera *Sargassum* or *Cystoseira* being highly characteristic in the Macaronesian area.

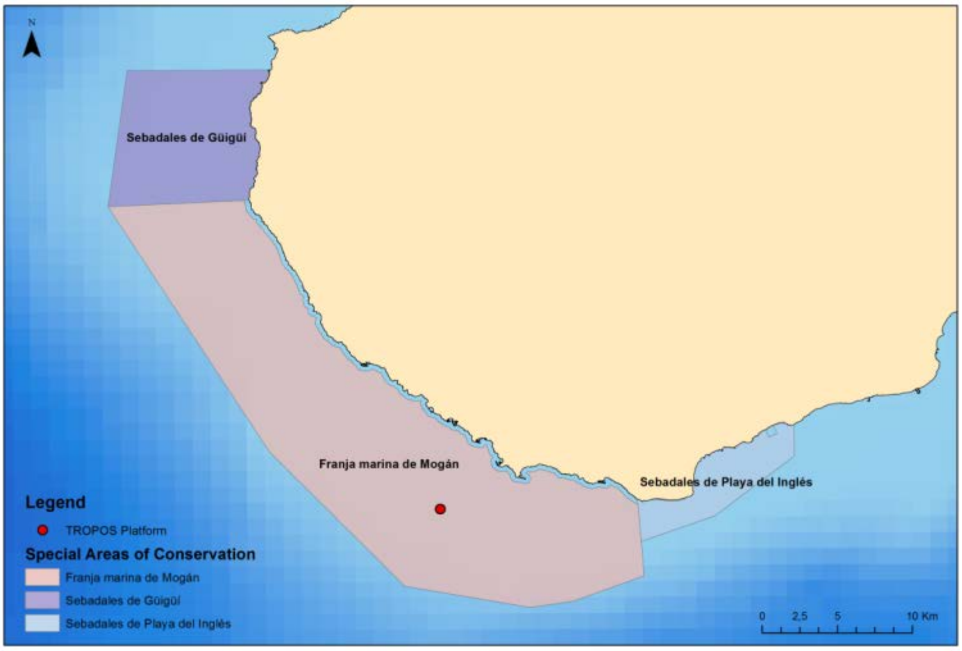

Figure 1.20: Special Areas of Conservation (SAC) in the Southwest of Gran Canaria: Franja Marina de Mogán, Sebadales de Playa del Inglés and Sebadales de Güigüi

The area presents a rich faunal composition, with a considerable biodiversity of invertebrates, particularly where there are rocky outcrops with algae coverage. Within the fish community several species stand out as the short snouted seahorse (*Hippocampus hippocampus*), parrotfish (*Sparisoma cretense*), seabream (*Diplodus vulgaris*) or salema (*Sarpa salpa*). This area is also an important location of feeding and seasonal rest for several species of medium and large cetaceans such as the bottlenose dolphin (*Tursiops truncatus*), spotted dolphin (*Stenella frontalis*), common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*) and the fin whale (*Balaenoptera physalus*), among others, as well as loggerhead turtle (*Caretta caretta)* and green turtle (*Chelonia mydas*).

In "Franja Marina de Mogán" there are different types of natural habitats of communitary importance present such as the habitat 1110: "Shallow sand banks permanently submerged" and the habitat 1170: "Reefs". The habitat 1110 includes sandy banks deprived of vegetation or associated with distinct biological communities (seagrass, maerl communities, etc.), always submerged.

Community interest supported classification of some of the species as protected; these are 1224 *Caretta caretta,* 1227 *Chelonia mydas* and 1349 *Tursiops truncates* (MARGRAMA, 2012g)*.* These species are described below.

The **bottlenose dolphin** (*Tursiops truncatus*) is a marine mammal with dark grey coloration on the back which is degraded into the lower areas and with a white or pink belly. It has a curved dorsal fin in the middle of the back and proportional pectoral fins. It is a cosmopolitan species typical of tropical and temperate regions, although they can also live in estuarine waters. It is characterised by having a gregarious behaviour and a varied diet: hake, bream, mackerel, octopus, squid and shrimp, among other marine animals. This species lives in the waters of the Canary Islands all year, forming small groups.

The **loggerhead turtle** (*Caretta caretta*) is considered a priority species and endangered in Europe. This marine reptile has a medium size and a slightly oval shell with roughly serrated edges. It has a reddish-brown colour on the carapace and clearer colour in the ventral area, turning to yellow or cream. It is a cosmopolitan species of tropical and subtropical waters and has solitary habits and omnivorous diet, including crustaceans, fish, molluscs, marine phanerogams and jellyfish. The archipelago is a feeding area and important for the development of juveniles of this species from different American and Cape Verdean populations.

The **green turtle** (*Chelonia mydas*) is a marine reptile with medium to large size, having heart-shaped carapace without protruding margins. It has a greenish to brownish colour on the carapace, which may be crossed by lighter shades of brown. It has a whitish ventral color, tending to yellow with age. It is a cosmopolitan species of tropical and subtropical waters. The Canary Islands are home to juvenile green turtle possibly from multiple nesting populations from America and Africa. They are closely linked to the coastal environment (less than 50 m deep) and to the presence of algae and marine phanerogams on which they feed and so their presence in the Canary Islands is related to the existence of well developed seagrass meadows.

1.4.2 BIOSPHERE RESERVES

The Canary Islands have five Biosphere Reserves within the Man and Biosphere Programme (MAB) of UNESCO: La Palma (1983), Lanzarote (1993), El Hierro (2000), Gran Canaria (2005) and Fuerteventura (2009); they include surfaces of marine importance (Figure 1-21).

The Gran Canaria Biosphere Reserve covers approximately a third of the island and includes several natural protected areas and monuments. The Biosphere Reserve includes a transition area established at the contact point between the core area, the buffer zones, and the sea (Figure 1-22). On one hand, the marine area has been designated as a large transition area to promote activities compatible with the conservation of the territory such as artisanal fishery, and on the other hand, to surround the terrestrial core area of the Reserva Natural Especial del Güigüí, protecting the coastal cliffs that possess a large number of protected and endemic species of flora and fauna, both Macaronesian species and Canary Islands exclusive species (UNESCO, 2013).

The protected marine area of the reserve is located between the beach of Maspalomas and the Punta de las Tetas (see Figure 1-22). The marine area comprehends the major continental platform of the island and is on the coastline of Mogán. This reserve includes the area with highest productivity in the Gran Canaria Island, presenting large communities of seagrass meadows or *sebadales,* a basic marine ecosystem in marine food chains.

In recent years, different specific programmes have been developed and co-financed with the European Commission through the LIFE project; these programmes have promoted the conservation of blue chaffinch (*Fringilla teydea*), loggerhead turtle (*Caretta caretta*) and bottlenose dolphin *(Tursiops truncatus*), endangered flora, fighting invasive vertebrate species, evaluation of the ecological impact of whale-watching (UNESCO – Biospheres Reserve Directory).

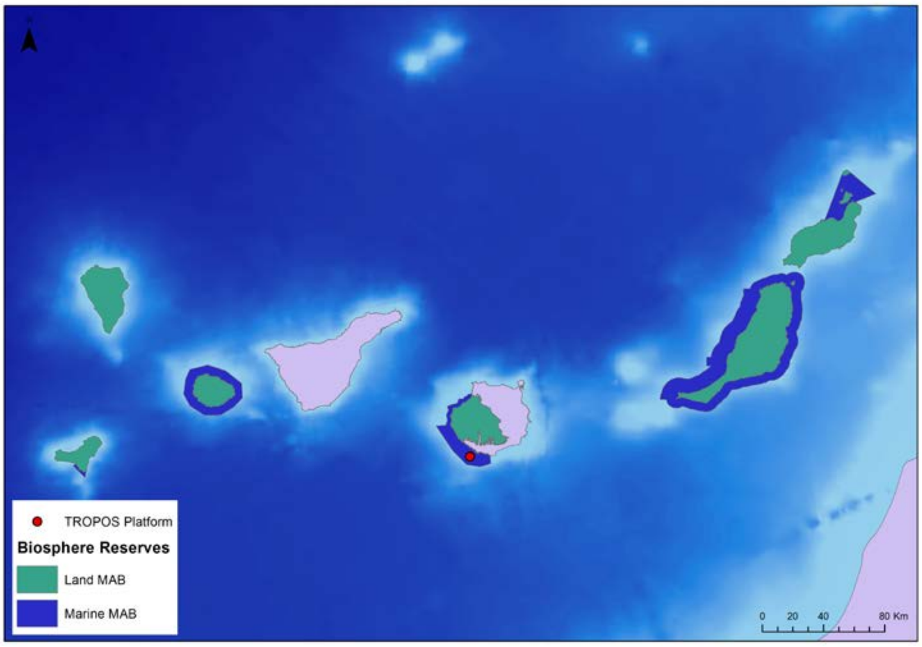

Figure 1-21: Land and Marine Man and Biosphere (MAB) Programme in Canary Islands (Source: UNESCO)

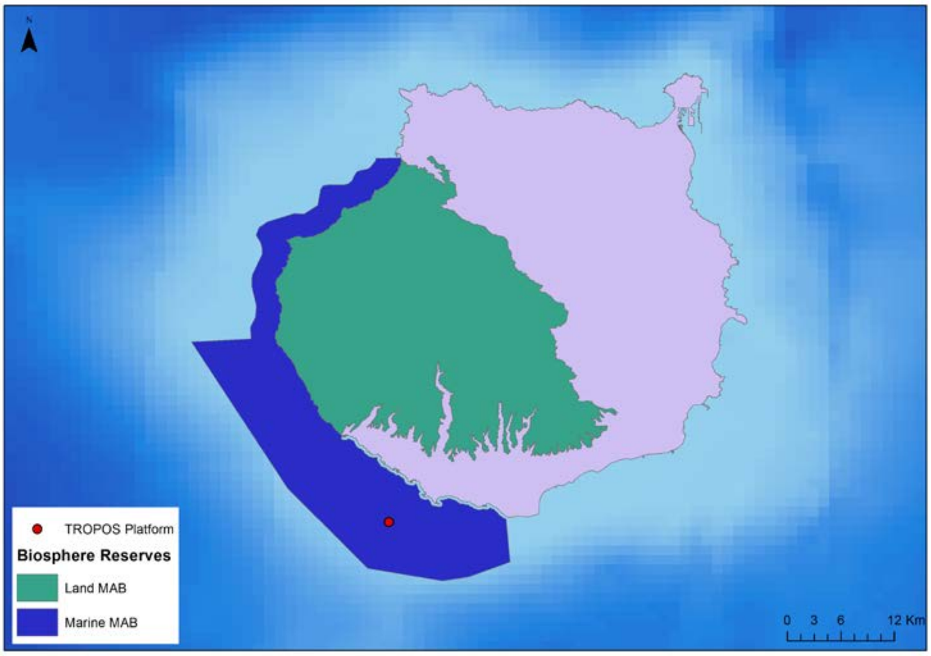

Figure 1-22: Land and Marine Man and Biosphere (MAB) in Gran Canary Island (MAB Programme) Source: UNESCO)

1.5 PROTECTED SPECIES

The oceanic nature of the Canary Islands allied to its bioclimatic, geological and historical features makes the Canary Islands very important on international level because of their high rate of biodiversity, containing a high level of endemic flora and fauna. Thus, the proportion of endemic species of wild vascular flora accounts for almost half of existing endemic species in Spain, while the invertebrate fauna has about forty percent of endemic species, and this proportion decreases in the case of vertebrate wildlife species. Many of these species currently are in a critical condition, mainly due to the impact of human activities on these fragile island ecosystems and habitats.

Concerning wildlife protection, the Canary Islands Autonomous Community has lacked an updated legal framework to give regional focus and coherence to the set of national rules. The Law nº4/2010, BOC nº 112 of June 9 has established the Canary Island Catalogue of Protected Species and integrates the necessary criteria to adapt the Canary legislation for species protection to the national and Community legislation, in order to promote a coordinated and effective implementation of all these rules, based on the latest knowledge and showing the opportunity and necessity of updating the Canary Island Catalogue of Protected Species.

The Canary Island Catalogue of Protected Species includes 3 categories of species, subspecies or populations of endangered biodiversity, which are of interest to Canary Islands or of special protection: **1)** Endangered Species (a. Species "in danger of extinction "(Annex I), (b "Vulnerable" species (Annex II); **2)** Species "of interest to the Canary islands ecosystems"(Annex III); **3)** Species of "special protection" (Annex IV).

There are also the categories of species "sensitive to habitat alteration" or of species with "special interest" included in Annexes V and VI. There are species present in the Canaries Island which, in spite of being protected by Community legislation or international agreements, are not included in the Canary Island Catalogue of Protected Species (Annex VII).

The Canary Island Catalogue of Protected Species only include 4 "endangered" marine species (Annex I), 8 "vulnerable" species, such as the red algae (*Alsidium corallinum*) and the marine sponge (*Neophrissospongia nolitangere*) (Annex II) and 36 species "of interest to Canary Islands ecosystems" (Annex III), as the brown macroalgae (*Cystoseira abies-marina*). These marine species are included in Appendices I, II, III, IV, V and VI.

Tursiops truncatus (bottlenose dolphin) and *Caretta caretta* (loggerhead seaturtle) are the only two species protected by the Habitats Directive that were included in the Canarian document for species protection. Some Special Areas of Conservation (SAC) were declared protected because of the presence of one or both of these species, while other areas were declared protected by the presence of the habitat 1110 and of one or both of these species. This is the case of "Franja Marina de Mogán" where the TROPOS platform will be located.

As for marine birds, seven species of the order Procellariformes, which breed in Canary, are considered threatened (by loss of habitat, predation by introduced mammals, artificial lights, etc.). So, except for the Manx shearwater, they are all included in Annex I of the Birds Directive. In the Canary Islands, there have been 10 Important Bird Areas (IBA) for the conservation of marine birds identified, most of which are marine extensions of breeding colonies (6 species 10 IBA). Additionally, some areas of concentration in the sea have also been identified (1 species 3 IBA), but most of the breeding birds in the Archipelago feed in waters of the continental shelf of northwest Africa, or in strictly oceanic waters, in a very dispersed form.

1.6 INTRODUCED MARINE SPECIES

The presence of alien species in the ecosystems has been recognised as one of the greatest threats to biodiversity worldwide. In the marine environment, there are numerous vectors that facilitate their introduction: ballast water, boat incrustations, aquarium and aquaculture activities, inter-ocean open channels, etc. Furthermore, ecosystem degradation induced by environmental pressures and the resulting variations of the ongoing climate changes may favour the settlement of alien species and enhance its invasiveness.

The existence of large ports, open to intense international traffic, such as Puerto de la Luz in Las Palmas de Gran Canaria that is a traditional port of call and supply on the Middle Atlantic, represents an important potential route of entry of invasive species. Its geographic location in the transition zone between temperate and tropical climate may also favour the settlement of species characteristic from both areas (MARGRAMA, 2012a).

In the context of the Marine Strategy Framework Directive a study was performed that enabled the collection of 257 specific quotations about 59 alien species in the Canary Islands. It is important to notice that in this region many species cannot be safely classified as alien due to the lack of previous studies of reference, so that the percentage of cryptogenic species in taxonomic listings Canaria is very high. Cryptogenic species are those for which it is not possible to determine with certainty whether they are native or not. Also note that species considered as exotic or alien in some literature sources, not necessarily are, because in fact the official definition was not considered (Olenin *et al.,* 2010), which involves the intervention of an anthropogenic vector at some point in the process of expansion of the species.

Thus, in the following table there are only those species that are considered strictly meeting the definition adopted of alien species shown.

Table 1-1: Alien species detected in the Canary Islands Region (Source: MAGRAMA. 2012c, 2012)

Algae	***Asparagopsis armata***	Bryozoa	*Aetea anguina*
Algae	*Antithamnion diminuatum*	Bryozoa	*Aetea ligulata*
Algae	***Asparagopsis taxiformis***	Bryozoa	*Aetea longicollis*
Algae	*Bonnemaisonia hamifera*	Bryozoa	*Aetea sica*
Algae	***Caulerpa racemosa var. cylindracea***	Bryozoa	*Aetea truncata*
Algae	*Ceramium atrorubescens*	Bryozoa	*Beania mirabilis*
Algae	*Ceramium cingulatum*	Bryozoa	*Bugula avicularia*
Algae	***Codium fragile fragile***	Bryozoa	*Bugula fulva*
Algae	*Colpomenia sinuosa vara. peregrina*	Bryozoa	*Bugula neritina*
Algae	*Corynophlaea cystophorae*	Bryozoa	*Bugula simplex*
Algae	*Dipteroshiphonia dendritica*	Bryozoa	*Bugula stolonifera*
Algae	*Grateloupia doryphora*	Bryozoa	*Chorizopora brongniartii*
Algae	*Grateloupia imbricata*	Bryozoa	*Electra pilosa*
Algae	***Grateloupia turuturu***	Bryozoa	*Escharina vulgaris*

Algae	*Gymnophycus hapsiphorus*	Bryozoa	*Fenestrulina malusii*
Algae	*Laurencia caduciramulosa*	Bryozoa	*Membranipora tuberculata*
Algae	*Neosiphonia harveyi*	Bryozoa	*Microporella ciliata*
Algae	*Predaea huismanii*	Bryozoa	*Puellina innominata*
Algae	*Scinaia acuta*	Bryozoa	*Reptadeonella violacea*
Algae	*Scytosiphon dotyi*	Bryozoa	*Schizoporella errata*
Algae	***Stypopodium schimperi***	Bryozoa	*Schizoporella unicornis*
Algae	***Undaria pinnatifida***	Bryozoa	*Scruparia ambigua*
Algae	***Womersleyella setacea***	Gastropoda	*Haminoea callidegenita*
Amphipoda	***Caprella scaura***	Gastropoda	*Terebra corrugata*
Tunicata	*Botrylloides leachi*	**Myxozoa**	***Sphaerospora testicularis***
Tunicata	*Botryllus schlosseri*	Teleostei	*Argyrosomus regius*
Tunicata	*Cystodytes dellachiajei*	Teleostei	*Dicentrarchus labrax*
Tunicata	*Diplosoma listerianum*	Teleostei	*Monodactylus sebae*
Tunicata	***Microcosmus squamiger***	Teleostei	*Pomacanthus maculosus*
Teleostei		*Sparus aurata*	

Of the 59 species safely considered alien, 30 have been accredited as having invasive potential in other areas, but this does not mean that its impact on the region has been quantified and whether the impact on the ecosystem really deserves to be called negative . In fact, only 8 species have concrete data in the region. These are the algae *Asparagopsis armata, A. taxiformis, Caulerpa racemosa, Codium fragile, Grateloupia turuturu, Undaria pinnatifida, Stypopodium schimperi* and *Womersleyella setacea*; the amphipod *Caprella scaura*, the ascidia *Microcosmus squamiger* and the parasite *Sphaerospora testicularis* (Table 1-1). These results show all the existing studies on invasive species, spatial and temporal distribution, not existing any invasive species impact study to date, with the exception of the parasite *sphaerospora testicularis* (MAGRAMA 2012c, 2012).

Moreover, with the purpose of compiling information for the Marine Strategy Framework Directive (MSFD) an analysis of the cumulative of pressures was performed that can cause the introduction of alien species in the marine environment. Considering the data used, no distinction was made between the input factors and the factors that facilitate the dispersal of alien species. Therefore, all the pressures that have spatial information available and that can cause entry and spread of alien species were jointly considered, namely:

- Aquaculture facilities.

- Ports of general interest.

- Other ports.

- Berth.

- Locations for authorised disposal of dredged material from harbour areas.

- Aquariums.

Given the difficulty of establishing zones of influence of alien species for the development of the index, cells that contain or intersect any of the layers used and which are at a distance of less than 5 km of any aquarium, were selected . To each pressure a unit value was assigned, except for the ports of general interest that were given a double score (except for the port of Santa Cruz de Tenerife that was given a quadruple score given the high volume of bulk cargo handling). All the values were added in the final and the index was calculated

The cells are classified according to the following criteria:

Very High: 5 / High: 4 / Medium: 3-2 / Small: 1 / Very Low: 0

Areas with a high potential for alien species introduction were identified and classified as "very high" and areas with moderate potential were classified as "High" (Figure 1-23).

In Gran Canaria one area was identified with moderate potential for alien species introduction (Arinaga) (Figure -24).

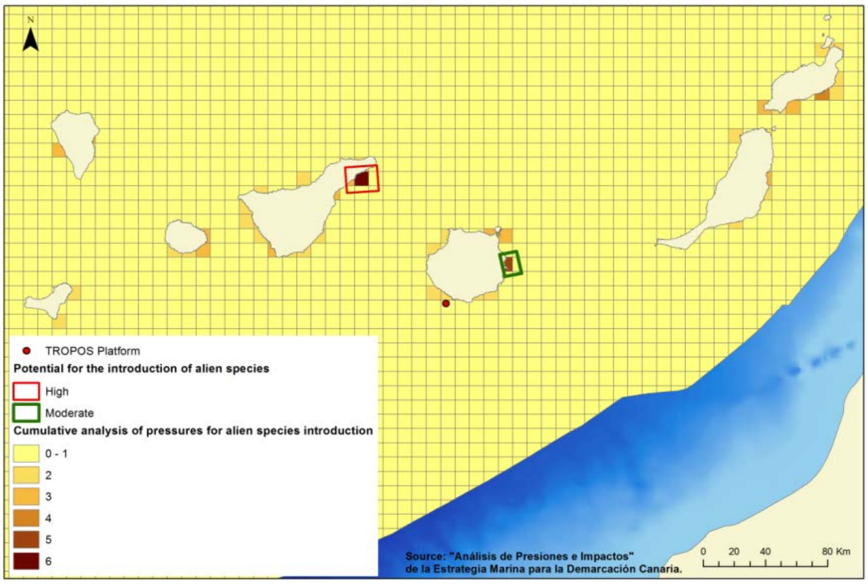

Figure 1-23: Cumulative analysis of pressures for alien species introduction in Canary Islands (Source: MAGRAMA, 2012c)

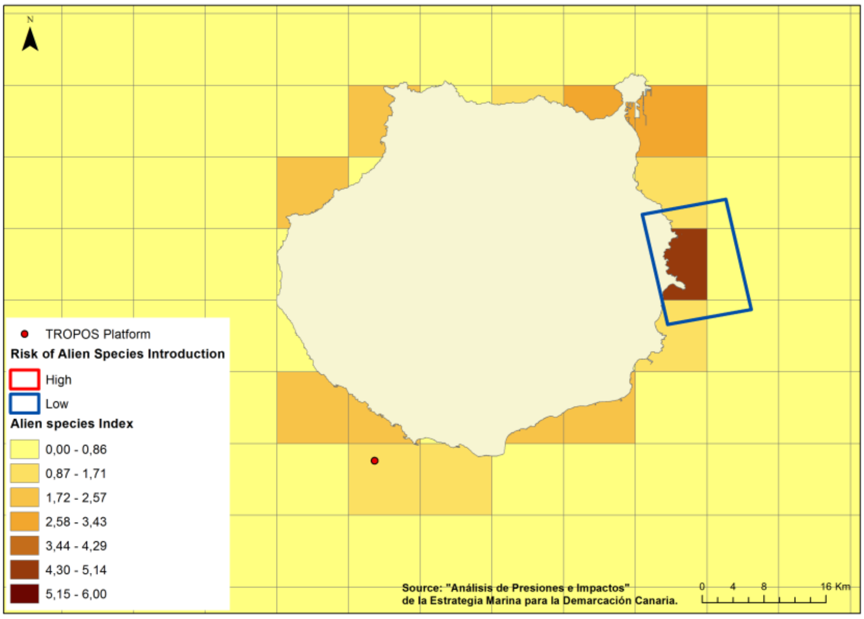

Figure 1-24: Cumulative analysis of pressures for alien species introduction in Gran Canaria (Source: MAGRAMA, 2012c)

1.7 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

1.7.1 TOURISM

The main economic sector in Canary Islands is tourism that represents 29.5% of the archipelago GDP, creating 262,823 jobs in 2011. More specifically, in 2011, Gran Canaria has received 2,913,431 tourist arrivals. The beaches are one of its main touristic attractions and Gran Canaria has 134 beaches according to MARGRAMA data.

1.7.2 PORTS

Gran Canaria includes an airport and port installations. The most important ports are the port of la Luz in Las Palmas, the larger city in Gran Canaria and the port of Arinaga, although there are other harbours of minor importance managed by the Canary Islands government and marinas. Close to the deployment area there exist small harbours and marinas as the La playa de Arguineguín harbour, El Pájaro harbour, Puerto Rico harbour and the Pasto blanco harbour (see Figure 1-25).

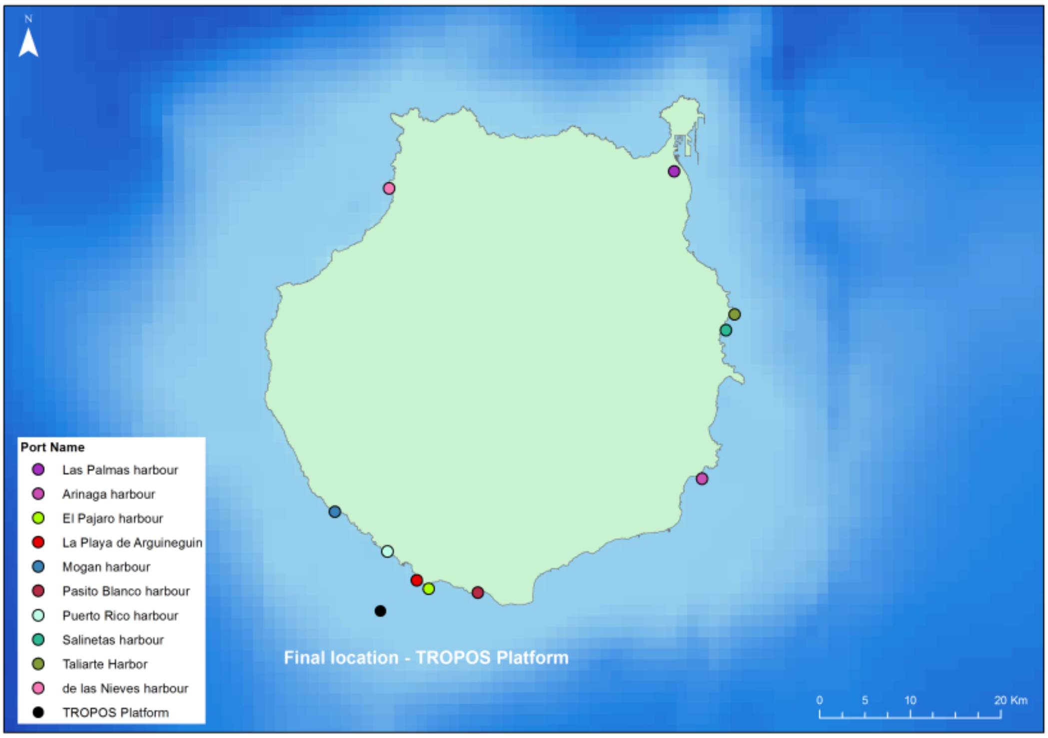

Figure 1-25: Ports location in Gran Canaria Island

1.7.3 FISHING FLEET

Regarding the fishing activity, the fishing fleet of Canary Islands can be grouped accordingly to its extraction capability, technical level and operational range in two major categories: the industrial fleet and the artisanal fleet.

In general, the artisanal fishing fleet shows a highly seasonal pattern, related to the biological cycle of the different target species and with the arrival of different species of tunas, particularly the skipjack tuna or oceanic bonito (*Katsuwonus pelamis).* This situation is explained by the large flexibility of the fleet that dedicates, during most part of the year, to the capture of benthic/ demersal species using mostly gillnets, long lines and pots, but that abandons this activity to dedicate to tuna fishing during its harvest season (from the end of May until September or October), using live bait as a fishing technique.

The contribution of the artisanal fisheries to the regional GDP shows a continuous decreasing trend. In 2000, fisheries contributed nearly with 0.31% of the total regional GDP, while in 2008 the relative value shrunk to 0.10% (INE, 2012), with more than two-thirds of reduction in nine years. This shows that the fisheries crisis in the Canary Islands is deep and structural.

Within the entire archipelago it is not possible to establish fishing grounds since, except those areas found within the integral areas of marine reserves, all neritic waters of the islands undergo fisheries exploitation throughout the year.

Recreational fishing in the whole archipelago is very heterogeneous, increasing in the islands with higher population and attraction, and may surpass professional fishing. It has also experienced a considerable increase in the Canaries, intensified since the beginning of the economic crisis in Spain. Thus, while in 2005 some 48,600 recreational fishing licenses are estimated in 2011 that number increased to 116,000 (currently recreational fishing licenses have a term of 3 years). According to the MapyA (2006), recreational fishing in 2005 contributed to 31.7% of the total catch landed, with an estimated catch of 6,737.4 tonnes, although this report concludes that the impact on coastal resources is low. However, the central conclusion of the report seems erroneous in the current scenario of exploitation (González, 2008).

1.7.4 AQUACULTURE

Canary marine aquaculture production peaked in 2009 with 8,200.4 tonnes making up 3.2% of the total Spanish production, with an estimated 34.8 million euros (in 2005 it contributed 18% to the national output, up from 24 million Euros in annual turnover). The same year, 45% of the production was destined for the domestic canary market, while 47% was sent to the Spanish mainland market and 6.6% was sold in European Union countries or other third world countries. Still, it is estimated that the contribution to the regional GDP of aquaculture was 3.3 times lower than fishing.

Most active farms are located in Gran Canaria, in the coastal strip of Melenara, Sandy Vargas and Castillo del Romeral, producing 60% of the total (in 2005 was only 34% of the total) produced in the entire archipelago.

Among the most important species for aquaculture in Canaries are the bream (*Sparus aurata*) and the sea bass (*Dicentrarchus labrax*), with an authorised 14,400 tonnes (although, according to data provided by the Ministry of Agriculture, Livestock and Fisheries, in 2011 capacity actual production was around 6,400 tonnes), the second production potency in Spain in 2011.

1.7.5 ENERGETIC INSTALLATIONS

As for the energy production system, Gran Canaria has two power plants, one in Jinámar (Las Palmas de Gran Canaria) with 416 MW, and another in Barranco de Tirajana with 235 MW. In the latter location there is also a combined cycle which the power is of 465 MW.

There are also two wind power plants in Gran Canaria , one in the vicinity of the Matorral (Santa Lucia) and another in the Carrizal (Ingenio).

1.7.6 MARINE TRAFFIC

The maritime traffic in Canary Islands is composed by mostly intra- insular movements between the islands and the peninsula. Additionally, the Canary Islands are located in the route of international traffic of boats between Europe and South Africa and between Europe and occidental Africa and the extreme south of Africa.

1.7.7 CUTURAL, ARCHAEOLOGICAL AND SUBAQUATIC PATRIMONY

It is important to mention the existence of archaeological sites on the coastal perimeter of all the islands. However, as part of studies conducted within the Campaña Ambiental del Estudio de Fondo Marino, it was concluded that there is no underwater archaeological elements that can be affected (Tecnoambiente, 2013).

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1.9 APPENDICES

Annexes of the Law nº4/2010, of 4th June, that establishes the Canary Islands Catalogue of Protected Species. BOC n º 112, dated 9th June, 2010

APPENDIX I			
SPECIES IN DANGER OF EXTINCTION			
GROUP	SUBGROUP	SCIENTIFIC NAME	COMMON NAME (Spanish)
Flora	Algae	*Gracilaria cervicornis* *	Glaciliaria cornuda
Fauna	Arthropods	*Panulirus echinatus*	Langosta pintada
Fauna	Mammals	*Monachus monachus*	Foca monje
Flora	Spermatophyte	*Zostera noltii*	Seba fina

APPENDIX II			
VULNERABLE SPECIES			
GROUP	SUBGROUP	SCIENTIFIC NAME	COMMON NAME (Spanish)
Flora	Algae	*Alsidium corallinum*	Alsidio
Fauna	Fish	*Anguilla Anguilla*	Anguila
Fauna	Porifera	*Neophrissospongia nolitangere*	Esponja cerebro
Flora	Algae	*Cystoseira mauritanica*	Mujo mauritano
Flora	Algae	*Cystoseira tamaricifolia* *	Mujo ramudo
Flora	Algae	*Gelidium arbuscula***	Gelidio rojo
Flora	Algae	*Gelidium canariense*	Gelidio negro
Fauna	Mammals	*Physeter macrocephalus*	Cachalote

APPENDIX III			
SPECIES OF INTEREST FOR THE CANARIAN ECOSYSTEMS			
GROUP	SUBGROUP	SCIENTIFIC NAME	COMMON NAME (Spanish)
Flora	Algae	*Acetabularia acetabulum*	Piragüita de mar común
Fauna	Molluscs	*Aldisa expleta*	Babosa marina morada

Fauna	Echinoderms	*Asterina gibbosa*	Estrella de capitán
Flora	Algae	*Avrainvillea canariensis*	Abanico de fondo
Fauna	Molluscs	*Charonia tritonis variegata* a	Bucio de hondura
Flora	Spermatophyte	*Cymodocea nodosa*	Seba
Flora	Algae	*Cystoseira abies-marina*	Mujo amarillo
Fauna	Cnidarians	*Dendrophyllia laboreli*	Cabezuelo
Fauna	Echinoderms	*Echinaster sepositus* b	Estrella rugosa
Fauna	Fish	*Gaidropsarus guttatus*	Brota de tierra
Fauna	Annelid	*Gesiella jameensis*	Gesiela de Los Jameos
Fauna	Fish	*Gymnothorax bacalladoi*	Murión atigrado
Fauna	Molluscs	*Hacelia attenuata*	Estrella naranja
Fauna	Molluscs	*Haliotis coccinea canariensis* c	Almeja canaria
Flora	Spermatophyte	*Halophila decipiens*	Hojitas de arena
Fauna	Fish	*H. guttulatus*	Caballito de mar
Fauna	Cnidarians	*Isaurus tuberculatus*	Isauro
Fauna	Fish	*Labrus bergylta*	Romero capitán
Flora	Algae	*Lamprothamnium succintum*	Alga breve
Fauna	Echinoderms	*Marthasterias glacialis*	Estrella picuda
Fauna	Molluscs	*Mytilaster minimus*	Almejillón enano
Fauna	Echinoderms	*Narcissia canariensis*	Estrella canaria
Fauna	Echinoderms	*Ophidiaster ophidianus*	Estrella púrpura
Fauna	Cnidarians	*Palythoa canariensis* d	Palitoa canaria
Fauna	Cnidarians	*Palythoa caribaea* e	Palitoa caribeña
Fauna	Molluscs	*Phalium granulatum* f	Yelmo estriado
Fauna	Fish	*Pomatoschistus microps*	Cabozo enano
Flora	Algae	*Rissoella verruculosa*	Risoela
Flora	Algae	*Sargassum filipendula*	Sargazo llorón
Flora	Algae	*Sargassum vulgare*	Sargazo común
Flora	Arthropods	*Scyllarides latus*	Langosta mocha
Fauna	Molluscs	*Taringa ascitica*	Taringa de La Santa
Fauna	Molluscs	*Taringa bacalladoi*	Taringa de Bacallado
Fauna	Molluscs	*Tonna galea*	Tonel

Fauna	Molluscs	*Tonna maculosa g*	Tonel manchado

APPENDIX IV
SPECIAL PROTECTION SPECIES
AT THE MOMENT, THERE IS NO MARINE SPECIES INCLUDED IN THIS ANNEX

APPENDIX V					
CATEGORÍA SUPLETORIA EN EL CATÁLOGO CANARIO EN CASO DE DISMINUCIÓN DE LA PROTECCIÓN EN EL CATÁLOGO NACIONAL DE LAS ESPECIES CON PRESENCIA SIGNIFICATIVA EN CANARIAS					
GROUP	**SUBGROUP**	**SCIENTIFIC NAME**	**COMMON NAME (Spanish)**	**CATEGORY IN THE NATIONAL CATALOGUE**	**SUPPLEMENTARY CATEGORY IN CANARY ISLANDS CATALOGUE**
Fauna	Mammals	*Balaenoptera borealis*	Rorcual norteño	Vulnerable	Special protection
Fauna	Mammals	*Balaenoptera musculus*	Rorcual azul	Vulnerable	Special protection
Fauna	Mammals	*Balaenoptera physalus*	Rorcual común	Vulnerable	Special protection
Fauna	Molluscs	*Charonia lampas*	Bucio de hondura	Vulnerable	Canary ecosystems interest
Fauna	Fish	*Chilomycterus atringa*	Tamboril espinoso	Vulnerable	Canary ecosystems interest
Fauna	Mammals	*Eubalaena glacialis*	Ballena franca	Danger of extinction	Special protection
Fauna	Mammals	*Globicephala macrorhynchus*	Roaz	Vulnerable	Special protection
Fauna	Arthropods	*Munidopsis polymorpha*	Jameito	Danger of extinction	Canary ecosystems interest
Fauna	Molluscs	*Patella candei*	Lapa majorera	Danger of extinction	Vulnerable
Fauna	Arthropods	*Speleonectes*	Remípedo	Danger of	Canary ecosystems

		ondinae	de Los Jameos	extinction	interest
Fauna	Mammals	*Tursiops truncatus*	Tonina	Vulnerable	Special protection

APPENDIX VI			
SPECIES INCLUDED IN THE CATHEGORY OF SPECIAL INTEREST IN THE NATIONAL CATALOGUE AFFECTED BY PARAGRAPH 4 OF THE TRANSITIONAL DISPOSITION			
GROUP	**SUBGROUP**	**SCIENTIFIC NAME**	**COMMON NAME (Spanish)**
Fauna	Reptiles	*Caretta caretta*	Tortuga boba
Fauna	Reptiles	*Chelonia mydas*	Tortuga verde
Fauna	Mammals	*Delphinus delphis*	Delfín común
Fauna	Reptiles	*Dermochelys coriacea*	Tortuga laúd
Fauna	Reptiles	*Eretmochelys imbricata*	Tortuga carey
Fauna	Mammals	*Globicephala melas*	Calderón común
Fauna	Mammals	*Grampus griseus*	Calderón gris
Fauna	Mammals	*Kogia breviceps*	Cachalote pigmeo
Fauna	Mammals	*Megaptera novaeanglicae*	Yubarta
Fauna	Mammals	*Orcinus orca*	Orca
Fauna	Mammals	*Stenella coeruleoalba*	Delfín listado

2 EXISTING ENVIRONMENT CRETE, GREECE (EXTENDED VERSION)

2.1 OVERVIEW

The selected site at Crete is on the north side of the island, in the Cretan Sea, south of the southern Aegean sea. This document presents an overview of the physical conditions of the sea area around Crete, followed by an overview of the marine ecology. The document has been prepared by NIVA. Some of the physical baseline data was taken from the description provided in WP2. The coordinates for the location is shown in Table 2-1 The map in Figure 2 -1 shows the approximate location.

Table 2-1: Location for installation of the site in Crete

SITE	*CRETE*
AREA	*AVGO*
LOCATION	
A Coordinates	*35°43'13.32"N, 25°38'35.37"E*
B Coordinates	*35°42'8.38"N 25°24'39.82"E*
C Coordinates	*35°32'40.15"N 25°38'17.55"E*
D Coordinates	*35°31'55.48"N, 25°26'3.77"E*
Central point Coordinates	*35°37'13.78"B 25°33'35.70"A*
ICS Concept	*Green & Blue*

The proposed area is the one already described in WP2, at the north of Crete. It is an approximately 20 km by 20 km rectangle. In the specified area exists also a rocky peak (at 35°36'4.73"N, 25°34'39.03"E) that may also serve for the anchoring of the platform.

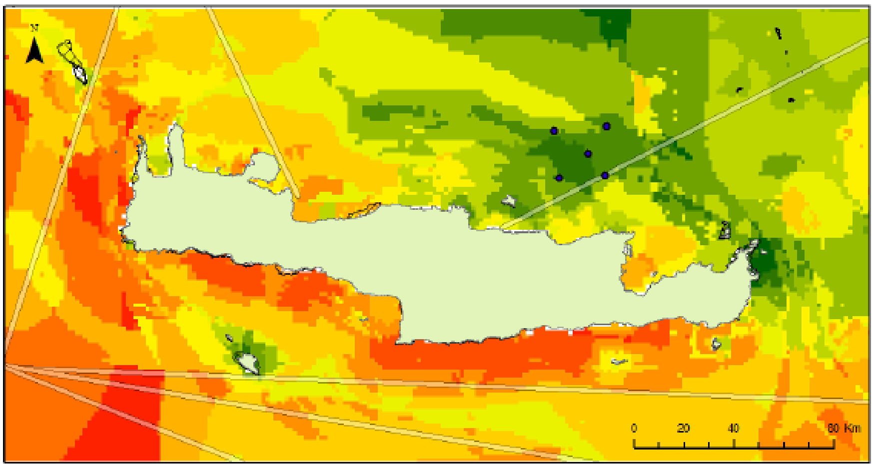


Figure 2-1: Tropos site location north of Crete (square denoted by black dots). From Site selection tasks, Deliverable 2.4. The straight lines are major maritime routes

2.2 THE PHYSICAL ENVIRONMENT

2.2.1 INTRODUCTION TO CRETE ISLAND

Crete (Figure 2-2) is the largest island in Greece and the second biggest (after Cyprus) of the East Mediterranean. It lies at the southern Aegean Sea and at the crossroads of three continents Europe, Asia and Africa. Crete covers an area of 8,336 km^2. The length of the island is 260 km, but the shore-length is 1,046 km. The biggest width is 60 km while the smallest is 12 km. Heraklion (Iraklion) is the largest city in Crete (and fifth in Greece).

A high mountain range crosses the island from West to East, formed by three different groups of mountains to the West the White Mountains (2,453 m), in the middle the mountain of Idi (Psiloritis-2,456 m) and to the East the mountain of Dikti (2,148 m). These mountains gifted Crete with fertile plateaus like Lassithi, Omalos and Nida, caves like Diktaion and Idaion cave, and gorges like the famous Gorge of Samaria. There are also quite a few valleys and small plains. The largest and most important plain is that of Messara located between Psiloritis and Asterousia mountains at the center - south of the island.

Figure 2-2: Map of the island Crete (from TROPOS Deliverable 2.3)

2.2.1 CLIMATE AND ATMOSPHERE

The air can be quite humid, depending on the proximity to the sea. The winter is fairly mild and tolerable. Snow fall is rare to the plains, but quite frequent in the mountains. During summer, average temperatures are between the low 20s°C and the high 30s°C. "Bad weather" periods in winter are often interrupted, during January and the first fortnight of February, with sunny days, known as 'Halcyon days'.

The climate in Crete is typically Mediterranean. Table 2-2gives an overview over monthly temperatures also in the sea. There are two main seasons: a dry, hot summer (May– October) and a damp, rainy winter (November– April). Rainfall is higher on the mountains and snow can be seen on the peaks until June. The temperature on the plains seldom falls to freezing point and snow is rare. The temperature along the south shores is high in the summer, while the "meltemia" (prevailing north strong winds) make the northern shores pleasantly cool from mid- June to the beginning of September. As a result of the ground structure, there is a great difference in climate between the three main areas: the northern coast, the southern coast and the mountainous area.

Table 2-2: Some statistical values for air temperature, monthly averages

Average Temperature

	Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
°F	65	53	54	56	61	66	73	77	77	73	68	62	56
°C	18	11	12	13	16	18	22	25	25	22	20	16	13

Average High Temperature

	Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
°F	70	58	58	61	67	73	80	83	82	79	74	66	61
°C	21	14	14	16	19	22	26	28	27	26	23	18	16

Average Low Temperature

	Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
°F	59	48	48	50	54	59	66	72	71	67	62	56	51
°C	15	8	8	10	12	15	18	22	21	19	16	13	10

Highest Recorded Temperature

	Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
°F	106	74	79	84	95	100	106	104	100	103	99	86	75
°C	41	23	26	28	35	37	41	40	37	39	37	30	23

Table 2-3: Typical average monthly temperatures in Crete, air and sea surface

Month	Air temperature	Sea temperature	Month	Air temperature	Sea temperature
January	12.3	17.1	July	26.4	24.2
February	12.5	16.2	August	26.4	24.8
March	13.8	16.9	September	23.6	24.4
April	16.8	17.9	October	20.3	22.5
May	20.4	20.0	November	17.2	19.6
June	24.4	22.3	December	13.9	17.4

Temperatures in °Celsius

2.2.1 NATURAL HAZARDS

Greece's natural hazards include severe earthquakes, droughts and wildfires. Current environmental issues include air pollution and water pollution.

Earthquakes

Crete and Greece are located in the most seismic part of the Mediterranean basin and historically there have had many earthquakes in Crete and Greece. Crete is the largest of the Greeks islands and so it is entirely possible to feel an earthquake on one part of the island and not another. Of course, this depends on the magnitude, location, depth and epicenter of the earthquakes in CreteThere have been no earthquakes in Crete more devastating than the AD 365 earthquake which has been estimated to be 8 or above magnitude on the Richter scale. Out of all Crete earthquakes this was tremendous, causing widespread destruction in Greece, Libya, Egypt and Cyprus. In Crete, nearly all towns were destroyed. As with many major earthquakes, a resulting tsunami followed in the wake of this Crete earthquakes impact devastating the southern and eastern coasts of the Mediterranean.

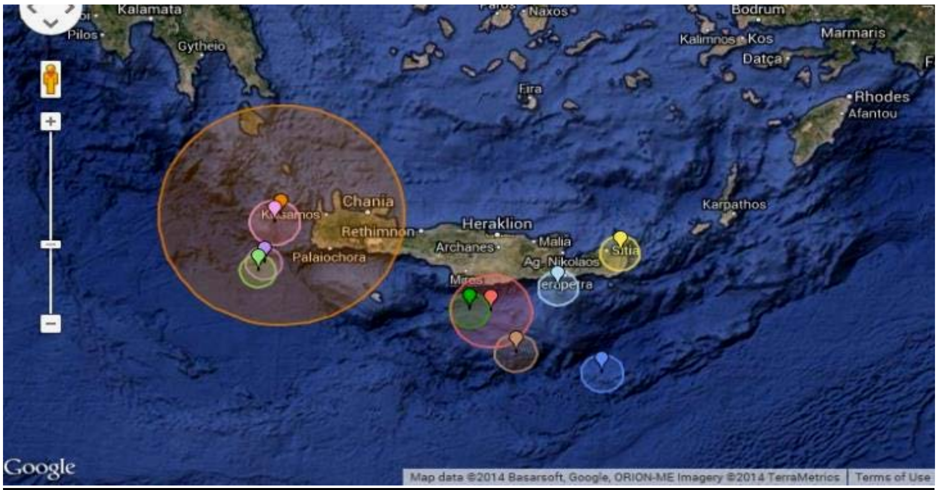


Figure 2-3: Some epicenters of recent earthquakes (source: Google Maps)

Many historical documents (such as Evagelatou Notara, 1993; Guidoboni and Comstri, 1997) explain about large earthquakes in the ancient times. The one in AD 365 was a very large tsunami igenic earthquake that ruptured the eastern segment of the Hellenic arc between Crete and Rhodes islands. A large tsunami attacked violently Iraklion, the capital city of Crete, north coast of the island. The sea swept into the city with such force that it destructed buildings and killed inhabitants. The exhaustive reviews of Evagelatou-Notara (1993) and Guidoboni and Comastri (1997) explains that Rhodes was not damaged by that tsunami.

There have been no earthquakes causing major damage, death or serious injury for over the last 50 years or more. The most recent strong earthquake to shake Crete had a 6.4 magnitude and occurred on 12 October 2013. The epicenter was s 37 km off the city of Chania in western Crete (Figure 2-3). The earthquake struck at 16:11 and its epicenter was 40 km below the seabed. There were no reports of casualties or major damage. Tremors were felt as far away as Athens, the Greek capital 180 miles (290 km) away, and across southern Greece.

A Crete earthquake occurred on 1st April 2011 and registered as 6.2 on the Richter scale with effects being felt clearly in Rethimnon.

Droughts and wildfires

The island of Crete is located in the southeastern part of the Mediterranean region and it is well known that it comprises an area that has been characterised as one of the most drought prone areas of Greece. The mean annual precipitation is estimated to be 750 mm, which varies from east (440 mm) to west (2,118 mm) and the potential renewable water resources reach 2,650 Mm^3 (Figure 2-4). The main water use in Crete covers irrigation, with a high percentage of 83.3% of the total consumption. The domestic use, including tourism, covers 15.6% and the industrial use 1% of the total consumption (Region of Crete, 2002). The eastern and southern parts are more arid than the west and northern parts, as there is higher precipitation in the northwestern coastal areas and lower in the southeastern part of the island, a fact that confirms regional variations in water availability (Chartzoulakis et al., 2005). There are significant effects when the uneven spatial and temporal precipitation distributions of Crete, although common in many Mediterranean areas, are related to intensive agricultural activities and the tourism industry (Tsanis and Naoum, 2003).

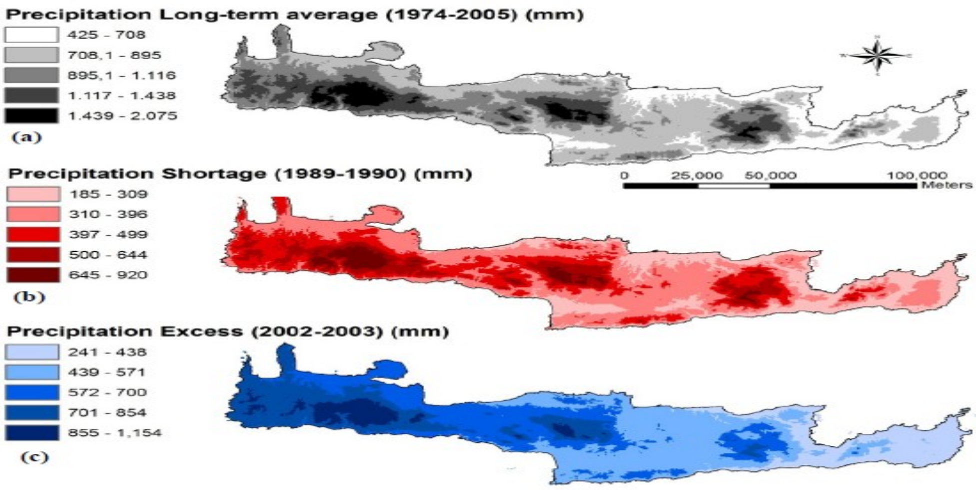


Figure 2-4: Dpatial distribution of (a) precipitation for a long term average of the period 1974–2005, (b) precipitation shortage concerning the year 1989–1990 and (c) precipitation excess concerning the year 2002–2003 (Vrochidou K.A.E and Tsanic I.K 2012)

2.2.2 OCEANOGRAPHIC CONDITIONS

2.2.2.1 Bathymetry and Sediments

The south Aegean Sea, the eastern Ionian and the northwest Levantine Basin constitute the central part of the eastern Mediterranean. This dynamically active area presents unique physiographic and hydrodynamic characteristics and plays important role in the regime of the Mediterranean. Cretan Sea constitutes the larger and deepest basin of the south Aegean with an average depth of 1,000 m and contains two depressions in the eastern part reaching 2,500 m. To the northwest the Mirtoan basin Between the Mirtoan and Cretan Sea depths are of the order of 600 m.

The Cretan Sea is bounded to the north by the Kikladhes Plateau at a depth of 400 m and to the south by the Cretan Arc islands. It communicates with the Ionian and the Levantine Seas through a series of six Straits, namely the Cretan Arc Straits. These are characterised by high relief and have sill depths ranging from 150 m to 1,000 m (Theocharis, 1992). Outside the Straits the sea bed plunges towards the deep basins of the Hellenic Trench (depths of 3,000–4,000 m). Maximum depth at the TROPOS site square (Figure 2-5) is 972.6 m while the mean value is 450.4 m.

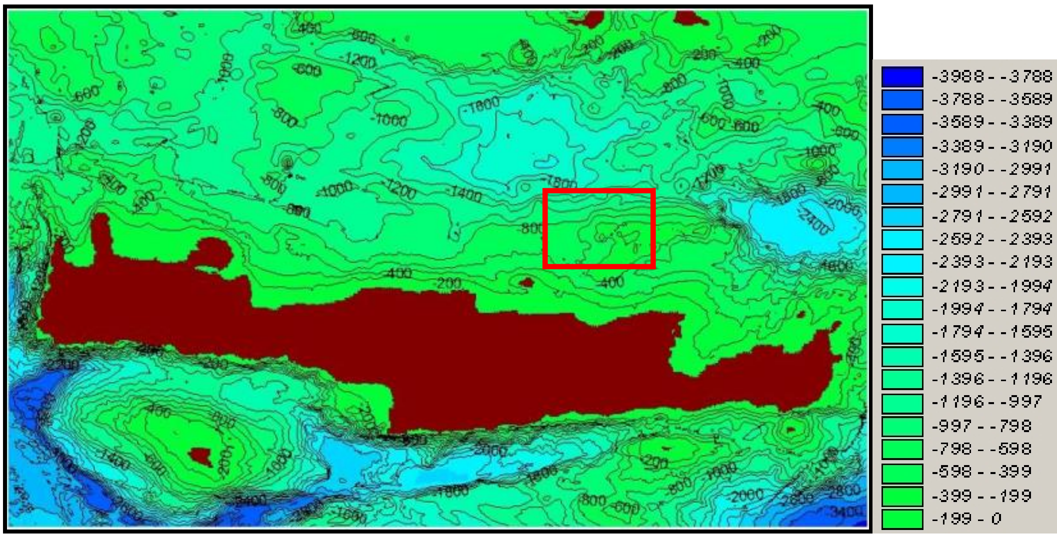


Figure 2-5 Bathymetry (in m) around Crete. Source: GEBCO

Seabed geology characteristic is available from GIS applications of HCMR (original data from NCEAS 2013). The map in Figure 2-6 shows the distribution of sediment softness.

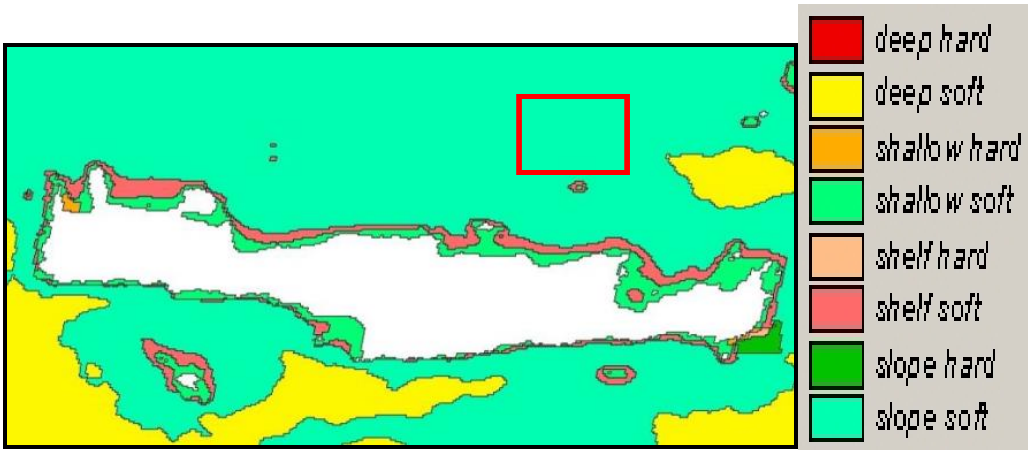


Figure 2-6: Sea bed geology around Crete. Source: GIS-HCMR

The particular area of interest due to the presence of the rocky island the general characteristics of the seabed are summarised below.

In the deep: Clay

Intermediate depths: Sand

Shore: Rocky seamount.

Figure 2-7 shows the distribution of mud, sand and gravel/mixed, around Crete. Sand and gravel bottom seems to dominate the TROPOS site.

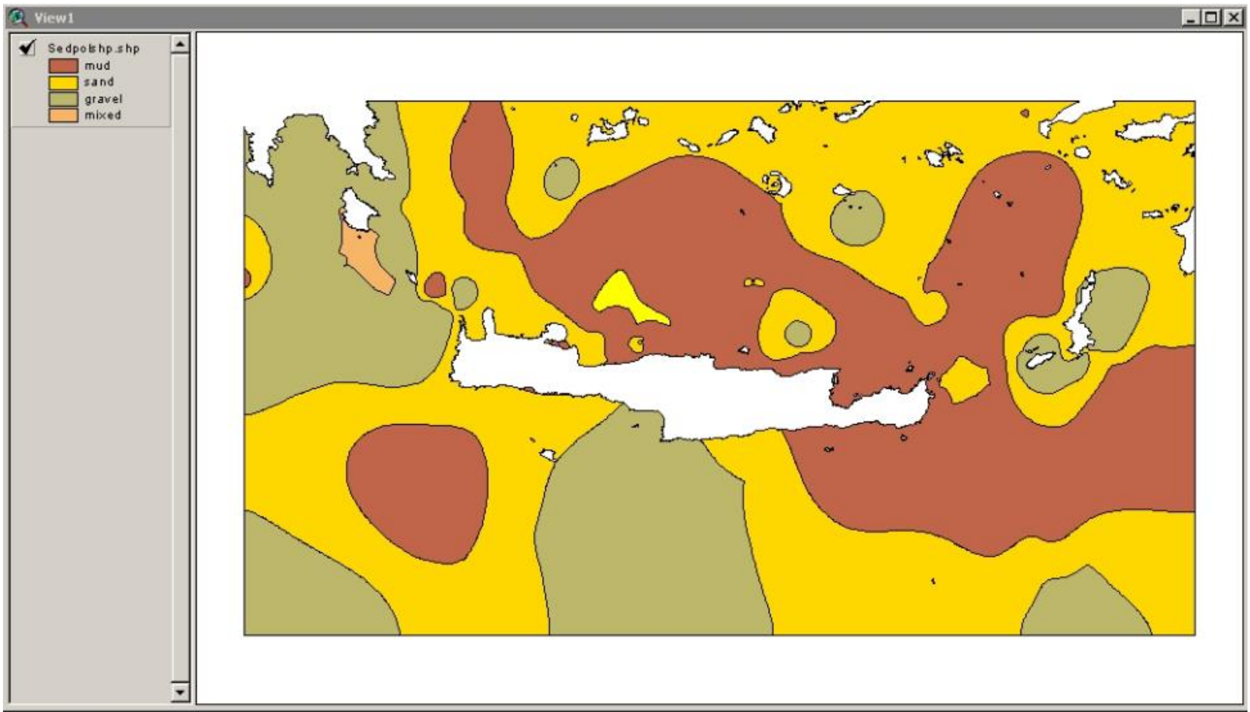


Figure 2-7: Sea bed geology around Crete. Source: TROPOS WP2 database

2.2.2.2 Wind and Wave Conditions

Some values of ambient parameters were provided in WP2, and is summarised in Table 2-4.

Winds mainly blows from the west or north-west at the Tropos site north of Crete (Table 2-4, Figures 2-8 and 2-9). Typical wind speeds are 6–7 m/s. Stonger winds can come from a more northerly direction, reading speeds of 17 m/s or more.

From Table 2-4 it is shown that typical wave conditions at the site have wave heights (significant, Hs; see D2.3 p 40) of less than 1 m, while the extreme cases have Hs of 5 m. The predominant wave propagation direction is from the west /north.

Table 2-4: Some typical values for wind, currents etc at the TROPOS site in Crete (Source: D2.3, for details see D2.3 p 40)

SITE: AVGO		Normal conditions			Extreme conditions		
		Direction	Average speed, v (m/s)		Direction	Average speed, v (m/s)	
Oceanographic Characteristics and Marine Dynamics	Wind	270-300	6-7		345	17	
		Direction	Average speed, v(m/s)		Direction	Average speed, v (m/s)	
	Currents	266 (195-302)	16.4		250-270	22.3	
		Direction	Height, H (m)	Period, T (s)	Direction	Height, H (m)	period, T (s)
	Waves	270–360 deg	0.75Hs	3.8–6.1 Te	0 deg	5 Hs	8.1–9.8 Te
		H_{max} (m)	H_{min} (m)				
	Tides	-	-	-	-	-	-
	Biodiversity						
Geological characteristics	Depth (m)	From 0 m to 972.6 m					
	Seabed type	clay (bottom) sand (intermediate) rock (seamount)					

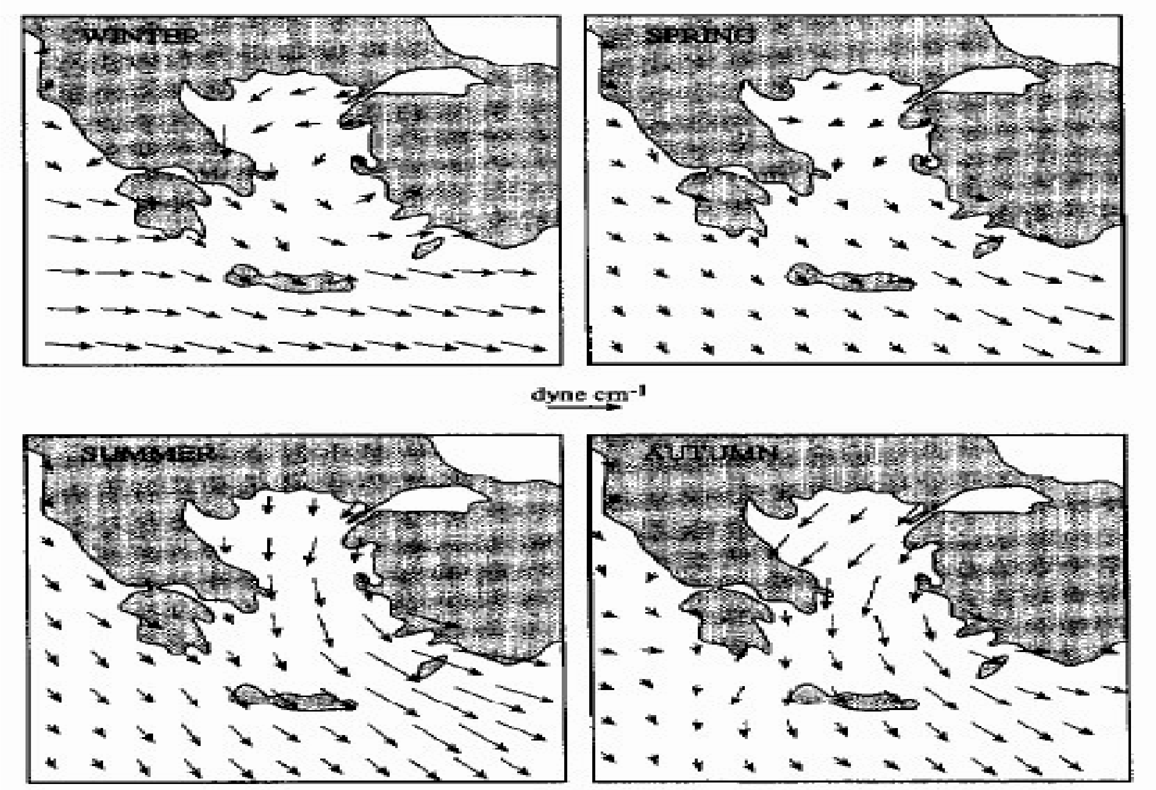


Figure 2-8: Seasonal variations in the wind stress over the Aegean Sea (Poulos et al 1997)

The site is essentially exposed to waves generated by the different local wind regimes with western lies dominating. Northerlies are more common in summer. North easterlies also occur as a result of low pressure in the eastern Mediterranean. Although summer and winter climatology are quite different, severe sea conditions, *H* 4 m, near shore may occur at any season. Wave directions at the TROPOS site are predominantly northwest to northeast. Figure 2-9 shows an example from a model study. Figures 2-10 and 2-11 show examples of measured waves on the north shore off Rethimnon, sligthly to the west of our site tides are not significant in this area and local currents are essentially wind-generated. The general circulation of the water in this area is slow a few cm/s.

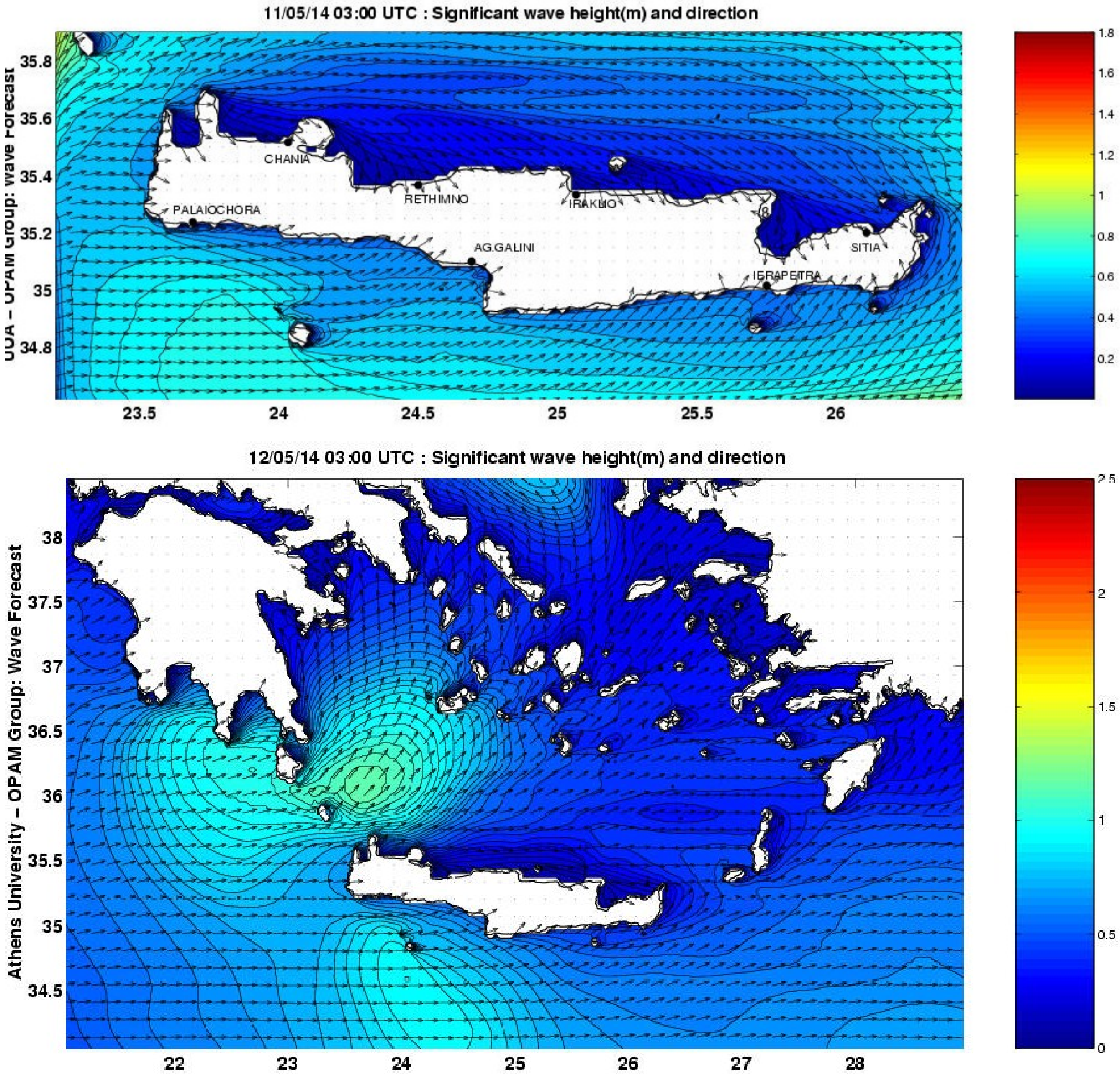


Figure 2-9: Modelled significant wave height in (m) and directions for 5 November, 2011 (source: Paillard et al. 2000)

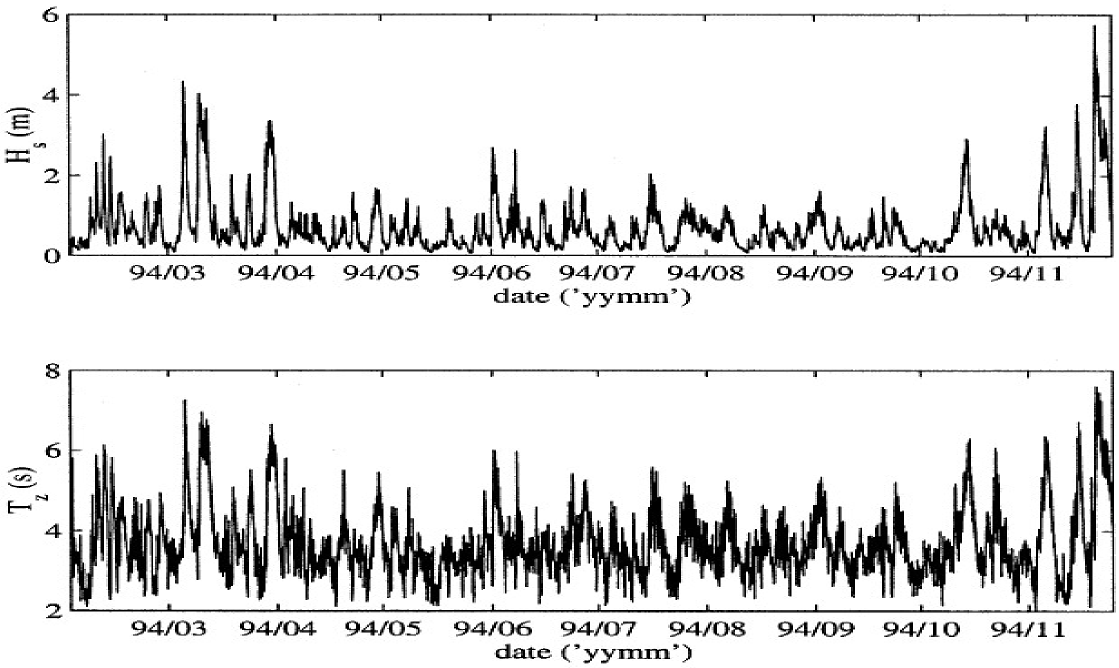


Figure 2-10: Hs and Tz for Cretan Sea obtained from buoy located at sea, near (1km) from Rethimon (Source: Paillard et al. 2000)

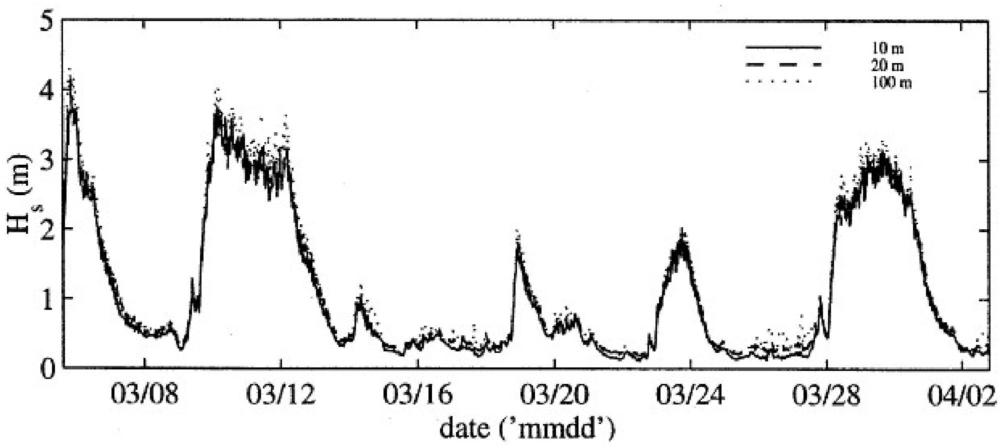


Figure 2-11: Hs and Tz for CretanSea obtained from buoy located at sea, near (1km) from Rethimon city (Source: Paillard et al. 2000)

A small bay, exposed to the north and situated on the western side of the town of Rethimon was identified for the Mediterranean field experiment. The choice was due to several factors: relatively long fetch in the Aegean sea topography, sea conditions, wind conditions, logistic facilities, etc. The topography of the site chosen is not very complex and the slope is around 2.5%. As a result, diffraction and reflection are not too important.

The Aegean and Ionian Sea, located in the eastern part of Mediterranean, are two maritime regions characterised by large naval activity, not only for marine trades but also for sailing, fishing and other marine activities, especially during the summer season. The complexity of the shoreline and the topography and the large number of islands play a significant role in modulating the wind and the wave fields, creating, in many cases, ideal conditions for very strong winds and very high waves. An example is the etesian, local northerly dry winds, which blow from May to September over the Aegean Sea. They may create dangerous conditions for small vessels as their speed can exceed 15–20 m/s for a period of 1 to 6 consecutive days. For this reason the knowledge of the wave conditions, either as a forecast or as observation, is critical for all the human maritime activities including transportation, fishing and sailing.

Figure 2-12 shows another example of the evolution of the wave field subject to a passing low pressure system in the winter. It is seen that in this case, the Tropos site is leeward of the exposure, with moderate waves only. Figure 2-13 and Figure 2-14 show other examples of the wave field surrounding Crete, both measured and modelled.

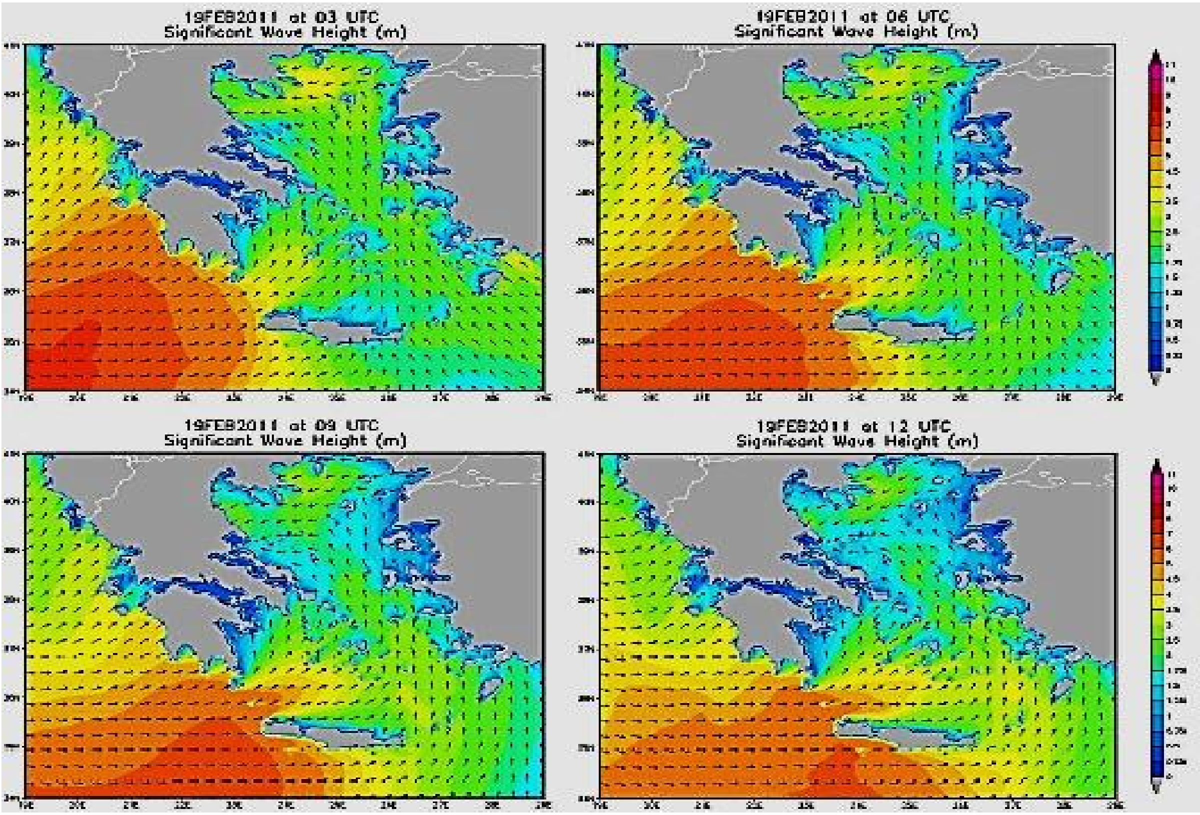


Figure 2-12: Evolution of the wave height and direction produced by the first 24 hours forecast of the WAM model. The fields refer to a) 03:00, b) 06:00, c) 09:00, d) 12:00, 19 February 2011. The red colours in the southern part of the region denote significant wave heights higher than 4.5 m. The arrows represent the main direction of the waves (Source: Mazarakis et al. 2012)

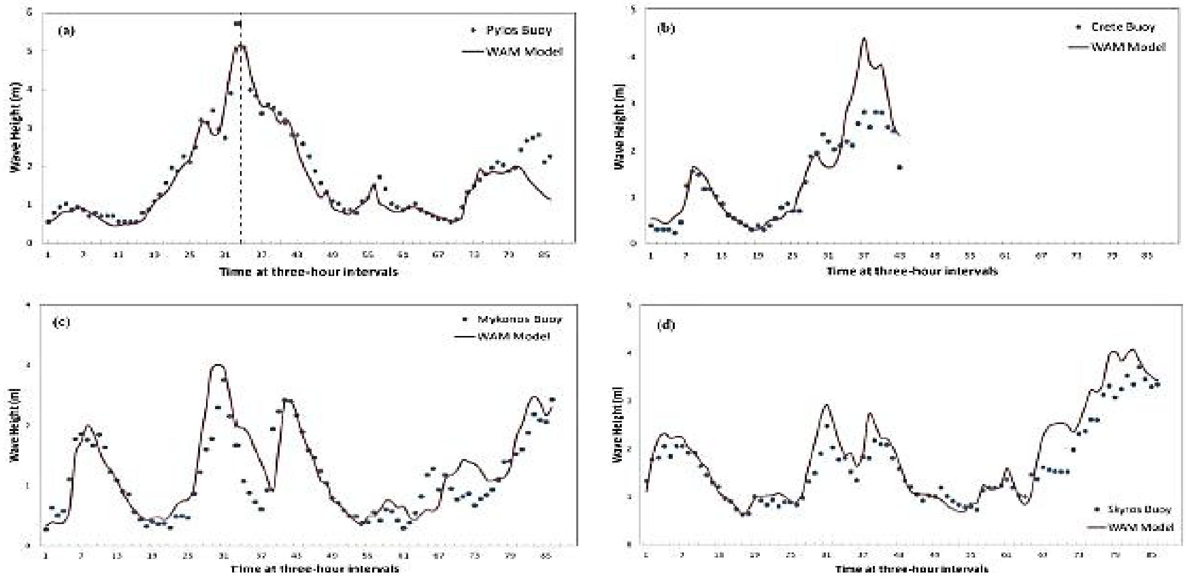


Figure 2-13: Time series of the significant wave height at Pylos as forecast by WAM model (line) and measurements by the buoy (dots). Time ticks at 3 ourh intervals; 25 correspond to the 03:00 UTC of the 18 February while 41 correspond to the 03:00 UTC of 20 February 2011. The dotted line corresponds to the maximum observed wave height. (b) as in (a) but for Crete. Measurements were available up to 20 February 2011. (c) as in (a) but for Mykonos and (d) as in (a) but for Skyros (Source: Mazarakis et al. 2012

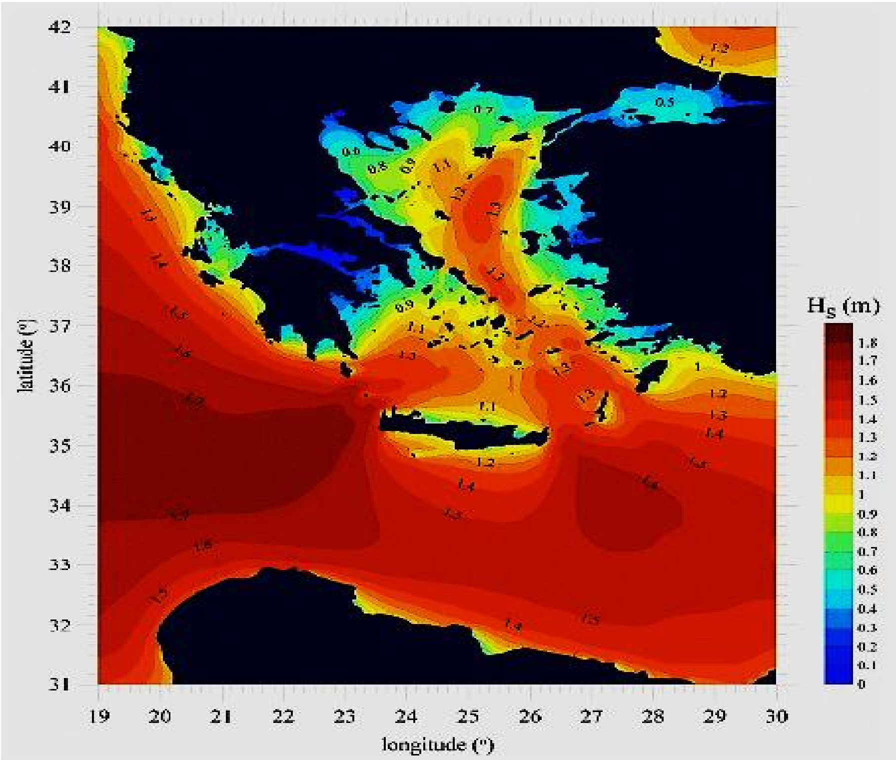


Figure 2-14: Spatial distribution of mean significant wave height for winter in the studied area of Crete (Source: Soukissian et al. 2008)

2.2.2.3 <u>Currents</u>

Water circulation and hydrography of the South Aegean Sea, the Straits of the Cretan Arc and the adjacent open sea regions of the northwestern Levantine Basin and southeastern Ionian Sea were sporadically studied in the framework of the great expeditions undertaken in the Mediterranean between 1912–1975. Three main water masses occur in the eastern Mediterranean Basin, namely, the Modified Atlantic Water (MAW), the Levantine Intermediate Water (LIW) and the Eastern Mediterranean Deep Water (EMDW) (Wust, 1961; Hopkins, 1978; The POEM Group, 1992; Theocharis et al., 1993). In addition to these water masses, the Aegean receives into its northeastern sector a considerable input of less saline waters (24.0–35.0) of Black Sea (BSW) origin through the Straits of Dardanelles (Theocharis & Georgopoulos, 1993), see Figure 2-15 for the pattern og surface currents (Poulos et al 1997).

Figure 2-16 shows the pattern for intermediate, thermohaline gyres, and Figure 2-17 shows simulated currents around Crete. It seems that westerly currrents dominate at the TROPOS site, with typical speed in the range 16–22 cm/s (Table 2-4).

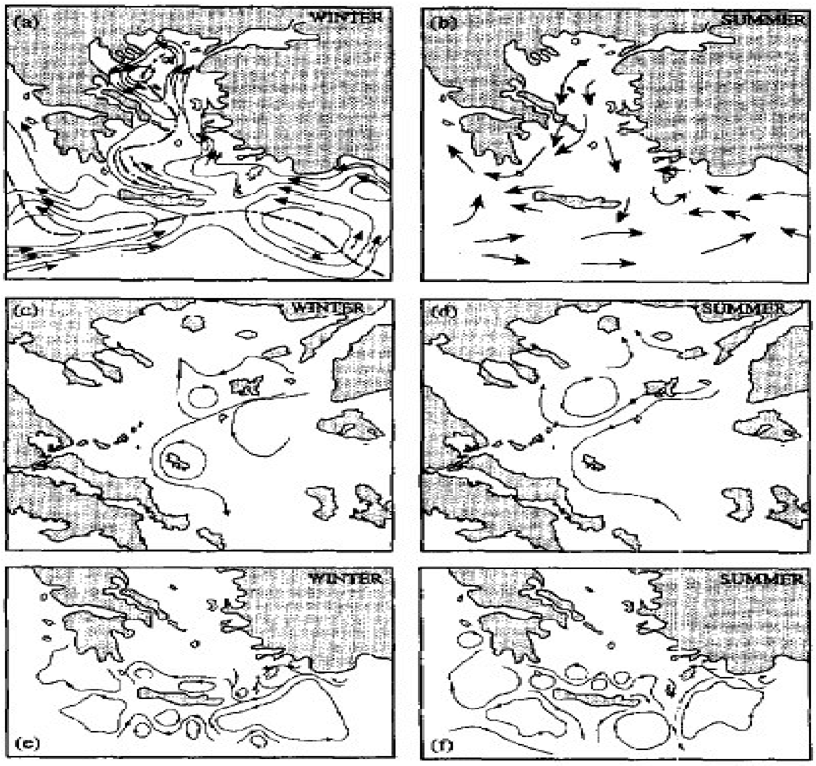


Figure 2-15: Principal circulation pattern of the surface waters of Aegean Sea, in winter and summer: (a) Ovchinnikov (1996), (b) Lacombe and Tchernia (1972), (c) and (d) Zodiatis (1994), (e) and (f) Theocharis et al. (1993). Note that vectors indicate flow direction, whilst the dashed line indicates a convergence zone. In (c) and (d), vectors represents schematically generalised flow patterns, dericved from numerical model graphical outputs (Poulos et al 1997)

Sea currents seem to flow dominantly towards the east/southeast, as part of a gyre system in the Cretan sea, but also westerly currents occur, interconnected by jets, without well-defined time scales. A large multicentered cyclonic circulation present in winter and summer has been observed to transform into a reverse pattern in summer, consisting of an west to east meandering current associated with three anticyclonic and two cyclonic mesoscale eddies (Cardini et al. 2003). The current field is composed of both barotropic and baroclinic components (modes). Geostrophic currents seem generally, from literature, to be slower than 0.3 m/s in the Cretan Sea, down to several hundred meters. The TROPOS site is located within an area of generally cyclonic (anti-clockwise) circulation, while an anti-cyclonic gyre exists further to the west (a dipole system). The current speed magnitude according to model studies is in the range 30-40 cm/s.

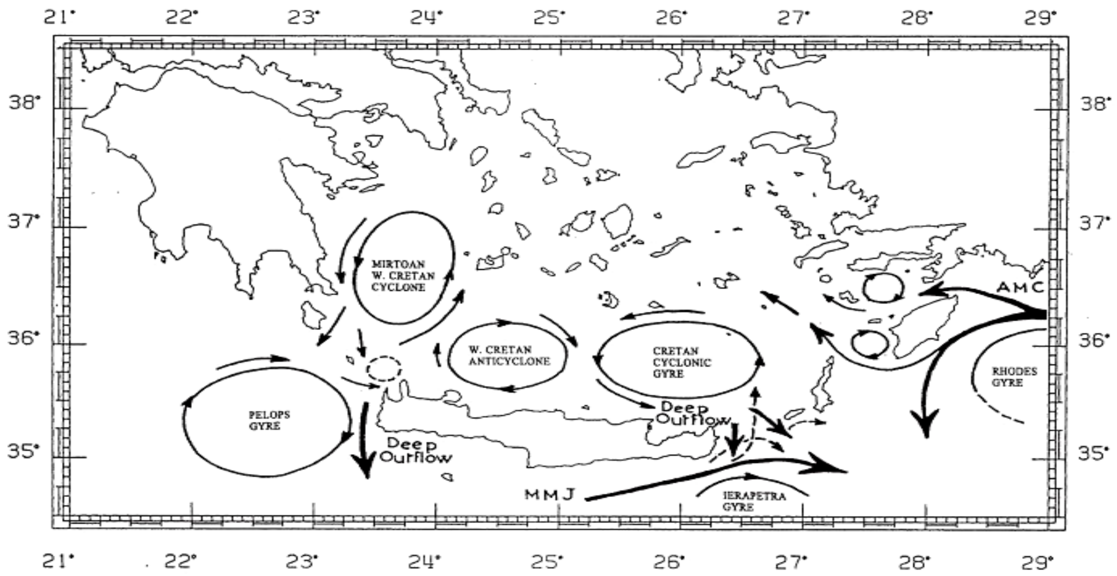


Figure 2-16: Schematic configuration of the main upper thermocline circulation features and deep Aegean outflow, as inferred from the synthesis of the PELAGOS Cruises. MMJ: Mid-Mediterranean Jet; AMC Asia Minor Current (Theocharis et al. 1999)

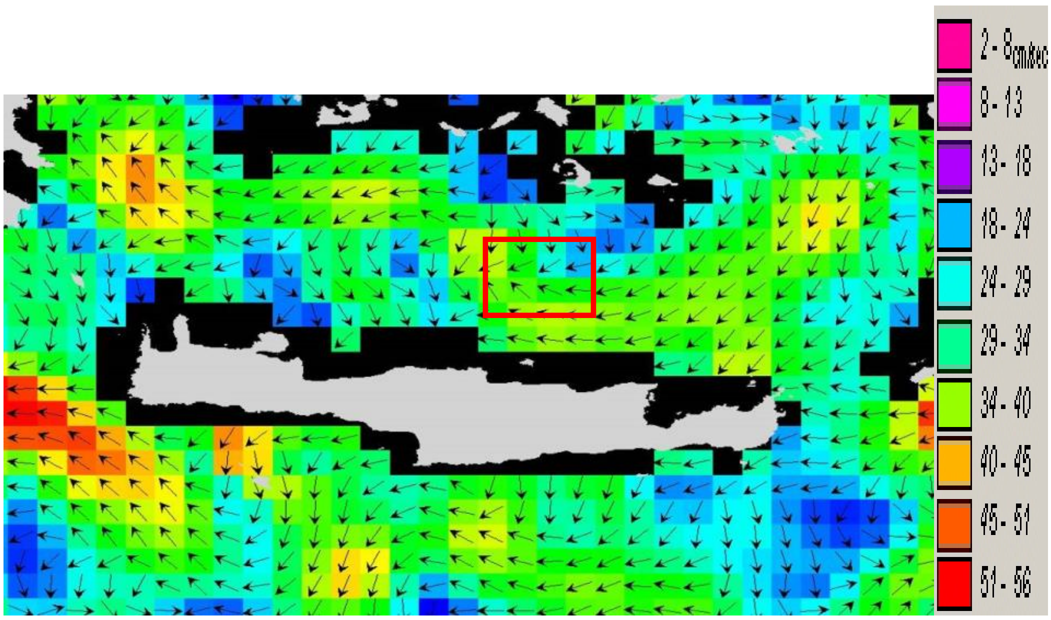


Figure 2-17: Modelled water current velocity (upper layers) around Crete. Mean values of August 2012 (Source: AVISO⁺ 2014)

2.2.2.4 Sea Water Temperature

The pattern of seasonal temperature variations is shown in Figure 2-18. Winter temperatures are in the range of 13–16 °C at the TROPOS site, while over 25°C can be reached in summer. See also Table 2-3-

.

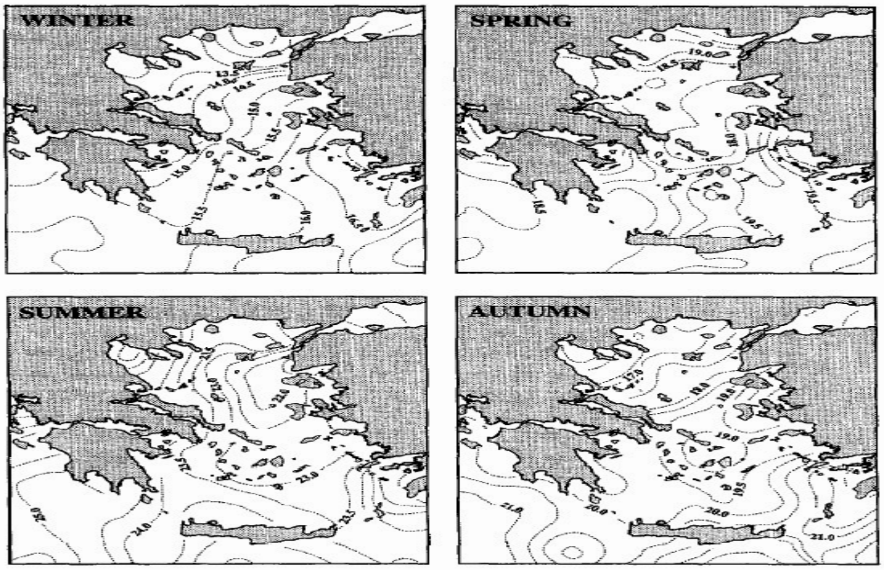


Figure 2-18: Seasonal spatial resolution in sea surface temperature in °C over the Aeagean Sea for the various period of the year (Poulos et al 1997)

In winter, there is a zonal distribution of sea surface temperature with values increasing towards the southeast. The colder waters (cooler than 14°C) dominate the northern part of the Aegean Sea, as a result of the relatively colder and less saline bottom sea water inflow and that at the main river systems discharging into the area. The relatively warmer waters (over 16°C) occupy the eastern part of the Cretan Sea and adjacent straits, being attributed to the Levantine inflow (Poulos et al 1997).

In summer, sea surface temperature varies from 22°C at the entrance to the Dardanelles and within inner Thermaikos Gulf, to more than 24°C within the Cretan Straits. There is a general increase in SST of 2–3°C, from east to west. The lower values along the eastern coastline and, partially in the central Aegean Sea, may be attributed to an upwelling phenomenon induced by the Etesians for the prevailing wind condition which blow generally from north to northeast directions (Poulos et al 1997).

2.2.2.5 Salinity

During the warm season of the year, the warm, saline Levantine Surface Waters (LSW) can also be detected, in most of the regions of the eastern Mediterranean (Lacombe & Tchernia, 1960), which are considered to be the product of intense evaporation (Unlu¨ata, 1986), developing particularly high salinity (39.5 psu) by the end of summer, especially in the Rhodes area LSW enter the Aegean through the eastern Straits of the Cretan Arc.

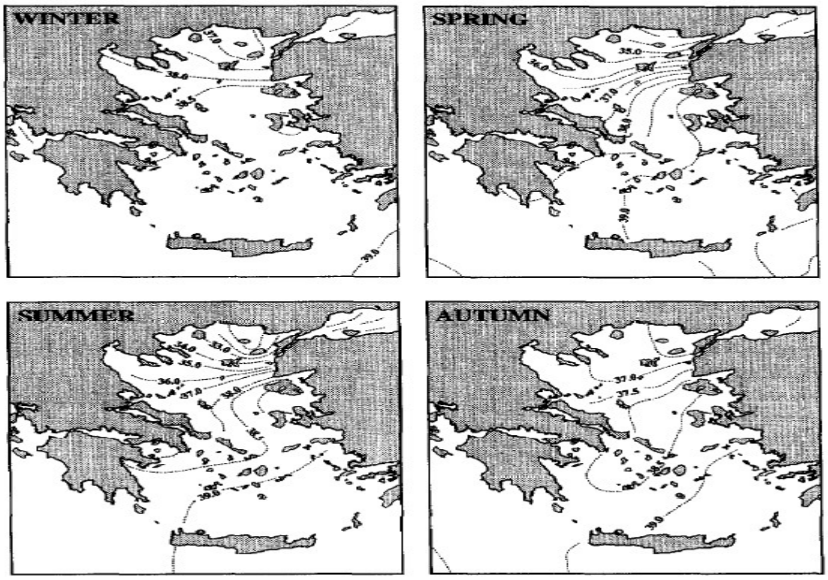


Figure 2-19: Seasonal spatial distribution in sea surface salinity (in psu) over Aegean Sea (Poulos et al 1997)

2.2.2.6 Water Quality

The island of Crete could be characterised by a significant increase in urban and touristic activities, particularly over the past twenty years. As a result of this development, the majority of the population has become concentrated in coastal areas. In many cases the infrastructure required to support this type of economic development is inadequate.

The Mediterranean Sea, especially the eastern Basin, is a unique environment whose structure and function is poorly known. It is considered to be one of the most oligotrophic regions in the world with an overall nutrient deficit that develops towards the east (Ignatiades, 1969). In the Mediterranean Sea, unlike in other ocean basins, phosphates, as opposed to nitrates, that are considered to be the factor limiting phytoplankton growth (MacIsaac & Dugdale, 1972 Becacos-Kontos, 1977; Fiala, Cahet, Jacques, Neveux & Panouse, 1976; Berland, Bonin & Maestrini, 1980;Berland et al., 1988; Bonin,

Bonin & Berman, 1989; Krom, Kress, Brenner & Gordon,1991; Krom, Brenner, Kress, Neori & Gordon, 1992; Thingstad & Rassoulzadegan, 1995).

Consequently, the southeastern Mediterranean is strongly phosphorus limited (Krom et al., 1991, 1992), with concentrations decreasing from west to east across the entire basin so N/P ratios (NO_3:PO_4) increase in the same direction from 22.5 in the Alboran Sea to 27–29 in the eastern basin. In the Cretan Sea the ratio is 26.8 (Tselepides, Zivanovic & Dafnomili, 1993). Nitrate shows a more normal distribution and seasonal variation, see Figure 2-20, with highest concentrations in the surface layer in the autumn and winter. Total dissolved inorganic Nitrogen (DIN) in the Mediterranean at 180 m depth is shown in Figure 2-21. Values are generally low north of Crete, illustrating the oligotrophic character of the waters in general, in the eastern Mediterranean.

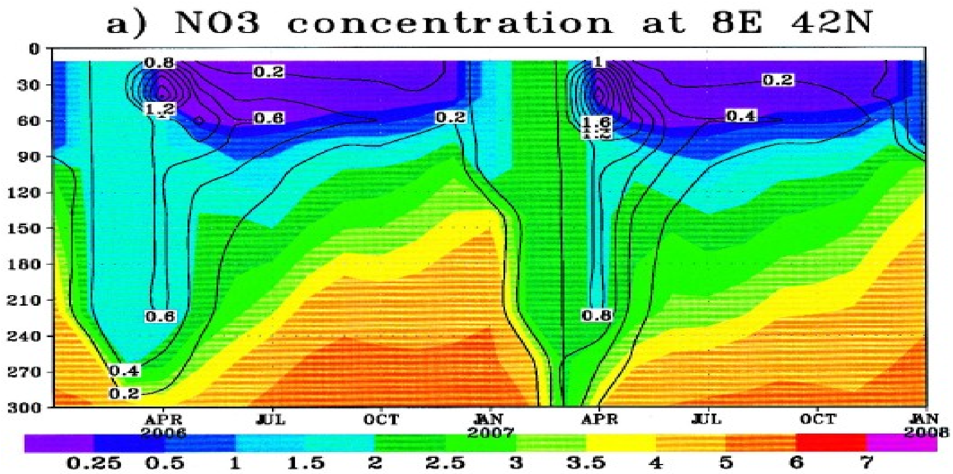


Figure 2-20: Vertical distribution of nitrate (NO_3:N) concentration as function of time of the year (Crise et al.1998)

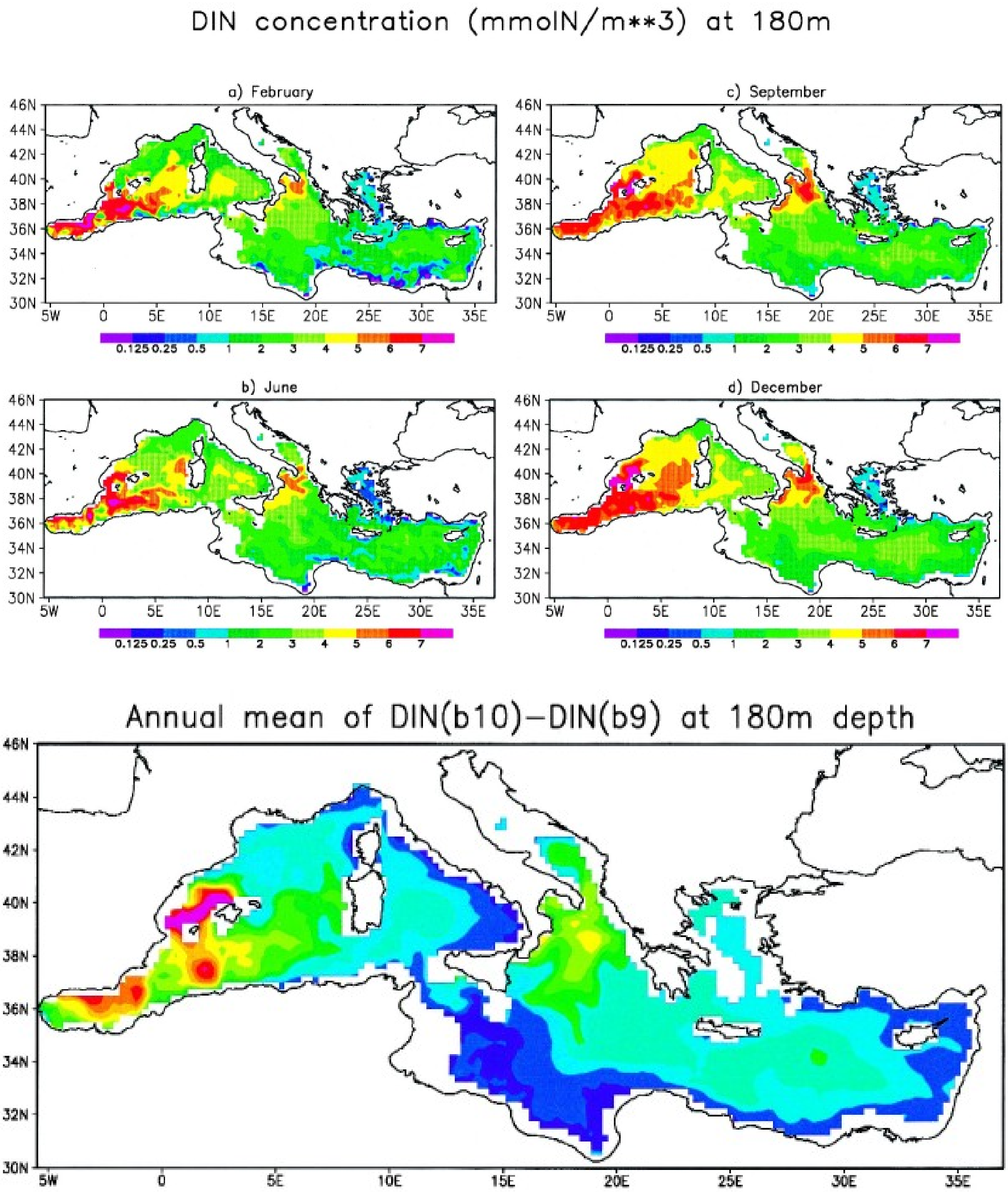


Figure 2-21: Seasonal and Annual DIN concentration at 180 m depth (Crise et al.1998)

Oxygen content:

In general, low oxygen–high nutrient concentrations are found in the cyclonic centres in the Mirtoan and the Eastern Cretan Sea, which is spreading at intermediate depths in the Cretan Sea; while high oxygen-low nutrient masses are exported by the Cold Deep Water (CDW) into the deep and bottom layers outside the Cretan Sea. There is no clear seasonal signal in the total oxygen and nutrient concentrations; only the surface and subsurface layers appear to be richer in nutrients and poorer in oxygen in late winter– early spring than in late summer–early autumn (see below), (Balopoulos et al 1999).

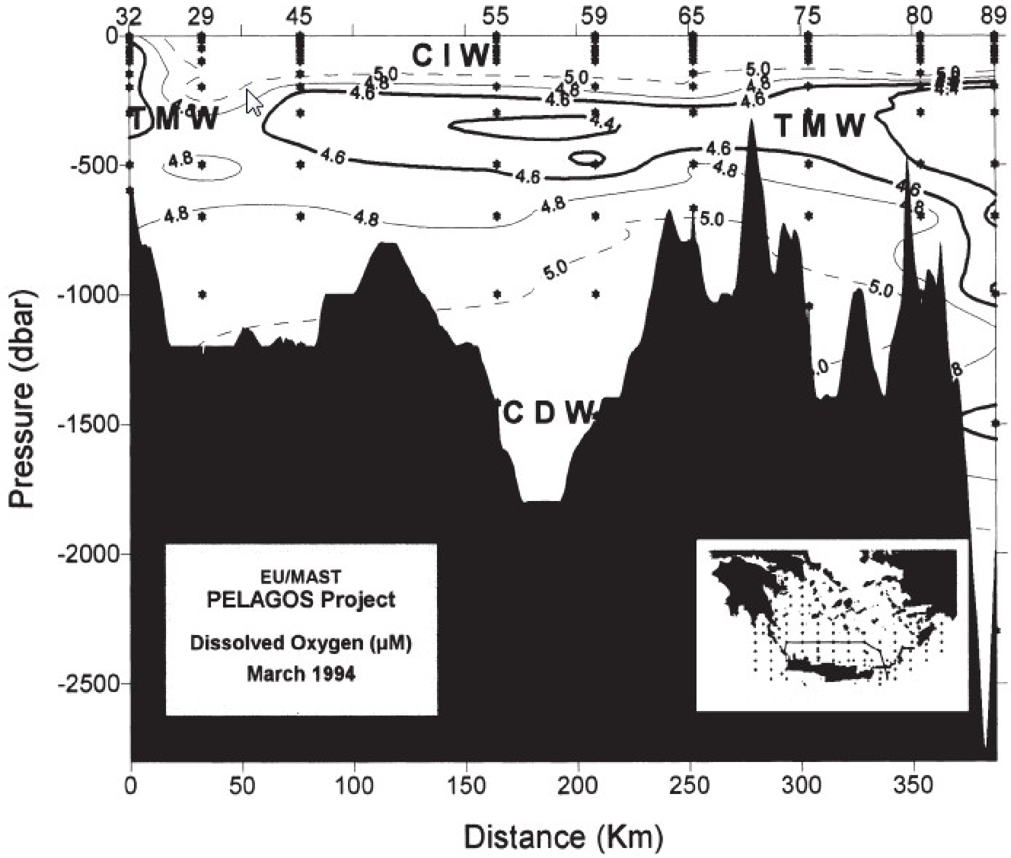


Figure 2-22: Vertical distribution of dissolved oxygen (mM) in the Cretan Sea, during PELAGOS-I Cruise (Balopoulos et al. 1999)

2.3 ECOSYSTEMS, COMMUNITIES AND HABITATS

2.3.1 INTRODUCTION

The biology in the Cretan Sea is largely governed by the oceanographic patterns and in particular by the gyral dipole, with chlorophyll concentrations closely following the circulation patterns (Petihakis et al. 2002). This section will describe known distribution and conservation status of species, species communities, migration routes, relative protected areas and important habitats in the Cretan Sea/South Aegean Sea.

2.3.2 NOISE CONDITIONS

The issue of underwater noise and its effects on marine life is the subject of increasing attention and concern. The three most significant sources of ocean noise pollution are ship noise, oil and gas exploration and military sonar.

Marine traffic such as ferries between the islands and fishing vessels will cause noise pollution. Crete has many ferry connections. The main ports that ferries come into are in Heraklion, Chania, Rethymno, Sitia, and Kastelli-Kassamos. Greece possesses the largest fishing fleet in the European Union comprising of 16,323 vessels (EU Fleet Register, 2012), the vast proportion of which involves costal fisheries.

Cetaceans (whales, dolphins, porpoises) are especially sensitive to underwater noise. Several studies have showed that noise pollution can harm the animals directly, or cause behavioural changes that can interfere with the health and survival of the animals (e.g. Hatch et al. 2012, Pirotta et al. 2012). Known distribution of cetaceans in the Cretan Sea is presented in chapter 2.3.3.2.

2.3.3 FISH AND PELAGIC COMMUNITIES

The pelagic zone can be thought of in terms of an imaginary cylinder or water column that goes from the surface of the sea almost to the bottom. Pelagic life consists of three categories:

- Phytoplankton, which constitute the food base of all marine animals, are microscopic organisms that inhabit only the sunlit uppermost oceanic layer, using sunlight to photosynthetically combine carbon dioxide and dissolved nutrient salts.
- Zooplankton is the marine animals that rely mainly upon water motion for transport, although some forms such as jellyfish are feeble swimmers.
- Nekton, the free swimmers, is dominated by the bony and cartilaginous fishes, molluscans, and decapods, with rarer mammals and reptiles.

2.3.3.1 Phytoplankton

The Mediterranean Sea, and particularly the Eastern Basin, is considered as one of the least productive sea regions in the world, in terms of both primary productivity and chlorophyll a concentrations (e.g. Azov 1991) (Figure 2-23). Low phytoplankton biomass and productivity levels are mainly due to phosphorous deficiency (Krom et al. 1991).

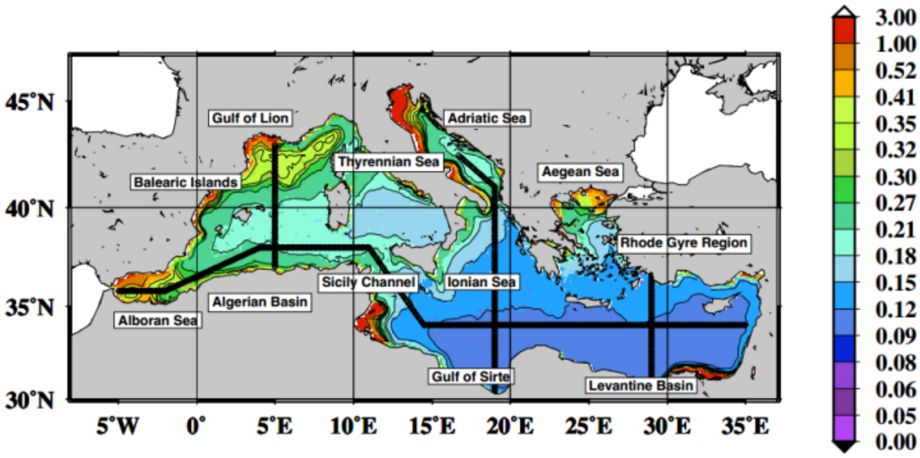


Figure 2-23: Ten years climatological mean map of the chlorophyll concentration in mg/m^3. Bold lines indicate the position of the four transects used to extract satellite data (D'Ortenzio and Ribera d'Alcalá 2009)

A study to assess the variability in spatial and temporal patterns of phytoplankton dynamics in the Aegean Sea was done in 1997–1998 (Ignatiades et al. 2002).The study showed that the chlorophyll concentrations and primary production was lower in the South Aegean than in the North Aegean (Table 2-5). Since the South Aegean Sea is close to the Cretan Sea, the reference to this study is relevant. The picoplankton fraction (phytoplankton size fraction <2µm) predominated and accounted for the 61% to 47% of total chlorophyll a and the 59% to 44% of total primary production in the northern and southern Aegean Sea, respectively. Throughout the sampling area, the levels of nanoplankton and microplankton were next in abundance proportions of total chlorophyll a (21–31%) and primary production (20–33%) and the levels of the ultraplankton were the lowest contributing the 18–22% of total chlorophyll a and the 20–23% of total primary production (Ignatiades et al. 2002).

Cell abundances (means over depth and station) exhibited a temporal variation in both areas with maxima in spring (north Aegean: 4.5 x 103 – 1.5 x 104 cells 1 - 1; south Aegean: 1.7 x 104 – 5.1 x 104 cells 1 - 1) and minima in autumn (north Aegean: 1.1 x 103 cells 1 - 1; south Aegean: 5.8 x 103 cells 1 - 1) (Figure 2-23). Qualitative comparisons in terms of percentage showed that the spectrum of the major taxa (diatoms, dinoflagellates, coccolithophores, others (flagellates, silicoflagellates)) in spring 1997 differed from that in spring 1998 in both areas (also in Figure 2-24) (Ignatiades et al. 2002).

Table 2-5: Overall means and standard deviations (in parentheses) of chlorophyll and primary production in north and south Aegean Sea (Ignatiades et al. 2002)

Area	**North Aegean**			**South Aegean**		
Parameter	Spring 1997	Autumn 1997	Spring 1998	Spring 1997	Autumn 1997	Spring 1998
Chl a (mg m^{-3})	0.379 (0.262)	0.260 (0.126)	0.344 (0.327)	0.301 (0.105)	0.119 (0.091)	0.217 (0.032)
Primary production (mg C m^{-3} h^{-1})	1.842 (1.626)	0.261 (0.229)	0.478 (0.524)	0.508 (0.351)	0.167 (0.086)	0.335 (0.199)

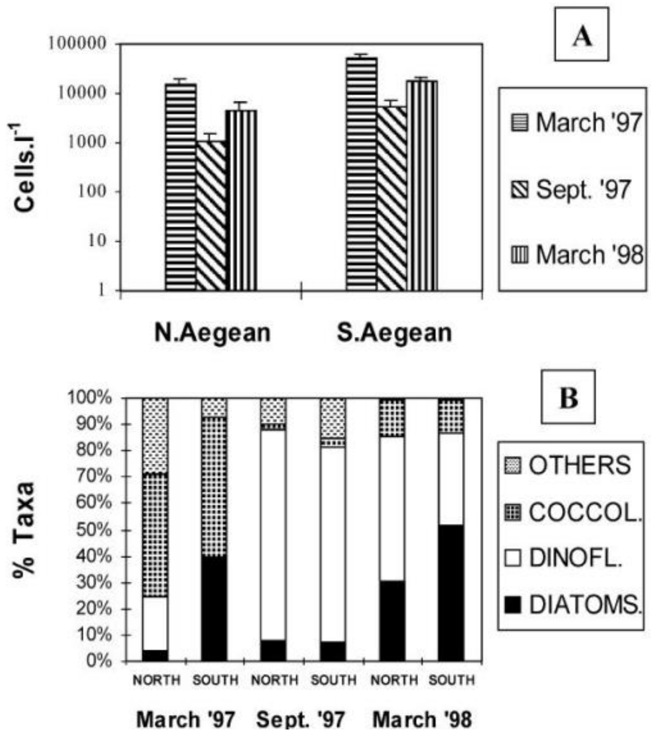


Figure 2-24: Temporal variation of mean (over depth and station) phytoplankton concentrations, and the corresponding percentage of taxa composition the north and south Aegean Sea (Ignatiades et al. 2002)

The spatial variability of the mean primary production for the four seasons integrated over the top 150 m was investigated in a study in 2002 (Petihakis et al. 2002; Figure 2-25). The Cretan Sea is oligotrophic with low annual productivity (30–80 g C * m $^{-2}$ * year^{-1}) and maximum rates between late winter and early spring (Psarra et al. 2000).

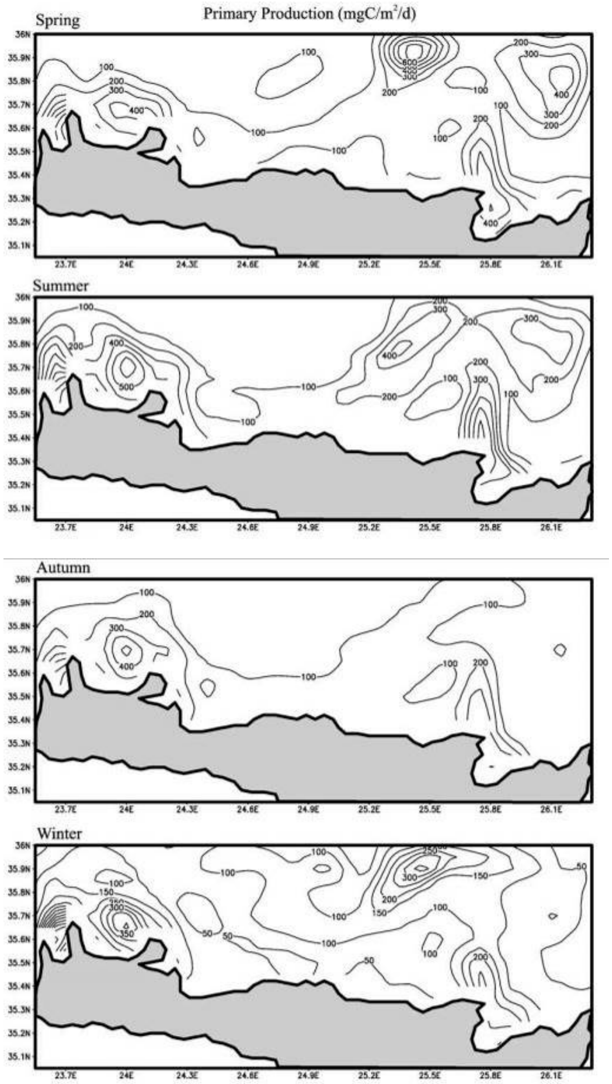


Figure 2-25: Primary production for the four seasons integrated to 100 m depth (Petihakis et al. 2002)

2.3.3.2 Zooplankton

A study of zooplankton composition and vertical distribution, and its relation to the hydrological regime was studied in the south eastern Aegean Seas in 1986 (Pancucci-Papadopoulou 1992). The study found a total of 19 taxonomic groups. They observed a decrease in the number of taxonomic groups with increasing depth, especially below 500 m. Copepods were by far the most dominant component of the samples; they identified a total of 110 copepod species. Other important groups present in the samples were Siphonophora, Appendicularia, Chaetognatha, Ostracoda and Polychaeta (Pancucci-Papadopoulou 1992).

A study of mesozooplankton distribution from Sicily to Cyprus in 1991 showed that the lowest value of zooplankton abundances (individuals * m^{-3}) were obtained in the Cretan Sea (45±11 ind. * m^{-3}), while slightly higher abundances were recorded in the Cretan Passage (56±6 ind. * m^{-3}) (Mazzocchi et al. 1997). Copepod abundances accounted for some 80% of the total zooplankton collected during the cruise in 1991 (Table 2-6).

*Table 2-6: Distribution of the taxonomic groups (%) and of the total zooplankton (mean abundance as ind. * m^{-3} and ind.* m^{-2}) in the Cretan Sea and the Cretan Passage sampled during the POEM-BC-091 cruise in the Eastern Mediterranean in 1999. 0-300 m, mesh size 200µm. (Mazzocchi et al. 1997)*

Taxonomic groups (%)	Cretan Sea	Cretan Passage
Medusac	0.07	0.05
Siphonophora	0.12	0.93
Ctenophora	0.00	0.01
Heteropoda	0.01	0.00
Pteropoda	1.00	2.32
Mollusca larvae	0.00	0.01
Polichaeta	0.26	1.07
Cladoccra	0.09	0.13
Copepoda	88.57	77.21
Ostracoda	4.27	9.61

Euphausiacea	0.20	0.77
Decapoda larvae	0.00	0.06
Decapoda (*Lucifer*)	0.03	0.20
Mysidacea	0.02	0.02
Isopoda	0.06	0.15
Amphipoda	0.05	0.47
Chaetognatha	3.22	5.86
Echinodermata larvae	0.01	0.01
Appendicularia	1.90	0.78
Doliolida	0.03	0.11
Salpida	0.01	0.01
Pisces eggs + larvae	0.07	0.09
Total zooplankton (ind. *m^{-3})	55	70
Total zooplankton (ind.* m^{-2})	13,490	16,827

2.3.3.3 Ichthyofauna

Currently, there are more than 600 marine fish species in the Mediterranean Sea, most of them being of Atlantic origin (Quignard and Tomasini 2000). However, in the Eastern Mediterranean, due to the east-west gradient of both salinity and temperature, fish diversity decreases to around 400 species (Abdul Malak et al. 2011). 519 species are considered to be native species in the Mediterranean (Figure 2-26).

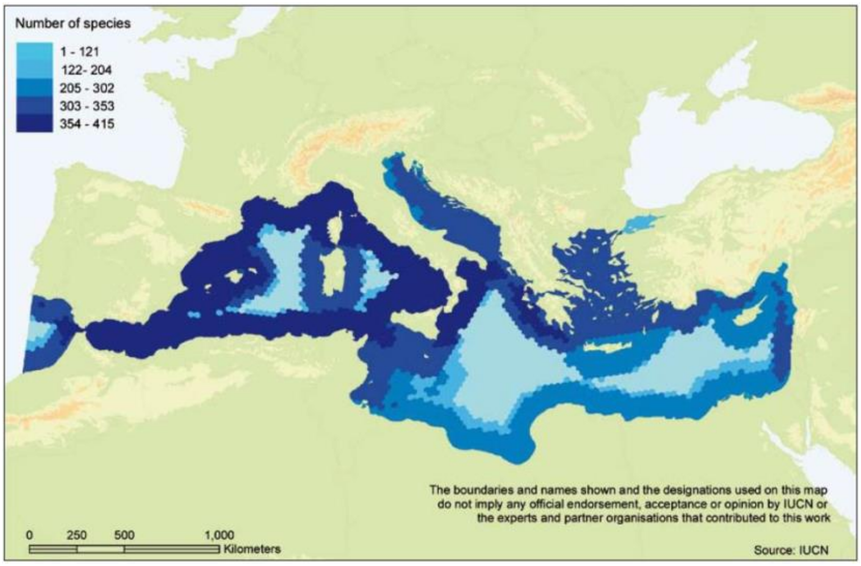


Figure 2-26: Species richness of native marine fishes in the Mediterranean Sea (Abdul Malak et al. 2011)

The demersal fish and megafaunal assemblages in the area of Heraklion Bay, Crete, were sampled during four research cruises from September 1994 to September 1995 using a stratified trawl survey at depths ranging from 50 m to 1000 m. (Kallianiotis et al. 2000).

A total of 127 species (*osteichthyes, chondrichthyes, crustaceans* and *cephalopods*) were collected in the study area. Osteichthyes were the most abundant class with 86 species of bony fish recognised during this survey. The majority of species were shallow living (i.e. from 50 m to 200 m). Several lived only in the lower slope, and some of these were caught for the first time in the eastern Mediterranean. Only five osterichthyes (*Aspitrigla obscura, Arnoglossus ruepelli, Capros aper, Diaphus holti* and *Trisopterus minutus capelanus*) had distributions restricted to the upper part of the continental slope. 15 species of chondrichthyes were recorded. The species were well represented at all depths and the coastal species were Dasyatis pastinaca, and Myliobatis aquila; the Rajidae species were found from 50–500 m depth, *Scyliorhynus canicula* and *Torpedo marmorata* at mid-depths (300–500 m); and the remaining species at larger depths (500–1000 m) (Kallianiotis et al. 2000).

There are 28 commercially important fish species occurring in Greece (Froese and Pauly 2014). Tuna, and tuna-like species, are very important economically, and a significant source of food. The atlas of tuna and billfish catches is an interactive web-based mapping tool (FAO 2014). Table 2-7 shows the average catches (1990–2014) of tuna and billfish, by fishing gears, in the eastern Aegean Sea (Figure 2-26).

Table 2-7: Average catches (aggregated catches 1990–2014) of tuna and billfish, by fishing gears, in the eastern Aegean Sea (FAO 2014)*.*

Gears	Species	Scientific Name	Catches (tonnes)
Longline	Albacore	*Thunnus alalunga*	36,349
	Atlantic bluefin tuna	*Thunnus thynnus*	14,328
	Bigeye tuna	*Thunnus obesus*	0,292
	Swordfish	*Xiphias gladius*	748,386
Purse seine	Albacore	*Thunnus alalunga*	97,365
	Atlantic bluefin tuna	*Thunnus thynnus*	1,622,739
	Skipjack tuna	*Katsuwonus pelamis*	12,483
Other gears	Albacore	*Thunnus alalunga*	344,917
	Atlantic bluefin tuna	*Thunnus thynnus*	0.042
	Swordfish	*Xiphias gladius*	166,250

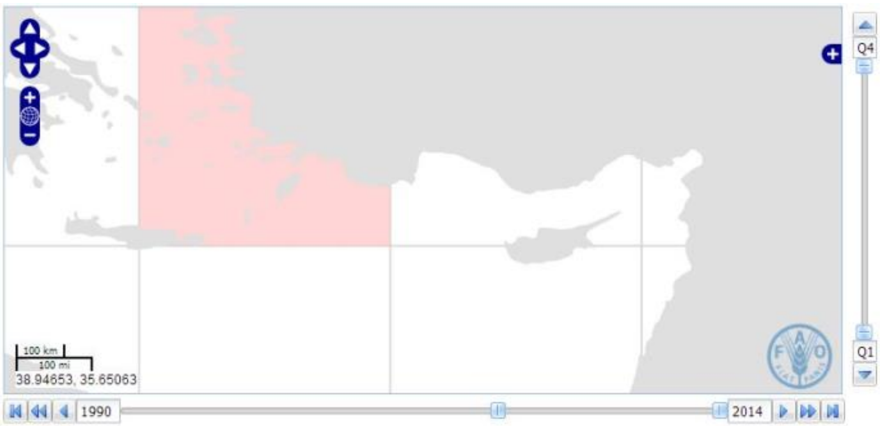


Figure 2-27: Eastern Aegean Sea area (FAO 2014)

An analysis of the total catch a day^{-1}, for a number of species throughout the Greek Seas, for various gears, was performed for the period 1996– 2000 (Stergiou et al. 2007). Table 2-8 shows the most abundant species, in terms of catch a day, caught in Cretan waters.

Table 2-8: The most abundant species in terms of catch a day in Cretan waters (Stergiou et al. 2007)

Gear	Species
Trawlers and purse seiners	*Trachurs* spp.(mackrel) *Boops boops* (seabream) *Mullus barbatus* (goatfish) *Spicara smaris* (picarel) *Sardina pilchardus* (european pilchard).
Longliners and netters	Various species *Merluccius merluccius* (european hake) *Boops boops* (seabream) *Pagellus bogareveo* (blackspot seabream) *Xiphias gladius* (swordfish) *Scorpaena* spp. (scorpionfish) Sepia spp. (cuttlefish) *Pagrus* spp. (seabream)
Beach seiners and 'other gears'	*Polyprion americanus* (atlantic wreckfish) *Boops boops* (seabream) *Spicara smaris* (picarel) *Pagellus bogareveo* (blackspot seabream)

Endangered fish species

Of the 519 native marine fish species and subspecies assessed in the Mediterranean Sea, 43 species (around 8%) were regionally classified in threatened categories ("critically endangered", "endangered" or "vulnerable") (Figure 2-28). Of the 15 species (3%) listed as "critically endangered", the highest threat category, 14 (93%) are sharks and rays. Thirteen species (2.5%) are listed as "endangered", 9 being sharks and rays, while 15 species (3%) are listed as "vulnerable", with roughly equal numbers of sharks (8 species) and bony fishes (7 species). An additional 22 species (4%), including 10 sharks and rays, were listed as "near threatened" (Abdul Malak et al. 2011).

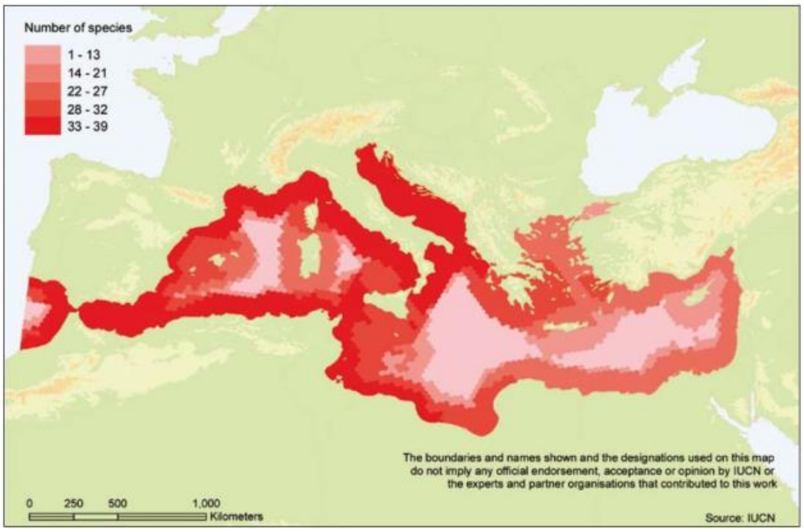


Figure 2-28: Distribution of threatened native marine fish species in the Mediterranean Sea (Abdul Malak et al. 2011)

Alien fish species

A list of exotic species in the Mediterranean (a survey of recent marine "immigrants" in the Mediterranean, which is undergoing drastic and rapid changes to its biota) lists a total of 146 species of exotic fishes in the Mediterranean Sea (CIESM 2014).

In Greece, there are 47 introduced fish species (Froese and Pauly 2014). A list of the 100 'worst invasive' alien species in the Mediterranean, lists 19 species of fish (Streftaris and Zenetos 2006). Of those 19 species, 13 have been recorded in Greece (Table 2-9).

Table 2-9: Introduced fish species in Greece (Froese and Pauly 2014) that are included in the list of the 100 'worst invasive' alien species in the Mediterranean (Streftaris and Zenetos 2006)

Species	FishBase name	Comments
Alepes djedaba	Shrimp scad	Recorded from the south-eastern Aegean Sea
Lagocephalus sceleratus	Elongated pufferfish	Recorded from the Cretan Sea
Fistularia commersonii	Bluespotted cornetfish	Recorded from the Aegean Sea

Pempheris vanicolensis	Vanikoro sweeper	Recorded from Dodecaneses where it is very common. Recorded from Kastellorizon
Sargocentron rubrum	Redcoat	
Scomberomorus commerson	Narrowbarred Spanish mackerel	
Siganus luridus	Dusky spine foot	Recorded from the south-eastern and central Aegean Sea
Siganus rivulatus	Marbel spine foot	Recorded from Rhodes and the south-eastern and central Aegean Sea
Sillago sihama	Silver sillago	Recorded from south-eastern Aegean Sea
Sphoeroides pachygaster	Blunthead puffer	Recorded from Rhodes, Simi, Karpathos, South Aegean, central Aegean and Ionian Sea
Sphyraena chrysotaenia	Yellow stripe barracuda	Recorded from Rhodes and the south-eastern Aegean Sea
Upeneus moluccensis	Goldband goatfish	
Upeneus pori	Por's goatfish	Recorded from Rhodes

During a survey from 1996–2006, 5 invasive species were caught in the south Aegean and Cretan Sea (Peristeraki et al. 2006): *Etrumeus teres* (round herring), *Upeneus moluccensis* (goldband goatfish), *Siganus rivulatus* (marbel spine foot), *Stephanolepis diaspros* (reticulated leatherjacket) and *Sphoeroides pachygaster* (blunthead puffer)

A survey on Karpathos Island in 2012 identified 5 invasive species: *Siganus luridus* (Dusky spinefoot), *Siganus rivulatus* (Marbled spine foot), *Sphyraena chrysotaenia* (Yellowstripe barracuda), *Sargocentron rubrum* (Redcoat) and *Fistularia commersonii* (Bluespotted cornetfish) (Thessalou-Legaki et al. 2012).

2.3.3.4 Marine Mammals

Marine mammals are mammals that are well adapted for life in the marine environment. Two major groups of marine mammals are:

- Cetaceans (whales, dolphins, and porpoises)
- Pinnipeds (seals, sea lions, and walruses)

All marine mammals are protected under the Marine Mammal Protection Act (MMPA); some marine mammals may be designated as "depleted" under the MMPA. Stocks of marine mammals may also be considered "strategic" under the MMPA. Endangered and threatened marine mammals are further protected under the Endangered Species Act (ESA).

Cetaceans

A study from 2003 showed that twelve cetacean species were identified from a total of 821 sightings and 715 stranded animals in the Greek Seas (Frantzis 2003). The following species were sighted/found stranded off the northeastern coast of Crete, and west of the Karpathos:

- Striped dolphin (*Stenella coeruleoalba*)
- Bottlenose dolphin (*Tursiops truncatus*)
- Cuvier's beaked whale (*Ziphius cavirostris*)
- Sperm whale (*Physeter macrocephalus*)
- Fin whale (*Balaenoptera physalus*)

A record of presence and distribution of cetaceans in the Greek Seas, from 1991–2008 (together with some older historical records), shows 1,416 sightings and 1,392 stranded animals. Eleven cetacean species have been identified within the limits of the Greek Seas (Table 2-10) (Frantzis 2009).

Monk seals

The Mediterranean monk seal (*Monachus monachus*) is the most endangered pinniped species in the world, with an estimated total population size of 350–450 animals, with 250– 300 in the eastern Mediterranean within the largest subpopulation, of which about 150– 200 are in Greece and about 100 in Turkey (Güçlüsoy 2004). In the IUCN Red List it is listed as "critically endangered" (Aguilar and Lowry 2013).

Today the distribution is widespread, but fragmented into an unknown but probably relatively large number of very small breeding subpopulations. In the Mediterranean, the stronghold for the species is on islands in the Ionian and Aegean Seas, and along the coasts of Greece and western Turkey. Overall abundance trends in the Mediterranean are not available, but mortality caused by adverse fishing interaction continues to be alarmingly high in Greece and Turkey, the main stronghold for the species in this sea (Aguilar and Lowry 2013).

Hellenic Society for the Study and Protection of the Mediterranean monk seal (MOm) proposed a list of sensitive areas to be included in the National Contingency plan against oil spills in view of the presence of Mediterranean monk seals in 1999. Among them was the Dionisades islets north off the bay of Sitia and Dia Island in Crete (Notarbartolo et al. 2009). The density of monk seal sighting reported to MOm between 1996 and 2006 is presented in Figure 2-29.

The island complex of Karpahtos and Kasos is one of the main breeding areas, for the Mediterranean monk seal, in Greece, and the most important in the Dodecanese (Fric et al. 2012).

Table 2-10: Number of sightings and stranded animals per cetacean species (Frantzis 2009)

Species	Sightings / stranded animals	Geographic distribution	IUCN Red List Status – Mediterranean
Stenella coeruleoalba (Striped dolphin)	523/197	Common in all areas over depths >500 m (present in >200 m), including Gulf of Corinth. Absent/vagrant in depths <200 m.	Vulnerable
Tursiops truncatus (Common bottlenose dolphin)	305/234	Present in all coastal areas, straits, gulfs, and also between islands in the entire Ionian, Aegean and Cretan Seas with no exceptions.	Vulnerable
Delphinus delphis (Short-beaked common dolphin)	140/55	Thracian Sea, Thermaikos Gulf, Northern Sporades, Pagasitikos Gulf, northeast Aegean Sea, Cyclades; south Evvoikos Gulf, Dodecanese;	Endangered

		Gulf of Corinth, Inner Ionian Sea, recorded in north Evvoikos Gulf	
Ziphius cavirostris (Cuvier's beaked whale)	70/100	Present and locally (south Crete, west Lefkada) common all along the Hellenic Trench; present or common over steep depressions of the Aegean (e.g. north Sporades)	Data deficient
Physeter macrocephalus (Sperm whale)	300/26	Mainly along the Hellenic Trench from Kefallonia to east Rodos, also in deep basins/trenches of the Aegean Sea (Myrtoon, Cretan, north Ikarion, northwest Aegean Sea)	Endangered
Grampus griseus (Risso's dolphin)	38/34	Common in Myrtoon Sea south to northwest Crete, present or common in north Sporades and Chalkidiki, present or rare or seasonal in all other Aegean and Ionian Seas	Data deficient
Balaenoptera physalus (Fin whale)	36/10	Present in north Ionian Sea and especially from northwest of Lefkada Island north up to north Corfu; at least occasionally in Saronikos	Data deficient
Phocoena phocoena (Harbour porpoise)	1/15	Thracian Sea, possibly present in Thermaikos Gulf and Chalkidiki peninsula. Only vagrant further to the South.	Endangered
Pseudorca crassidens (False killer whale)	1/1	Rerely been recorded in the Greek Seas	Data deficient (globally)

Megaptera novaeangliae (Humpback whale)	2/1	Rarely recorded in the Greek Seas	Least concern (globally)
Balaenoptera acutorostrata (Common minke whale)	- /1	Rerely been recorded in the Greek Seas	Least concern (globally)
Total identified	**1,416/1,392**		

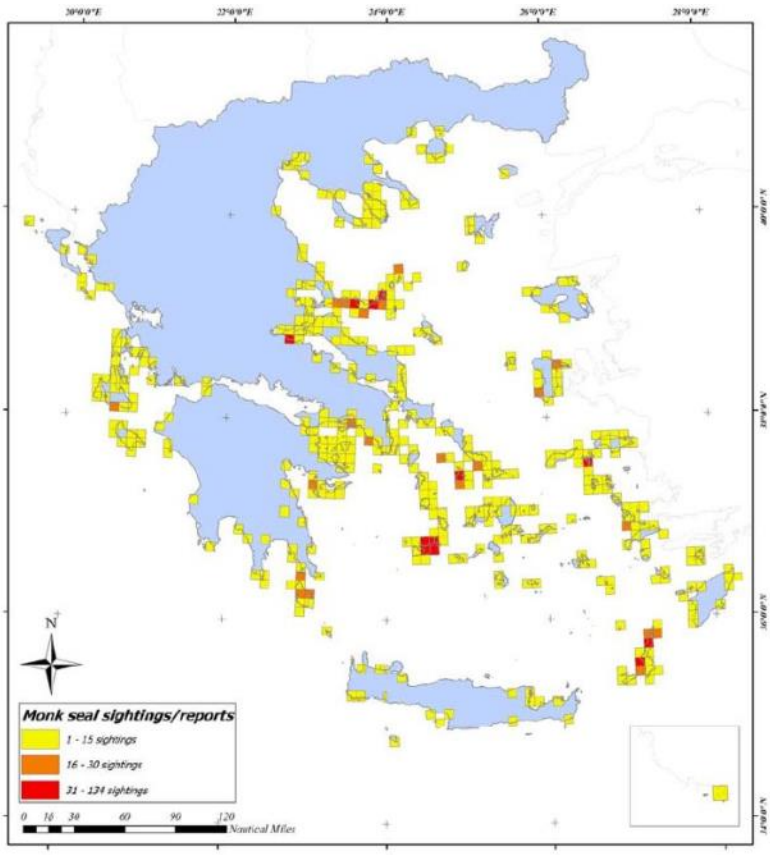


Figure 2-29: Mediterranean monk seal reports in Greece, 1996–2006 (Notarbartolo et al. 2009)

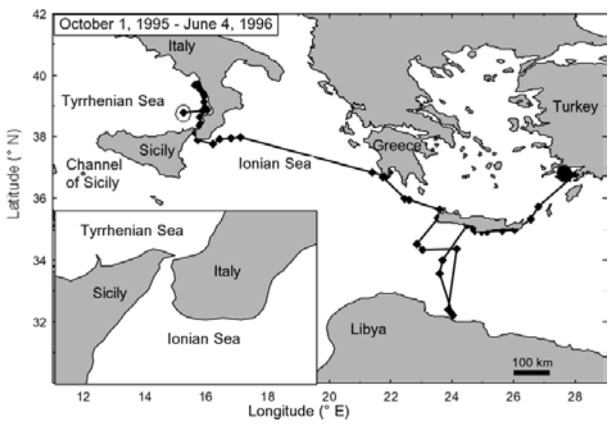
2.3.3.5 Others

Sea turtles

The Mediterranean region is an important breeding area for two marine turtle species: (1) the loggerhead turtle (*Caretta caretta*), with main nesting concentrations found in Greece, Turkey, Cyprus and the Libyan Arab Jamahiriya; IUCN Red List Status: endangered; (2) the green turtle (*Chelonia mydas*), with main nesting concentrations found in Cyprus and Turkey; IUCN Red List Status: endangered.

Another species distributed across the whole region is the leatherback (*Dermochelys coriacea*), although regular reproduction has not been observed. Some other turtle species, such as the hawksbill (*Eretmochelys imbricata*) and Kemp's ridley (*Lepidochelys kempii*) have also been observed occasionally (Camiñas 2004).

The greater part of the 16,000 km Greek coastline has been investigated through aerial and ground surveys, and nesting areas for loggerhead sea turtles have been found mainly along the western and southern coasts and on the island of Crete (Bolten and Witherington 2003). Data from surveys of nesting areas between 1990–1996 shows an average of 401 nests in Rethimno, 125 in Hania (northern coast of Crete), and 56 in Messara (southern coast of Crete), totalling 582 nests annually, or 21% of the total observed nesting for all of Greece (Irvine et al 2003). The green turtle are restricted to the eastern basin (Camiñas 2004). Loggerhead sea turtles have been tracked around the Cretan coast (Figure 2-30) (Bentivegna 2002).



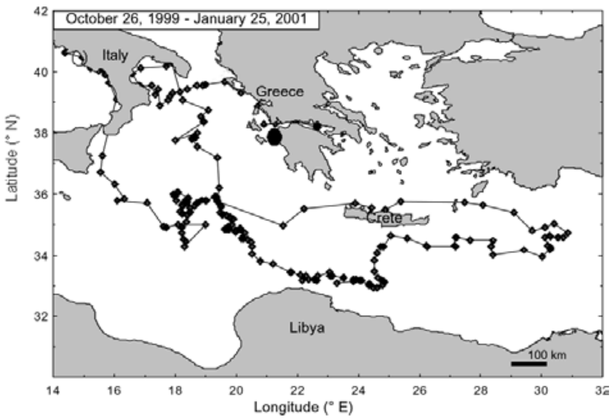


Figure 2-30: Movement of female loggerhead sea turtles (Caretta caretta). Left: female tracked 1995–1996, right: female tracked 1999–2001 (Bentivegna 2002)

Cephalopods

Cephalopods constitute increasingly important resources for human consumption and a principal food for many top predators. An analysis of cephalopods in the south Aegean Sea, using data collected from two different surveys carried out in 1994– 2001 and in 1995–1996 (between 30–778 m depths), identified 34 species of cephalopods (including 11 oegopsid squid, 3 myopsid squid, 7 octopod, 3 cuttlefish and 10 sepiolid) (Lefkaditou 2003). A total of 25 species have been known from the southern Aegean Sea. Among the 34 species recorded during the survey, 16 were new findings for the studied area. 9 species previously recorded in the southern Aegean Sea was not found during the surveys.

A study of deep-sea molluscs in the southern part of the Cretan Sea (1994–1995), identified 12 species of cephalopods between 40–1,570 m depth (Table 2-11) (Koutsoubas et al. 2000). The neon flying squid (Ommastrephes bartramii) has been recorded along the eastern Aegean and the periphery of the Cretan Sea (Lefkaditou et al. 2011).

Table 2-11: Cephalopod species recorded in the southern part of the Cretan Sea in 1994 –1995 (Koutsoubas et al. 2000)

Alloteuthis media	*Octopus vulgaris*	*Sepia officinalis*
Eledone cirrhosa	*Rondeletiola minor*	*Sepia orbignyana*
Eledone moschata	*Rossia macrosoma*	*Sepietta oweniana*

Illex coindetii	*Sepia elegans*	*Sepiola rondeletii*

A review of species with minor commercial interest identified 10 cephalopod species in the Hellenic Seas (Katsenevakis 2008) (Table 2-12).

Table 2-12: Cephalopod species with minor commercial interest recorded in the Hellenic seas, and their distribution (Katsenevakis 2008)

Alloteuthis media	Been reported as the most frequently caught cephalopod species on the shelf of the north Aegean, south Aegean, and the Ionian Sea.
Loligo forbesi	Widespread in Hellenic Seas, common in the neritic zone of the Ionian Sea and the area of the Kyklades, Kriti and the Dodekanisos islands.
Todarodes sagittatus	Reported in the Aegean and the Ionian Seas, being caught at depths between 120– 800 m.
Todaropsis eblanae	Widespread in Hellenic Seas, where it has been recorded from 100–850 m of depth, being more abundant on the upper slope of regions with steep waters, like the Toroneos Gulf and the Ionian Sea.
Sepia elegans	Common in Hellenic Seas where it has been reported at depths of between 20–600 m.
Sepia orbignyana	Throughout the Mediterranean Sea. Deepest record from a haul between 700–770 m in the southern Aegean Sea.
Rossia macrosoma	It is widespread in the Mediterranean Sea. It has been found in the Aegean Sea and the Ionian Sea, at depths between 72 m and 700 m.
Rondeletiola minor	Widespread in the Mediterranean Sea. In the Aegean Sea it has been caught down to 770 m, with the greatest part of its population distributed over the continental slope.
Sepietta oweniana	Common in Hellenic Seas, where it has been recorded at depths of between 20–820 m.
Scaeurgus unicirrhus	Widespread in Hellenic Seas, relatively more abundant in the Aegean Sea (30–550 m) than in the Ionian Sea (43– 850 m).

2.3.4 BENTHIC COMMUNITIES; SPECIES COMPOSITION AND DISTRIBUTION

The variability of benthic communities along the continental margins is mostly related to depth, which however may reflect changes in food supply, sediment characteristics or other factors. In the Mediterranean the continental shelf is very narrow and therefore the largest part of this enclosed sea is classified as deep sea. The Cretan continental shelf is rather large in comparison to most Mediterranean islands, its coastline exceeding 800 km.

2.3.4.1 Mollusca

A total of 1,160 mollusc species (1 *Solenogastra*, 2 *Caudofoveata*, 771 *Gastropoda*, 308 *Bivalvia*, 19 *Polyplacophora*, 12 *Scaphopoda* and 47 *Cephalopoda*) have been recorded in the Hellenic Seas. A total of 27 of these species (17 bivalves, 4 gastropods and 6 cephalopods), comprising less than 2.5% of the molluscan fauna of the Hellenic Seas, have a commercial interest, particularly in fisheries and aquaculture since they are collected and/or cultivated for human consumption (Katsanevakis et al. 2008). A review of species with minor commercial interest identified 18 gastropod and 13 bivalve species in the Hellenic Seas (Katsenevakis 2008).

A study of macrofauna on the continental shelf (at 40– 190 m depths) of Crete in 1988 identified 89 mollusc species (Karakassis 1997); the most dominant species/taxa in the samples were *Acinulus croulinensis, Axinulus crulinensis, Bathyarca grenophia, Caudofoveata, Kelia sp., Thyasira flexuosa* and *Turitella communis*.

The deep sea molluscan fauna of the southern part of the Cretan Sea was investigated in 1994–1995. Samples were taken between 40–1,570 m depths. They identified 147 mollusc species belonging to 6 different mollusc classes (Koutsoubas et al. 2000):

- *Bivalvia* (63 species) and *Gastropoda* (60 species) predominate in the collected molluscan fauna.
- *Cephalopoda* (12 species) and *Scaphopoda* (8 species) were the next most numerous taxa.
- *Polyplacophora* and *Caudofoveata* were represented by 2 species each.

The dominant species of the continental shelf assemblages (0–200 m) were the gastropods *Turritella communis*, *Aporrhais pespelecani* and the bivalve *Thyasira flexuosa*; the dominant species of the intermediate deep assemblages (200– 500 m, upper bathyal slope) were the gastropod *Aporrhais serresianus* and the bivalve *Kelliella abyssicola*. Out of the 42 deep sea species (recorded also at depths below 500 m – lower bathyal slope) only 13 species, namely the gastropods *Propilidium* *pertenue*, *Danilia otaviana*, *Putzeysia wiseri*, *Benthomangelia macra*, *Mangelia nuperrima*, *Pleurotamella eurybrocha*, *Pyramidella octaviana*, the bivalves *Propeamussium fenestratum*, *Delectopecten vitreus*, *Cyclopecten hoskynsii*, *NotoIimea crassa*, *Tbracia convexa*, and the scaphopod *Pulsellum lofotense* were confined to the deeper part (Koutsoubas et al. 2000).

2.3.4.2 Polychaeta

A study of macrofauna on the continental shelf (at 40– 190 m depths) of Crete in 1988 identified 238 polychaete species (Karakassis 1997); the most dominant species in the samples are shown in Table 2-23.

Table 2-13: The most dominant polychaete species recorded in a study of the macrofauna on the continental shelf of Crete in 1988 (Karakassis 1997)

Ampharete acutifrons	*Euclymene palermitana*	*Notomastus sp*
Aricidea catherinae	*Glycera capitata*	*Phthisica marina*
Aricidea catherinae	*Glycera rouxii*	*Pista cristata*
Asychis biceps	*Hyalinococia bilineata*	*Poecilochaetus serpens*
Chloeia venusta	*Hyalinoceia brementi*	*Prionospio steenstrupi*
Chone duneri	*Lumbrineris emandibulata*	*Pseudoleiocapitella fauveli*
Chrysopetallum debilis	*Lumbrineris gracilis*	*Pseydopolydora antenata*
Cirratulus filiformis	*Lumbrineris nonatoi*	*Rhodine loveni*
Cirrophorus fucatus	*lumbrines gracilis*	*Sarsonuphis sp*
Cirrophorus lyra	*Magelona minuta*	*Siophanes bombyx*
Cossura soyeri	*Melinna palmata*	*Tachytrypane jefreysii*
Ditrupa arietina	*Micronephtys maryae*	*Tauberia gracilis*
Ehlersia cornuta	*Myriochele heeri*	*Terebellides stroemi*
Euchone rosea	*Myriochele heeri*	*Tharyx heterochaeta*
Euclymene oerstedii	*Notomastus latericeus*	*Tharyx marioni*

Another study of benthic communities from 1994–1995 took samples in the southern part of the Cretan Sea, between 40–1,570 m depths (Tselepides 2000). 181 polychaete species were identified; the most dominant species in the samples were *Filogranula stellata*, *Galathowenia oculata*, *Levinsenia gracilis, Lumberineris graacilis*, *Magelona minuta*, *Melinna palmata*, *Paradioptra* sp., *Pholoides dorsipapillatus*, *Prionospio steenstrupi*, *Serpula* sp. and *Tharyx heterochaeta*.

2.3.4.3 Other benthic organisms

A study of macrofauna on the continental shelf (at 40–190 m depths) of Crete in 1988 identified 12 sipunculid, 23 echinoderm and 165 crustacean species (Karakassis 1997); the most dominant species (of each group) in the samples are shown in Table 2-14.

Table 2-14: The most dominant sipunculid, echinoderm and crustacean species recorded in a study of the macrofauna on the continental shelf of Crete in 1988 (Karakassis 1997)

Sipunculids	**Echinoderms**
Aspidosiphon kovalevski	*Amphioura filiformis*
Golfingia murina	**Crustacea**
Golfingia procera	*Ampelisca typica*
Nephasoma sp	Mysidacea
Onchenoesoma stenstrupi	*Eurydice truncata*
Sipuncula sp. 3	

A study of benthic communities from 1994–1995 took samples in the southern part of the Cretan Sea, between 40–1,570 m depths (Tselepides 2000). 8 sipunculid-, 17 echinoderm- and 115 crustacean species were identified. The most dominant group was the sipunculids, and the most dominant species were *Aspidosiphon muelleri*, *Golfingia* sp. 2, *Onchnesoma steenstrupi* and *Phascolion strombi*.

2.3.4.4 Sponges

Commercial sponges are a natural resource for most of the Mediterranean countries. The Mediterranean commercial sponges are (common English names):

- *Hippospongia communis* (honeycomb),
- *Spongia agaricina* (elephants ear),
- *Spongia zimocca* (leather sponge),
- *Spongia officinalis adriatica* (Greek bathing sponge)
- *Spongia officinalis mollissima* (Turkey cap, fine sponge of Syrie)

A survey was performed in 1994 along the coast of the islands in the central and southern Aegean Sea (Castritsi-Catharios et al. 2011). The honeycomb, Greek bathing sponge and Turkey cap were found at the stations on the northeastern coast of Crete (Sitia) (sampling depths between 12–38 m).

2.3.4.1 Seagrasses/Macroalgae

Seagrass ecosystems are among the most productive and economically valuable on Earth, and are found along the coasts of every continent except Antarctica. 5 species of seagrasses are found in the Mediterranean (*Cymodeca nodosa, Halophila stipulacea, Posidonia oceanica, Zostera marina and Zostera noltii*), which can form vast meadows at a depth of 0–50 m. Amongst these species, *P. oceanica*, a species endemic to the Mediterranean, plays a key role, often compared to that of the forests. The *Posidonia* meadows provide important ecological functions and services and harbour a highly diverse community, with some species of economic interest. *P. oceanica* meadows are identified as a priority habitat type for conservation under the Habitats Directive (Dir 92/43/CEE).

In the Aegean Sea, seagrasses are known to occupy an important area, but only a few sites have actually been mapped: Gulf of Geras, Lesvos Island, Saronikos Gulf, Gulf of Thermaikos and Palaeochori Bay (Aliani et al. 1998), Kos, Sikinos, Milos and Pholegandros (Green and Short 2003). *Posidonia* beds also occur to the west of Sidero Peninsula on the northeastern end of Crete. Common bottle-nosed dolphins and Mediterranean monk seals have been recorded in the area (Fric et al. 2012).

Table 2-15: Molluscan species with minor commercial interest in the Hellenic Seas that are under protection according to the Bern Convention, the Protocol of the Barcelona Convention and for some, the Presidential Decree 67/1981 (Katsenevakis 2008)

GASTROPODA	
Erosaria spurca	Reported in the Saronikos,Evvoikos, Messiniakos and Korinthiakos gulfs, the Kyklades, the Dodekanisos, Kriti, Rodos, Samos, and the north Aegean. Under **strict protection** according to the Bern Convention (Annex II), the Protocol of the Barcelona Convention (Annex II), and the Presidential Decree 67/1981.
Luria lurida	Reported in the Saronikos, Evvoikos, Pagasitikos, Lakonikos, and Korinthiakos gulfs, the Kyklades, the Dodekanissa, Kriti, the north Aegean, and the Ionian Sea. Under **strict protection** according to the Bern Convention (Annex II), the Protocol of the Barcelona Convention (Annex II), and the Presidential Decree 67/1981.
Zonaria pyrum	Reported in the Evvoikos Gulf, along the Peloponnisos coasts, the Kyklades, the Dodekanisos, Samos, the north Aegean, Kriti, and the Ionian Sea. Under **strict protection** according to the Bern Convention (Annex II), the Protocol of the Barcelona Convention (Annex II), and the Presidential Decree 67/1981.
Tonna galea	Wide distribution in Hellenic Seas and has been recorded in the Saronikos, Korinthiakos, and Evvoikos gulfs, the north Aegean Sea (sotheast Thermaikos Gulf, Chalkidiki – southeast Toronaios Gulf), the Kyklades, the Ionian Sea and the Cretan Sea. It is a **protected species** according to Annex II of the Bern Convention, the Protocol of the Barcelona Convention (Annex II), and the Presidential Decree 67/1981
Ranella olearium	Reported around the Sporades Islands, in the Evvoikos, on the Kymi coasts, and Chalkidiki. The species is **strictly protected** according to the Bern Convention (Annex II) and the Protocol of the Barcelona Convention (Annex II).
Charonia lampas	Reported in the north Aegean Sea and the coasts of the Peloponnisos, Samos, and Kriti. In the Mediterranean, both *C. lampas* and *C. variegata* have been **declared as endangered species** and are strictly protected according to the Bern Convention (Annex II) and the Protocol of the Barcelona Convention (Annex II).

Mitra zonata	Reported in the Saronikos and Evvoikos gulfs, Chalkidiki, Kymi (Evvoia), the Ionian Sea, and north Sporades Islands. In the Mediterranean, *both C. lampas* and *C. variegata* have been **declared as endangered** species and are strictly protected according to the Bern Convention (Annex II) and the Protocol of the Barcelona Convention (Annex II).
BIVALVIA	
Lithophaga lithophaga	Found in the Evvoikos Gulf, the Ionian islands, the Ipeiros coast, the Korinthiakos Gulf, the Sea of Kythira, the north Sporades Islands, the Dodekanisos, Kriti, Lesvos island. Maliakos, Argolikos and Chalkidiki. The species **is under strict protection** according to the 92/43/EC Directive (Annex IV), the Bern Convention (Annex II), and the Protocol of the Barcelona Convention (Annex II).
Pinna nobilis	Has become rare in many parts of the Mediterranean. Important local populations still exist in Hellenic Seas, especially in the Korinthiakos, Evvoikos, and Thermaikos gulfs, the islands of Chios and Lesvos (northeast Aegean), northwest Kriti, north Karpathos, as well as the Ionian Sea. The species **is under strict protection** according to the 92/43/EC Directive (Annex IV), the Protocol of the Barcelona Convention (Annex II), and the Presidential Decree 67/1981.
Pholas dactylus	Reported in the Thermaikos, Kalloni, Maliakos, Evvoikos, Saronikos, Amvrakikos, and Argolikos gulfs, on the Ionian coasts of the Peloponnisos, and Kefallonia. The species is **under strict protection** according to the Bern Convention (Annex II), and the Protocol of the Barcelona Convention (Annex II).

A survey of the marine macroalga of Karpathos Island (maximum 20 m depth) carried out in 2006, identified 202 taxa (136 *Rhodophyta*, 42 *Ocrophyta* and 24 *Chlorophyta*) 19 of which were new to Greece (Catra and Giardina 2009)

An updated checklist of the brown (*Phaeophyceae*), and green (*Ulvophyceae*) seaweeds of Greece, identified 90 taxa *Phaeophycea* and 80 taxa *Ulvophycea* in the south Aegean Sea (Tsiamis 2013, 2014). The checklist is based both on literature records and new collections.

2.3.4.2 Endangered/protected benthic species

A review of species with minor commercial interest in the Hellenic Seas, listed 41 species of molluscs (18 gastropods, 13 bivalves, and 10 cephalopods) (Katsenevakis 2008) and itshows the molluscan species that were recorded, that are under protection according to the Bern Convention, the Protocol of the Barcelona Convention and for some, the Presidential Decree 67/1981.

2.3.4.3 Benthic alien species

A total of 955 alien species are known in the Mediterranean and the vast majority of them were reported from the eastern Mediterranean (718 species), less from the western Mediterranean (328), central Mediterranean (267) and Adriatic Seas (171). Of these, 535 species (56%) have become established in at least one area (Zenetos et al. 2010). Alien species of Atlantic Ocean origin, as well as numerous species from the Indo-Pacific Ocean, have been introduced into the Mediterranean Sea (Golani et al. 2006).

Macrophytes. A list of exotic species in the Mediterranean (a survey of recent marine "immigrants" in the Mediterranean, which is undergoing drastic and rapid changes to its biota) lists a total of 110 species of exotic macrophytes in the Mediterranean Sea (CIESM 2014). 14 species are found in the south/south-east Aegean Sea (Table 2-16). A survey in Karpathos Island in 2012 identified 2 invasive macroalgae species (Thessalou-Legaki et al. 2012): *Ganonema farinosum (redalgae)* and *Caulerpa racemosa var. cylindracea (greenalgae).*

Crustaceans. The dominant group among alien species in the Mediterranean is molluscs (215 species). The second most dominant group is crustaceans (159 species), and among them decapods is the prevalent group (Zenetos et al., 2012). The Aegean Sea hosts 27 alien decapod (9 *Dendrobranchiata*, 1 *Caridea* and 17 *Brachyura*) crustaceans (21 Indo-Pacific, 6 Atlantic species) (Kapiris et al. 2012). A total of 27 decapods were found on the coasts of the Aegean Sea (Table 2-17) (Kapiris et al. 2012). In 2010 a total of 119 alien crustaceans had been reported in the eastern Mediterranean and 58 species belong to decapod crustaceans (Zenetos et al. 2010). Most of the alien decapods crustaceans observed in the Greek waters of the Aegean Sea have been encountered only in the south-eastern part of this sea (Dodecanese islands) and their occurrence decreasing substantially northwards and westwards (e.g. Corsini-Foca et al. 2010).

Table 2-16: Exotic macrophytes in the south/southeast Aegean Sea (CIESM 2014). M = Mediterranean, A= Atlantic, IP=Indo-Pacific, E=Established, H=High (introduction with no doubt), M=Medium (introduction likely), D=Debatable (open to question)

Taxon	Region of intro	Origin	Status	Degree
PLANTAE, RHODOPHYTTA				
Acanthophora nayadiformis (Delile) Papenfuss	M	IP	E	D
Asparagopsis armata Harvey	M, A	IP	E	H
Chondria coerulescens (J. Agardh) Falkenberg	M	A	E	M
Ganonema farinosum (J.V. Lamouroux) K.C. Fan & Y.C. Wang	M	IP	E	D
Lophocladia lallemandii (Montagne) F. Schmitz	M	IP	E	H
Polysiphonia atlantica Kapraun & J.N. Norris	M	A	E	D
Polysiphonia fucoides (Hudson) Greville	M	A	E	D
Womersleyella setacea (Hollenberg)	M	IP	E	H
STRAMENOPILES, CHROMOBIONTA				
Stypopodium schimperi (Buchinger *ex* Kützing) Verlaque & Boudouresque	M	IP	E	H
PLANTAE, CHLOROBIONTA				
Caulerpa racemosa var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque	M, A	IP	E	H
Caulerpa racemosa var. *lamourouxii* f. *requienii* (Montagne) Weber-van Bosse	M	IP	E	H
Codium fragile (Suringar) Hariot subsp. *fragile*	M, A	IP	E	H
Ulva fasciata Delile	M	IP	E	D

PLANTAE, STREPTOBIONTA				
Halophila stipulacea (Forsskal) Ascherson	M	IP	E	H

Molluscs. A list of exotic species in the Mediterranean (a survey of recent marine "immigrants" in the Mediterranean, which is undergoing drastic and rapid changes to its biota) lists a total of 137 species of exotic molluscs in the Mediterranean Sea (CIESM 2014). 5 species are found in the south/southeast Aegean Sea (Table 2-18).

Table 2-17: Alien decapods found on the Greek and the Turkish coasts of the Aegean Sea (Kapiris et al. 2012)

Species	Establishment success
Marsupenaeus japonicus (Bate, 1888)	established
Melicertus hathor (Burkenroad, 1959)	established
Metapenaeopsis aegyptia (Galil & Golani, 1990)	established
Metapenaeopsis mogiensis consobrina (Nobili, 1904)	established
Metapenaeus affinis (H. Milne Edwards, 1837)	established
Trachysalambria curvirostris (Steinitz, 1932)	established
Alpheus rapacida (De Man, 1908)	established
Leptochela pugnax (De Man, 1916)	established
Processa macrodactyla (Holthuis, 1952)	established
Synalpheus tumidomanus africanus (Crosnier & Forest, 1965)	cryptogenic
Atergatis roseus (Ruppell, 1830)	established
Calappa pelii (Herklots, 1851)	casual
Callinectes sapidus (Rathbun, 1896)	established
Carupa tenuipes (Dana, 1851)	established
Charybdis helleri (A. Milne-Edwards, 1867)	established

Charybdis longicollis (Leene, 1938)	established
Gonioinfradens paucidentatus (A. Milne Edwards, 1861)	casual
Ixa monodi (Holthyis & Gottlieb, 1956)	established
Coelusia signata (Paulson, 1875)	casual
Macrophthalmus graeffei (A. Milne Edwards, 1873)	casual
Micippa thalia (Herbst, 1803)	established
Myra subgranulata (Kossmann, 1877)	casual
Percnon gibbesi (A. Milne Edwards, 1853)	established
Pilumnus minutus (De Haan, 1835)	casual
Portunus segnis (Forskal, 1775)	casual
Sirpus monodi (Gordon, 1953)	established
Thalamita poissonii (Audouin, 1826)	cryptogenic

Table 2-18: Exotic molluscs in the South Aegean Sea (CIESM 2014). AS = Arabian Sea, RS = Red Sea, IP=Indo-Pacific, PG = Persian Gulf, E=Established, A = Alien (considered non-established)

Taxon	Origin	Status
Nerita sanguinolenta Menke, 1829	RS	A
Strombus persicus Swainson, 1821	PG, AS	E
Cylichnina girardi Audouin, 1826	IP	E
Pinctada radiata Leach, 1814	IP, RS	E
Malvufundus regulus Forsskål, 1775	IP, RS	E

A review of species with minor commercial interest in the Hellenic Seas, listed 41 species of molluscs (18 gastropods, 13 bivalves, and 10 cephalopods) (Katsenevakis 2008). Table 2-19 shows the molluscan species that were recorded, that are listed as invasive species.

Table 2-19: Introduced molluscan species with minor commercial interest in the Hellenic Seas (Katsenevakis 2008)

GASTROPODA	
Strombus persicus	Has become locally invasive in the south-eastern Mediterranean. In Greece, it has been established in Rodos, the south Peloponnisos coasts, Kriti, the Kyklades, the Argolikos, Evvoikos, and Saronikos gulfs. It is a successful **invader** in the Mediterranean Sea and its spatial distribution keeps increasing
BIVALVIA	
Pinctada radiata	Mostly reported close to areas where it was originally introduced for aquaculture (mainly in the Dodekanisos islands, Argolikos, the Saronikos, Evvoia, and the island of Lesvos in the N Aegean Sea). Recently, the species was also recorded in the Kyklades Isles complex (in 2006) and in Kriti (in 2003). It is a **successful invader** into the Mediterranean Sea and its spatial distribution keeps increasing
Donacilla cornea	Very abundant in the north Aegean and is also found in the Evvoikos, Saronikos, Lakonikos, Amvrakikos, and Patraikos gulfs, the Kyklades, the Ionian and the Cretan Seas. It is classified as **one of the Worst Invasive Species in Europe** (EEA, 2007)

2.3.5 SEABIRDS

2.3.5.1 Species composition and distribution

Seabirds represent only 3% of the world's bird species. There are about 359 species of birds in Crete, of which 11 are globally threatened and 2 are introduced (Avibase 2014).

Although costal and marine habitat variety in Greece is high, seabird abundance and diversity is generally lower than expected. Of the 334 species of seabird occurring worldwide, 39 have been recorded here, of which only 12 breed, some occurring on the edge of their breeding range (Fric et al. 2012). Of the 39 seabirds recorded in Greece, 20 are present on the Crete bird checklist (Table 2-20; Avibase 2014).

2.3.5.2 Endangered seabird species

According to the Greek Red Data Book (Handrinos and Kastritis 2009) the red-breasted merganser

(*Mergus merganser*) is classified as "critically endangered", the Mediterranean gull (*Larus melanocephalus*), and black tern (*Chlidonias niger*) as "endangered", while the Audouin's gull (*Larus audouinii*), slender-billed gull (*Larus genei*), gull-billed tern (*Sterna nilotica*) and sandwich tern (*Sterna sanvicensis*) as "vulnerable", and the European shag (*Phalacrocorax aristotelis*), Cory's shearwater (*Calonectris diomedea*) and little tern (*Sternula albifrons*) as "near threatened".

On an international level in the IUCN Red Data List (IUCN 2012), the velvet scoter (*Melanitta fusca*) is classified as "endangered", the Yelkouan shearwater (*Puffinus yelkouan*) and long-tailed duck (*Clangula hyemalis*) are classified as "vulnerable", and the Audouin's gull as "near threatened".

Important bird areas (IBAs) are priority sites for the conservation of biodiversity and especially birds, often irreplaceable or vulnerable, as they may host on a regular basis significant populations of one or more endangered, endemic or congregatory species (Fric et al. 2012). There are 54 marine IBAs in Greece (Figure 2-31), BirdLife International 2014).

Table 2-20: Seabirds recorded in Greece (Fric et al. 2012). Birds Checklist – Crete follows Clements 6th edition (updated 2013) (Avibase 2014)

Scientific name	Common name	Bird Checklist - Crete	IUCN Red list categories (2012)	Greek Red data book after Handrinos & Kastritis 2009
Aythyra marila	Greater scaup			
Somateria mollissima	Common eider			
Melanitta nigra	Common scoter			
Melanitta fusca	Velvet scoter		Endangered	
Clangula hyemalis	Long-tailed duck		Vulnerable	
Bucephala clangula	Common goldeneye			
Mergus serrator	Goosander	Yes		
Mergus merganser	Red-breasted merganeres	Yes		Critically endangered
Gavia stellata	Red-thorated loon	Rare/Accidental		
Gavia arctica	Arctic loon	Rare/Accidental		
Calonectris diomedea	Cory's shearwater	Yes		
Puffinus yelkouan	Yelkouan shearwater	Vulnerable	Vulnerable	Near threatened
Hydrobates pelagicus	European storm-petrel	Rare/Accidental		Data deficient
Podiceps grisegena	Red-necked grebe	Yes		
Podiceps cristatus	Great crested grebe	Yes		
Podiceps auritus	Horned grebe			
Podiceps nigricollis	Black-necked grebe	Yes		
Morus bassanus	Northern gannet			
Phalacrocorax carbo	Great cormorant	Yes		
Phalacrocarax aristotelis	European shag	Yes		Near threatened
Phalaropus lobatus	Red-necked phalarope	Yes		
Larus canus	Mew gull	Yes		
Larus audouinii	Audouin's gull		Near threatened	Vulnerable
Larus marinus	Great black-backed gull			
Larus argentatus	Herring gull	Rare/Accidental		
Larus michahellis	Yellow-legged gull	Yes		
Larus fuscus	Lesser black-backed gull	Yes		
Larus ridibundus	Black-headed gull			
Larus genei	Slender-billed gull			Vulnerable
Larus melanocephalus	Mediterranean gull			Endangered
Larus minutus	Little gull			
Rissa tridactula	Black-legged kittiwake			
Sterna nilotica	Gull-billed tern			Vulnerable
Sterna caspia	Caspian tern			
Sterna sandvicensis	Sandwich tern			Vulnerable
Sterna hirundo	Common tern	Yes		
Sternula albifrons	Little tern	Yes		Near threatened
Chlidonias niger	Black tern			Endangered
Stercorarius parasiticus	Parasitic jaeger	Yes		

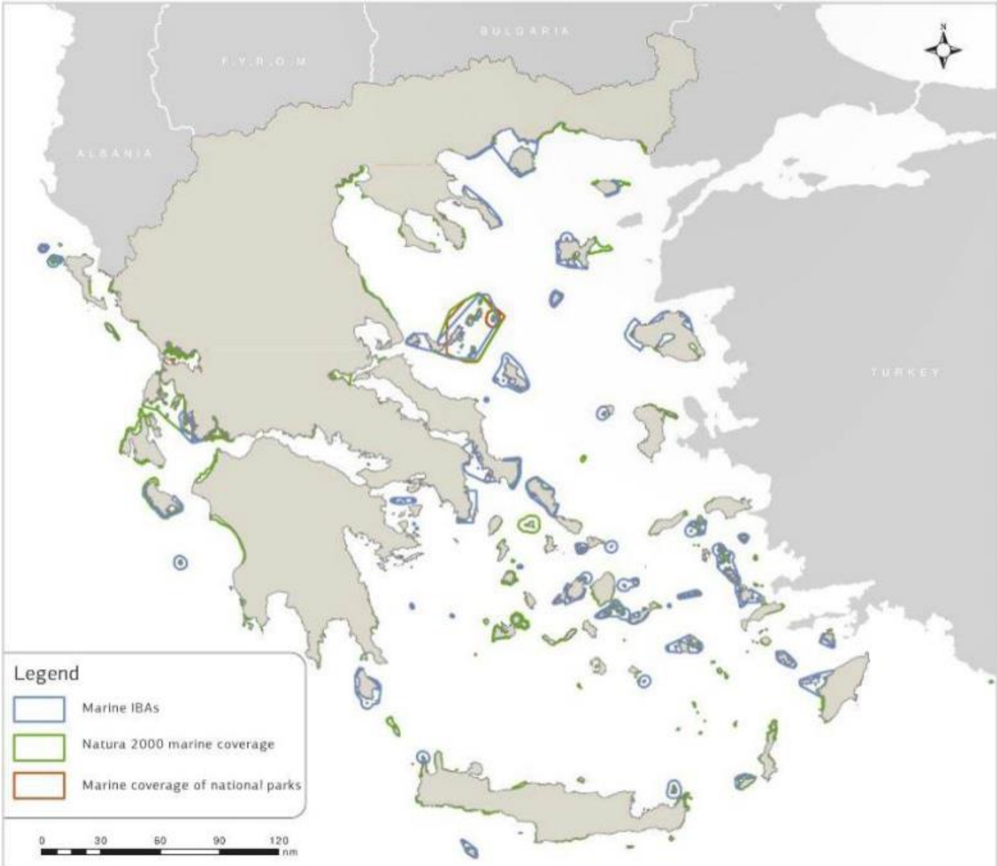


Figure 2-31: Marine IBAs in Greece, in relation to existing marine protected areas (Fric et al. 2012)

The ornithological importance in two marine IBAs, Dionysades islets and Kasos Island, in the Cretan Sea will briefly be presented under.

<u>Dionysades islets, Crete (Figure 2-32, left):</u>

Cory's shearwaters form on Dionysades one of the largest breeding populations of the species in the Aegean Sea. The colony comprises the southeastern limit of the species range. Adjacent marine waters include shearwater foraging, resting and rafting areas. Dionysades also host small breeding populations of the Yelkouan shearwater, Audouin's gull and the Yellow-legged gull (Fric et al. 2012).

Predation of eggs and chicks by rats is the main threat for seabirds on the islets. Illegal hunting also causes problems to breeding birds. A proposed wind farm on Dragonada and Gianisda poses a serious threat to the local Cory's shearwater population as well as other important bird species on the islets, such as the Eleonora's Falcon (Fric et al. 2012).

<u>Kasos Island and surrounding islets (Figure 2-32, right):</u>

The second largest Audouin's Gull breeding population in the southern Dodecanese occurs here. The species main foraging areas include shallow coastal waters surrounding the islets. The Mediterranean shag is resident in the area throughout the year. Mixes flocks of Cory's and Yelkouan shearwaters have been recorded foraging here, particularly in the shallow waters surrounding Kasos and the strait between Kasos and Karpathos (Fric et al. 2012).

The area is threatened by a planned wind farm in the marine area between Kasos and Kasonisia, and also north of Makronisi islet. Area overlaps with the greatest part of the shallow waters where seabirds forage, mainly Audouin's gull and Mediterranean shag. Kasos is renowned for its fishing grounds and the beaches of Armathia is also an important tourist attraction (Fric et al. 2012).

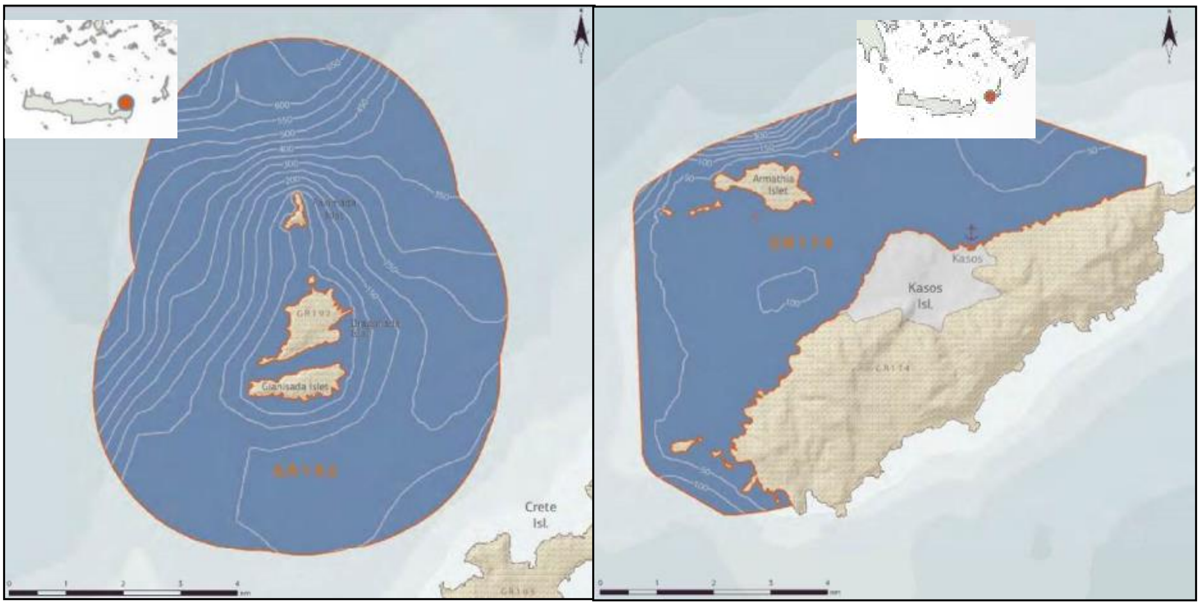


Figure 2-32: Marine IBAs near Crete (dark blue areas) Left: Dionysades islets, Crete. Right: Kasos Island and surrounding islets (Fric et al. 2012)

2.3.5.1 Seabirds – migration

Bird migration is a natural process, whereby different birds can fly over distances of hundreds and thousands of kilometres in order to find the best ecological conditions and habitats for feeding, breeding and raising their young (Figure 2-33). There are many different migration patterns. The majority of birds migrate from northern breeding areas in the summer, to southern wintering grounds (Figure 2-34). Some birds breed in southern parts of Africa and migrate to northern wintering grounds, or horizontally, to enjoy the milder coastal climates in winter. Other birds migrate in terms of altitude, moving higher up a mountain in summer, and residing on lowlands during the winter months.

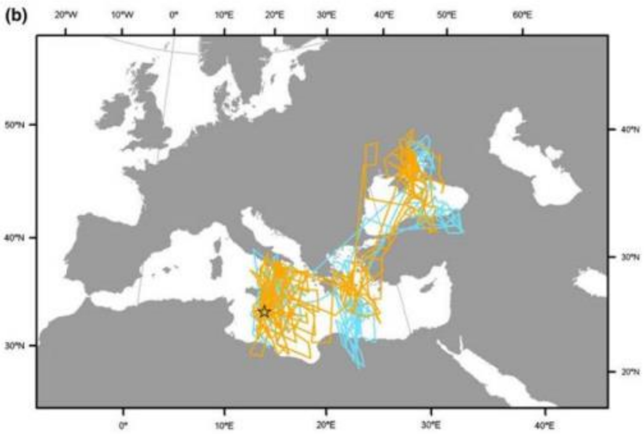


Figure 2-33: Migration track of a Yelkouan Shearwater tracked in 2008–2009 (blue track) and 2009–2010 (orange track) (Raine et al. 2012)

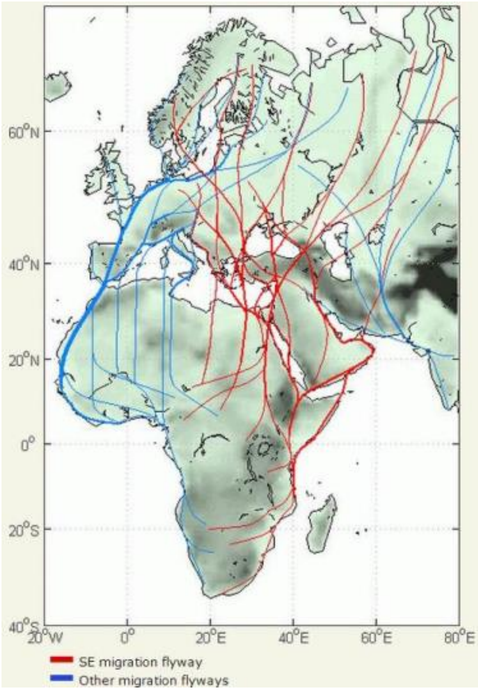


Figure 2-34: Migration flyways of Western Palearctic Passerines (SE European Bird Migration Network 2012)

Migration is a perilous journey and involves a wide range of threats. Only a small number of birds are actually threatened by natural events. Human activities are the source for most dangers migrating birds are exposed to, e.g. fisheries by-catch, illegal hunting, human disturbance (e.g. power lines, wind turbines), light and noise pollution and habitat destruction.

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3 EXISTING ENVIRONMENT LIUQIU ISLAND, TAIWAN (EXTENDED VERSION)

3.1 OVERVIEW

In this section, each of the factors that require consideration in any site selection decision for a TROPOS platform design will be introduced. A number of parameters will be relevant to any combination of TEAL components, such as bathymetry and sea-bed geology. For each TEAL component, there will be a range of more specifically relevant parameters to analyse. These will be presented in terms of their relative importance in a site-selection decision. Where the information on these parameters is available, it is shown here for each of the target regions. Figure 3-1 shows the case study site – Liuqiu Island, Taiwan.

Figure 3-1: Study area – Liuqiu island in Taiwan

3.2 PHYSICAL ENVIRONMENT

3.2.1 INTRODUCTION

Situated south of the mouth of Kaoping River, Liuqiu is governed by Pingtung County, and about 18 nautical miles south-southwest of Kaohsiung City, the second large city of Taiwan. Liuqiu is made of coral and covered with limestone, and the coral substances can be easily found in the island. The coral with limestone on Liuqiu is similar to that of Fengsan. The soil on the four terraces of the island look red due to plenty of the remains of iron oxide and silicon oxide after being weathered for a long period of time. Therefore, the land is dry and infertile and not suitable for planting.

As most of the islanders make their living by fishing, Liuqiu is characterised by various goods of local fish specialties and a lifestyle of fishing village. The ground inclines gently towards northeast. The area of the whole island is about 6.8 square kilometers with 4 kilometers long from north to south, and 2 kilometers wide from east to west.

Figure 3-2: Liuqiu Island

3.2.1 CLIMATE AND ATMOSPHERE

Climate

Liuqiu's climate is dry and warm. Its highest average temperature is 28.4°C in July and lowest average temperature is 19.5°C in January. The rainfall is about 1,000 mm in 2012. The maximum monthly rainfall is 548 mm in August and the minimum average monthly rainfall is 0 mm in January. In typhoon season during summer and fall, Liuqiu undergoes the highest frequency of being hit by typhoons in all of Taiwan's islands. Therefore, the islander takes the threat of typhoon, such as strong winds and huge waves, into consideration before constructing buildings and facilities.

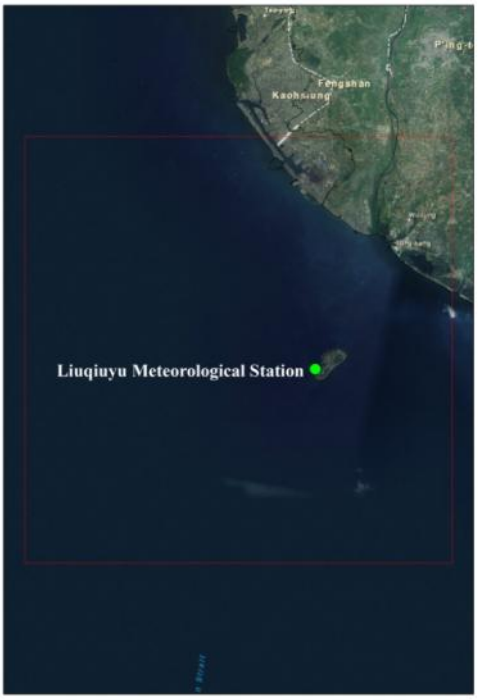


Figure 3-3: Liuqiuyu Meteorological Station (C0R27)

Longitude: 120.354194

Latitude: 22.334025

Altitude: 51 m

Location: The sea area of Kaohsiung and Fangliao

Organisation: Central Weather Bureau

Property: Automatic Weather Stations

Monitoring items: Pressure, Temperature, Precipitation, Wind, Sunshine

Table 3-1: Mean Station Pressure at Liuqiuyu Meteorological Station; Unit: hpa; Year: 2012

Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
C0R270	1008.7	1007.2	1006.3	1003.9	999.9	995.4	996.6	993.5	1001.3	1004.5	1006.6	1008.1	1002.7

Table 3-2: Mean Temperature at Liuqiuyu Meteorological Station; Unit: ℃; Year: 2012

Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
C0R270	19.5	20.6	23.7	25.8	27	27.6	28.4	27.3	28	26	24.5	21.3	25

Table 3-3: Precipitation at Liuqiuyu Meteorological Station; Unit: mm; Year: 2012

Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
C0R270	-	50.5	11	195	27.5	*2.0	64	548	20	10	40	14.5	*982.5

*: Statistics are based on incomplete data; - : None

Table 3-4: Number of Days with Precipitation at Liuqiuyu Meteorological Station; Unit: day; Year: 2012

Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
C0R270	-	6	4	11	*3	*2	12	20	4	2	1	4	*69

*: Statistics are based on incomplete data; - : None

Table 3-5: Maximum Precipitation in One Day at Liuqiuyu Meteorological Station; Unit: mm; Year: 2012

Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
C0R270	-	22.5	6.5	78	*18.5	*1.5	16	162.5	9.5	9.5	40	10.5	*162.5
		21	12	21	4	28	15	9	25	8	17	5	Aug,09

*: Statistics are based on incomplete data; - : None

Table 3-6: Mean Wind Speed and Prevailing Wind Direction at Liuqiuyu Meteorological Station; Unit: m/sec; Year: 2012

Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
C0R270	1.5	1.8	1.7	1.3	1.1	2.4	1.5	1.8	0.8	0.8	0.8	1.3	*162.5
	340	330	340	130	290	140	140	130	290	280	310	340	Aug,09

*: Statistics are based on incomplete data

Table 3-7: Sunshine Duration at Liuqiuyu Meteorological Station; Unit: hours; Year: 2012

Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
C0R270	203	190.2	242.1	203	226	162.5	241	155.4	96.7	239.4	202.9	183.7	2345.9

Reference: Climatological data annual report 2012 Part I –surface data, Central Weather Bureau.

The use of sun as an energy source need to consider the following issues: 1) how to sell the solar energy and transfer into the grid system, and 2) how to self-consumption the solar energy on site. For the first issue, to commercialise the solar energy need a minimum of 1,900 kWh/m^2 of GHI for the economic viability of a PV plant. For the issue for self-consumption, there is no minimum requirement for its viability. It depends on the cost of the alternative energy source (wind, onshore grid connection, diesel generator, etc.). A more detailed analysis may need in the case of Taiwan.

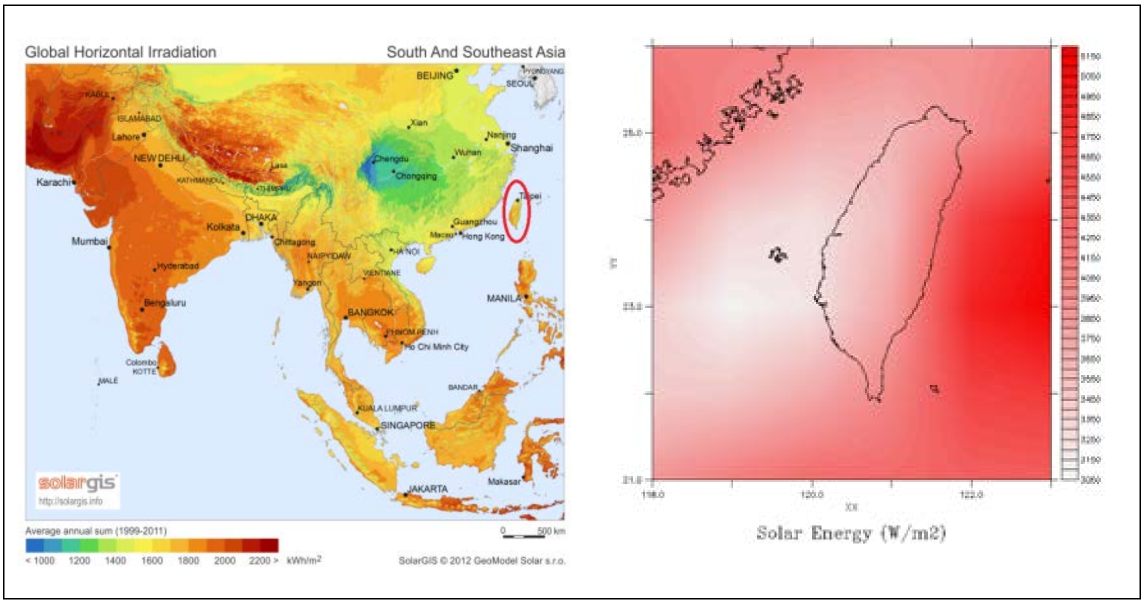


Figure 3-4: Solar of Taiwan (source: SOLARGIS 2014)

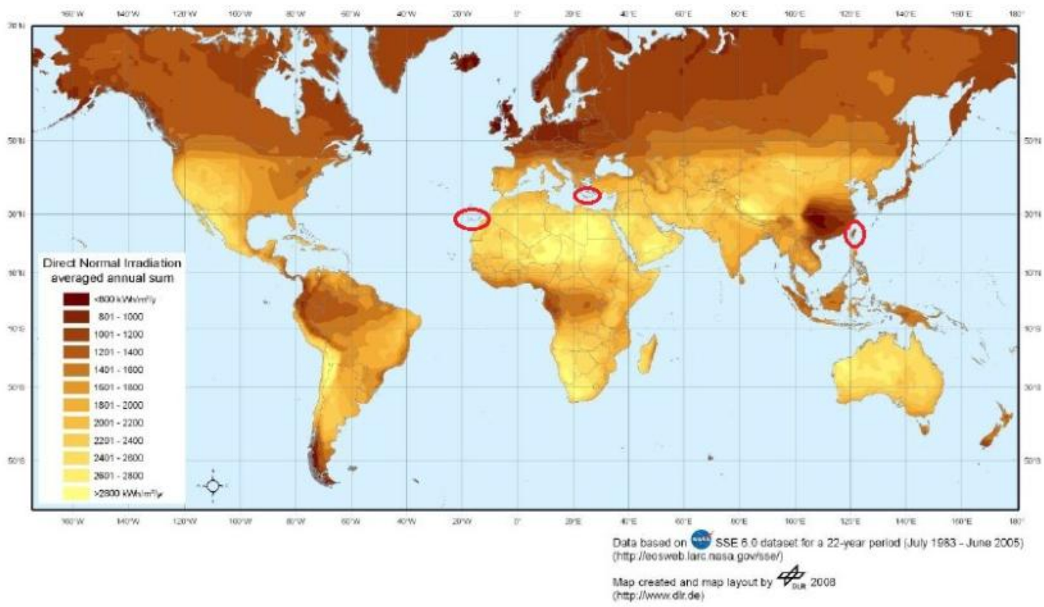


Figure 3-5: Global DNI

Atmosphere

There is no atmosphere monitoring station in Liuqiu island. According to the environmental quality monitoring survey via ship of Itu Aba Island in the Spratly Islands with the assistance of the Executive Yuan Coast Guard Administration, data is collected in the nearest sampling point, which includes VOC (volatile organic compounds), CO_2 (carbon dioxide) and atmospheric mercury.

Figure 3-6: Air Quality Monitoring

Longitude: 120.054217

Latitude: 22.360700

Organisation: Environmental Protection Administration, Executive Yuan

Property: Manual monitoring

Monitoring items: VOC, CO_2

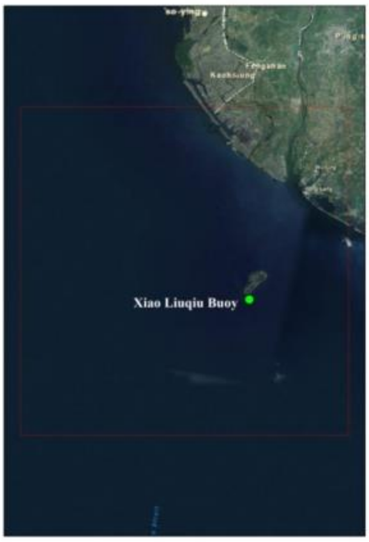
Table 3-8: Air quality sampling near with Liuqiuyu; Year: 2012 (Date: 06/06; Time: 19:31; Humidity: 82.6%; Temperature: 28.4℃; Pressure: 1,005 mbar)

No.	VOC (Unit: ppbv), CO_2 (Unit: ppmv)								
	Propane	Propylene	Hexane	Isoprene	Benzene	Toluene	Ethylbenzene	M, p-xylene	CO_2
9	0.033	0.060	0.006	0.008	0.045	0.020	0.005	0.015	385.9

Reference: EPA 2014

3.2.2 OCEANOGRAPHIC CONDITIONS

The ocean observation data is collected in 2011 and the information includes wind, wave, air pressure, air temperature, sea temperature.



Longitude: 120.362778

Latitude: 22.315278

Location: HaiTzuKuo fishing port in Liuqiu island off the coast about two kilometers, the water depth of about 78 meters.

Organisation: Central Weather Bureau

Property: Automatic Sea Weather Stations

Monitoring items: Wind, Wave, Air Pressure, Air Temperature, Sea Temperature

(Reference: Data buoy observation data annual report 2011, Central Weather Bureau)

Figure 3-7: Xiao Liuqiu Buoy (46714D)

3.2.2.1 Wind

In general, the average wind level needed is above 3 Bft to produce energy. In Liuqiu island, there is not enough wind power through the whole year.

Figure 3-8: Wind distribution around Liuqiu island in 2011

Table 3-9: Monthly Wind Statistics at Xiao Liuqiu Buoy; Year: 2011(Unit: m/s; Orientation: sixteen; Scale: beaufort; Altitude: 2 m)

Month	Number of observations	Average wind speed	average wind levels	Maximum of wind direction	Maximum mean wind			Maximum instant wind speed	
					Wind speed	Wind levels	Wind direction	Wind speed	Wind levels
Jan	744	3.6	3	NNW	8.3	5	NNW	11.2	6
Feb	672	3.6	3	NNW	8.3	5	NNW	10.7	5
Mar	728	3.2	2	NW	10.2	5	SE	13.2	6
Apr									
May	744	3.1	2	NW	10.0	5	NW	13.5	6
Jun	720	4.8	3	SSE	10.5	5	SE	13.7	6
Jul	744	3.8	3	SSE	11.2	6	SE	13.8	6
Aug	642	4.1	3	SSE	14.0	7	WSW	17.9	8
Sep	712	3.0	2	SE	12.7	6	SE	15.6	7
Oct	744	2.6	2	NW	8.3	5	SE	10.1	5
Nov	720	3.1	2	NNW	8.4	5	ESE	10.5	5
Dec	744	3.3	2	NNW	8.7	5	NNW	11.6	6
Annual	7914	3.5	3	NNW	14.0	7	WSW	17.9	8

Blank means no observed or equipment failure.

3.2.2.2 Wave

In general, the average wave high is above 2 m and average period is about 4 to 8 seconds to produce energy. In Liuqiu island, there exists enough wave power only for five months through the whole year.

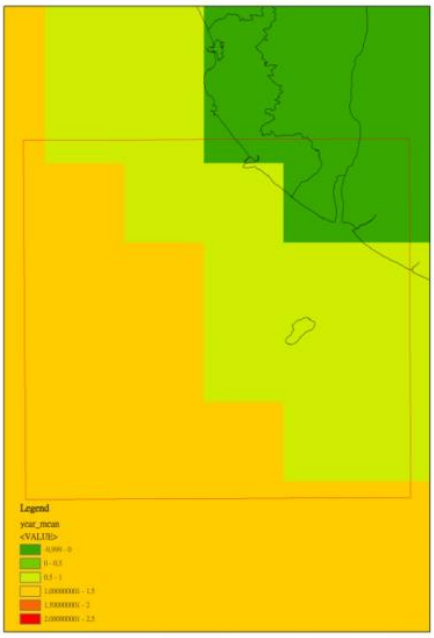


Figure 3-9: Average wave high around Liuqiu island in 2011

Table 3-10: Monthly Wave Statistics at Xiao Liuqiu Buoy; Year: 2011 (Unit: m; Wave level: - Wavelet, S Small waves, M Meddle waves, L Large waves above; Period: second(s); Wave Direction: North is 0, clockwise increases degrees)

Month	No of observations	maximum of wave (8 orientations)	maximum daily average wave height		average wave height	average period	wave height distribution			
							Less than 0.6 m	0.6 m ~ 1.5 m	1.5 m ~ 2.5 m	Higher than 2.5 m
Jan	744	W	1.24	S	0.88	5.5	7%	92%	1%	0%
Feb	672	S	0.87	S	0.55	4.9	67%	33%	0%	0%
Mar	728	SE	1.06	S	0.75	5.1	21%	79%	0%	0%
Apr										
May	728	SE	0.83	S	0.47	4.7	81%	19%	0%	0%
Jun	698	SW	2.30	M	1.16	5.4	25%	45%	26%	3%
Jul	737	SW	2.51	L	1.21	5.6	23%	46%	26%	4%
Aug	606	SW	4.39	L	0.91	5.5	31%	57%	11%	1%

Sep	709	SW	4.01	L	1.00	5.6	37%	47%	8%	7%
Oct	743	W	1.37	S	0.76	4.9	30%	68%	2%	0%
Nov	720	W	1.39	S	0.78	4.9	22%	77%	1%	0%
Dec	744	W	1.17	S	0.86	5.0	8%	92%	0%	0%
Annual	7829	SW	4.39	L	0.85	5.2	32%	60%	7%	1%

Blank means no observed or equipment failure.

3.2.2.3 Air pressure and air temperature

Air pressure and air temperature are stable in Liuqiu island.

Table 3-11: Air Pressure Statistics at Xiao Liuqiu Buoy; Year: 2011(Unit: hPa)

Month	Number of observations	Mean pressure	Maximum daily average pressure	Minimum daily average pressure	Maximum pressure	Minimum pressure
Jan	744	1016.9	1020.8	1013.4	1023.2	1019.9
Feb	672	1013.4	1017.5	1006.3	1019.7	1003.2
Mar	728	1014.5	1017.6	1009.0	1020.2	1007.5
Apr	706	1010.9	1015.5	1005.3	1017.6	1002.8
May	744	1006.8	1012.6	997.2	1014.1	993.3
Jun	720	1004.1	1008.1	993.1	1009.5	990.2
Jul	744	1002.9	1007.0	997.2	1008.4	995.3
Aug	642	1003.5	1009.4	993.1	1011.2	988.1
Sep	712	1005.5	1010.1	1000.2	1011.7	999.3
Oct	744	1012.0	1015.2	1006.5	1016.5	1005.0
Nov	720	1013.5	1019.3	1006.9	1021.1	1004.7
Dec	744	1017.4	1022.6	1011.6	1024.2	1010.0
Annual	8620	1010.2	1022.6	993.1	1024.2	988.1

Table 3-12: Air Temperature Statistics at Xiao Liuqiu Buoy; Year: 2011 (Unit: ℃)

Month	Number of observations	Average temperature	Maximum daily average temperature	Minimum daily average temperature	Maximum temperature	Minimum temperature
Jan	744	18.1	20.2	14.4	21.9	12.9
Feb	672	20.1	23.0	15.7	25.0	14.4
Mar	728	20.4	23.8	17.4	24.7	15.2
Apr						
May	744	25.5	27.2	23.8	28.1	22.3
Jun	720	27.5	28.6	25.5	29.6	24.0
Jul	744	27.2	28.7	25.5	30.5	24.0
Aug	642	28.0	29.3	25.7	30.5	24.6
Sep	712	27.5	29.0	26.9	30.0	25.3
Oct	744	26.6	27.9	25.5	29.5	24.0
Nov	720	25.1	27.2	23.0	28.2	21.7
Dec	744	20.7	24.0	17.4	25.1	15.8
Annual	7914	24.2	29.3	14.4	30.5	12.9

3.2.2.4 Sea temperature

Figure 3-10 shows that Taiwan is the potential place to develop OTEC.

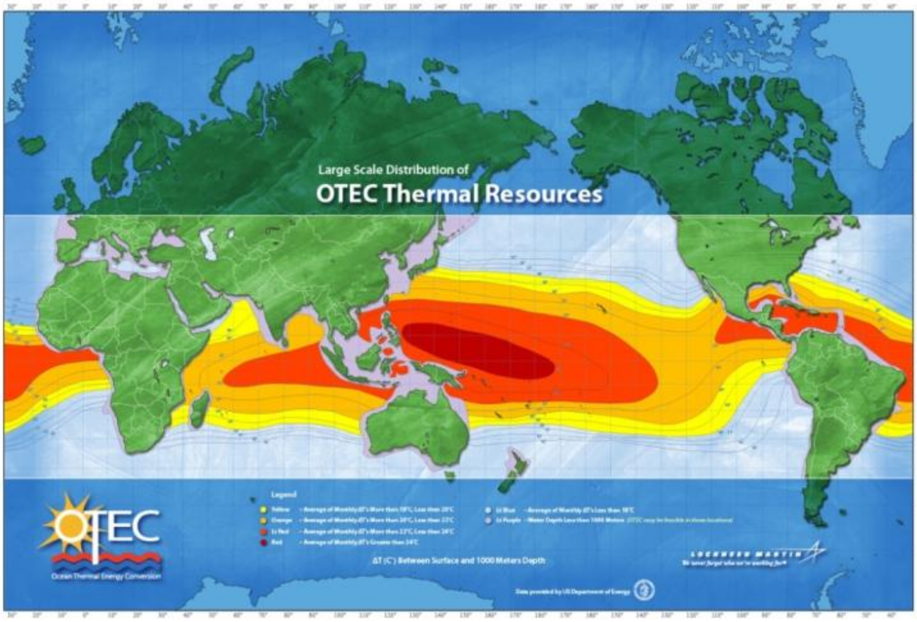


Figure 3-10: OTEC Thermal Resources in the World Ocean

Table 3-13: Monthly Sea Temperature Statistics at Xiao Liuqiu Buoy; Year: 2011 (Unit: ℃; Depth: 0 m)

Month	Number of observations	average sea surface temperature	Maximum daily average sea surface temperature	Minimum daily average sea surface temperature	Maximum sea surface temperature	Minimum sea surface temperature
Jan	744	24.0	24.6	22.9	24.9	21.9
Feb	672	24.5	25.4	23.9	26.0	23.7
Mar	728	24.3	24.7	23.9	25.2	23.7
Apr						
May	744	26.8	28.1	25.5	29.0	25.0
Jun	720	28.8	29.9	27.1	31.1	25.7
Jul	744	29.1	30.0	27.6	31.2	25.2
Aug	642	29.7	30.7	27.8	31.6	27.1
Sep	712	29.3	29.7	28.6	30.7	26.6
Oct	744	28.2	29.2	27.9	29.4	27.6
Nov	720	27.2	27.9	26.1	28.5	25.8
Dec	744	25.1	26.3	22.3	26.8	21.9
Annual	7914	27.0	30.7	22.3	31.6	21.9

Blank means no observed or equipment failure.

The Liuqiu island is near the Kaoping Canyon, which temperature has great changes. Figures 3-11 represents the temperature distribution, with the potential to develop OTEC.

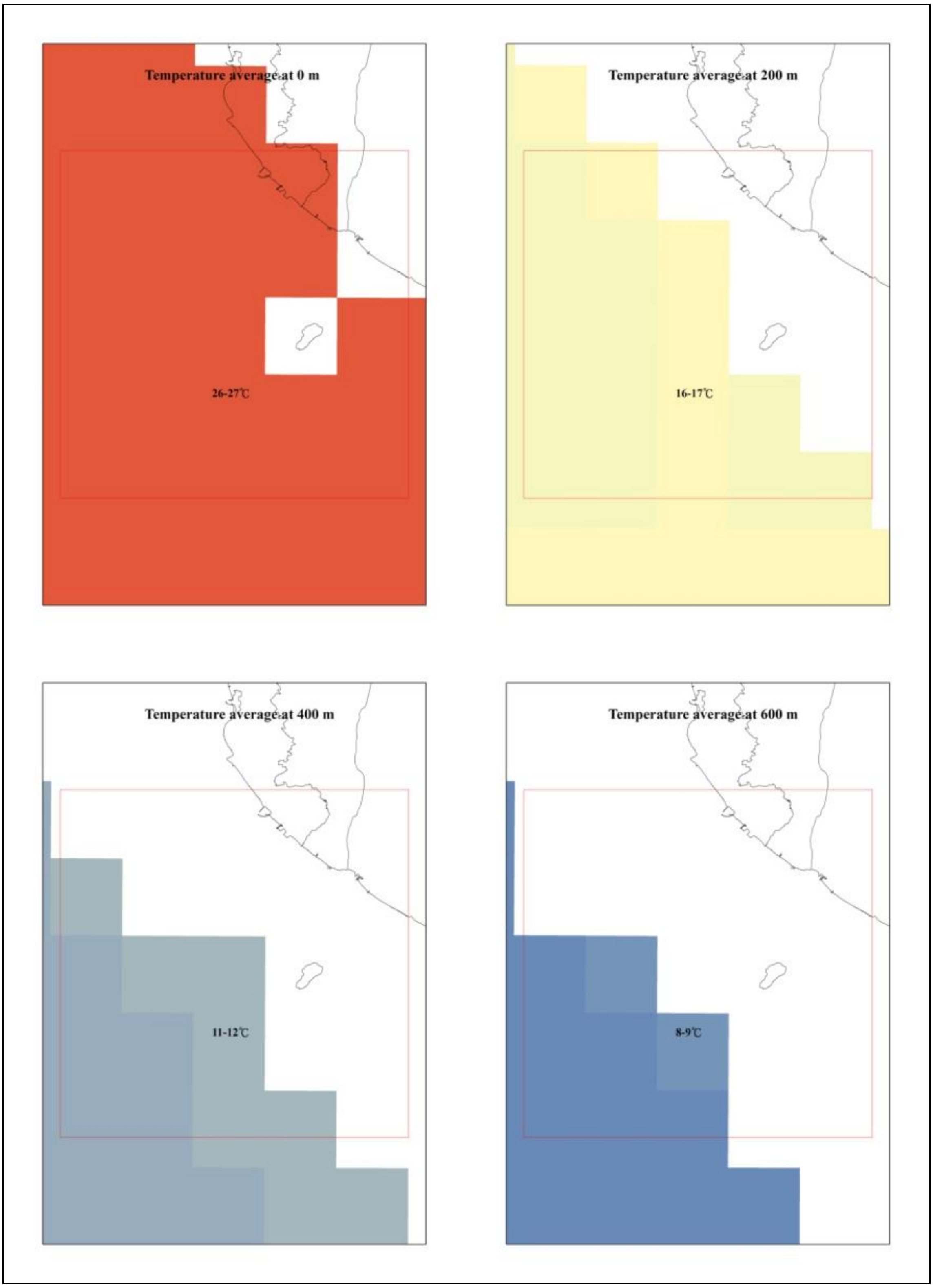


Figure 3-11: Temperature distribution around Liuqiu island in 2011

3.2.2.5 Tidal

The potential site for tidal energy is along the west coast of Taiwan. The tidal difference is less than 1 meter around the Liuqiu island, which is not suitable to develop tidal power.

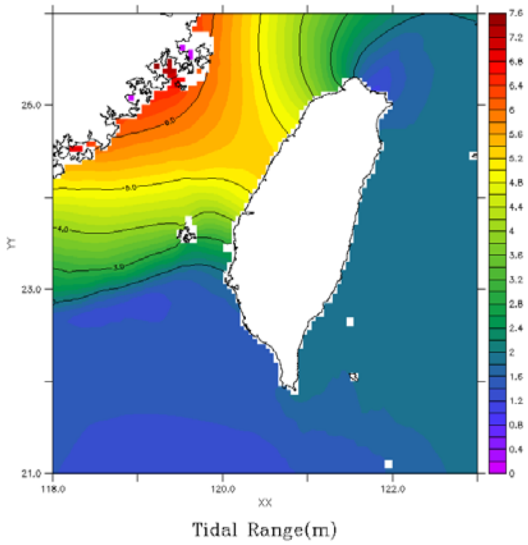


Figure 3-12: Maximum tidal range around Taiwan in 2009

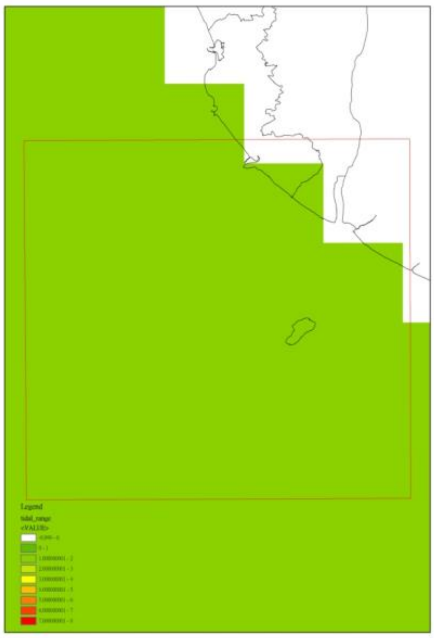


Figure 3-13: Maximum tidal range around Liuqiu island in 2009

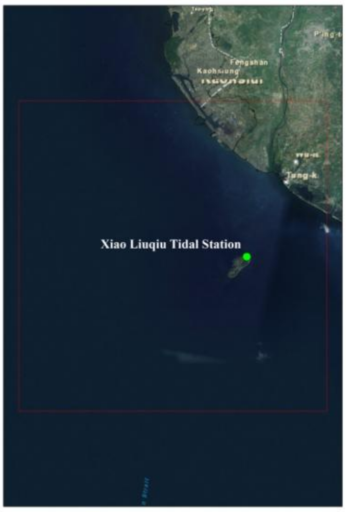


Figure 3-14: Xiao Liuqiu Tidal Station (1386)

Longitude: 120.383333

Latitude: 22.353333

Location: The sea area of Kaohsiung and Fangliao. Liuqiu fishing port.

Organisation: Central Weather Bureau

Property: Automatic Tidal Stations

Monitoring items: Tidal

Table 3-14: Annual Summary of Tidal Statistics at Xiao Liuqiu Buoy; Year: 2012(Unit: cm; TWVD2001)

Month	MSL	No.	MHWL	MLWL	MHWS	MLWS	HAT	LAT	MR	MSTR	STR	MTR
Jan	-14	52	11	-36	21	-43	79	-39	47	64	117	116
Feb	-1	88	30	-28	50	-37	70	-36	58	87	106	119
Mar	8	99	39	-22	54	-28	60	-33	61	82	93	98
Apr	4	96	35	-26	50	-32	72	-39	61	82	110	112
May	9	87	36	-20	62	-37	84	-43	55	98	127	129
Jun	12	92	38	-17	73	-37	88	-45	56	110	132	143
Jul	12	106	38	-16	63	-30	85	-42	54	93	127	150
Aug	16	102	46	-13	72	-23	79	-38	59	95	117	147
Sep	18	96	48	-13	61	-18	62	-33	61	79	95	113
Oct	15	102	42	-14	58	-20	73	-40	55	78	113	122
Nov	1	99	27	-28	52	-43	84	-45	54	95	128	127
Dec	-3	100	23	-30	51	-47	86	-46	53	98	131	136
Annual	6.7	1119	34	-22	56	-33	88	-46	56	89	133	171

Reference: Tidal observation data annual report 2012, Central Weather Bureau

3.2.2.6 Current

Figures 3-15 and 3-16 shows the potential sites to develop current power around Taiwan. The maximum currents can reach 1–2 knots over a tidal cycle around the Kaoping Canyon. The result represented that the Liuqiu island is not really suitable for the development of the current power.

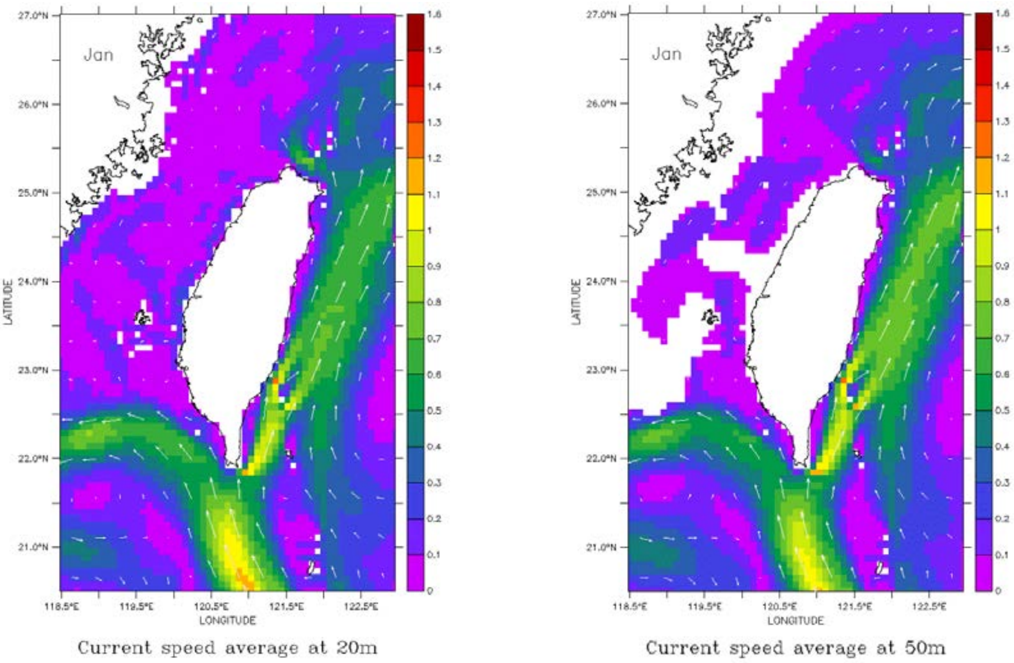


Figure 3-15: Average current speed at 20 m depth (left) and 50 m depth (right).

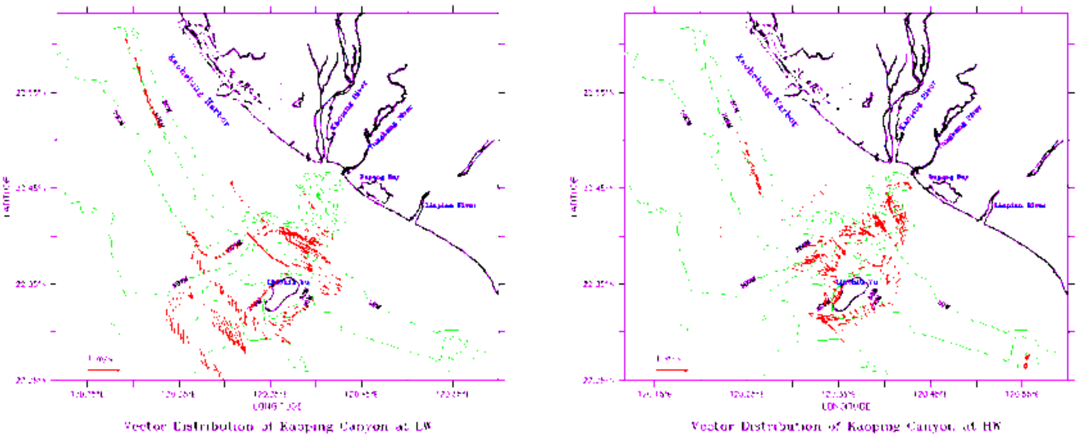


Figure 3-16: Currents at 20m depth during high water (left) and low water (right).

3.2.2.7 Bathymetry and seabed features

Figure 3-17 shows the water and electricity supplies from the mains island to the Liuqiu island.

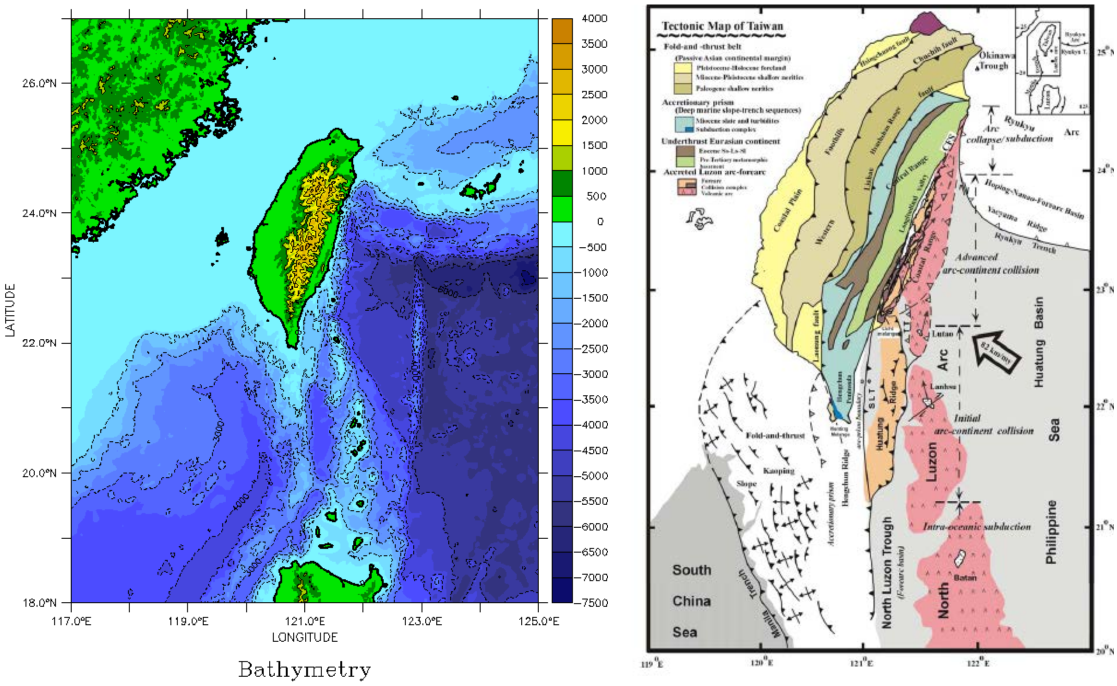


Figure 3-17: Bathymetry and seabed geology around Taiwan

Figure 3-18: Sea map around the Liuqiu island

(Reference: Republic of China Navy)

3.2.2.8 Sediment quality

Figure 3-19 show that the coastal area of the Liuqiu island is mostly silty sediments.

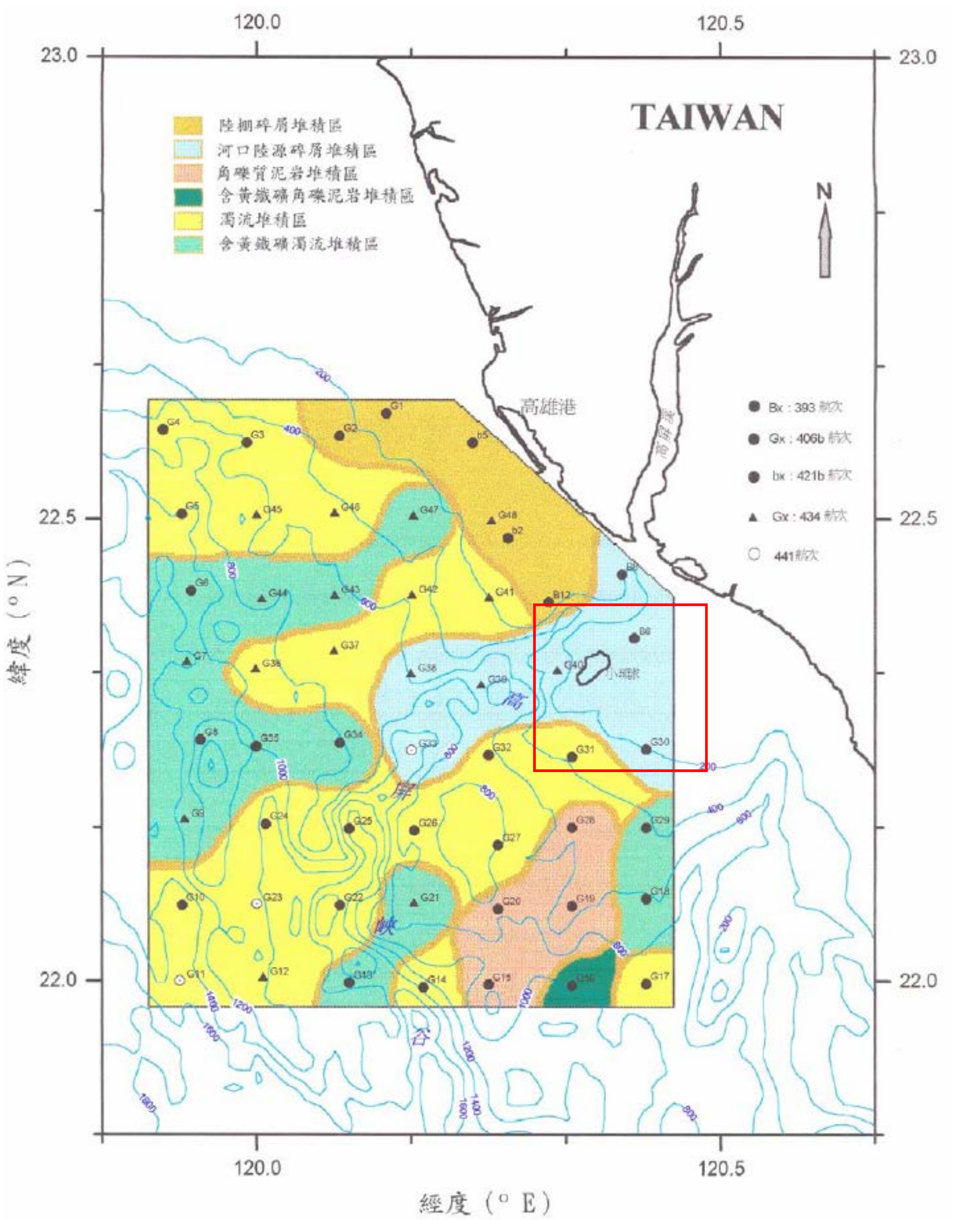


Figure 3-19: Taiwan's southwest coast with different accumulation

Figure 3-20: Core sampling (G40)

Longitude: 120.392700

Latitude: 22.413756

Organisation: Central Geological Survey, MOEA

Property: Manual monitoring

Monitoring items: Sand, Silt, Clay

Table 3-15: Core sampling near with Liuqiuyu; Year: 1995

Sampling station name	Voyage	Longitude	Latitude	Core length (cm)	Sand content of (%) averages	Silt content of (%) averages	Clay content of (%) averages	average particle diameter (Φ) averages
B06	ORI-393	No data	No data	15	25.01	57.69	16.83	5.75
B08	ORI-393	No data	No data	35	15.11	67.97	16.93	5.95
B12	ORI-393	No data	No data	20	40.54	44.98	14.38	5.12
G40	ORI-434	120.324277	22.335411	51	0.87	73.59	25.54	6.94

Reference: GEOREF 2002

3.2.2.9 Water Quality

According to the Water Pollution Control Act, water quality is monitored by Environmental Protection Agency, Taiwan. Figure 3-21 is the nearest sampling point near Liuqiu island, and Table 3-16 shows the basic information of water quality. There is no obvious pollution near the study site.

Figure 3-21: Water Quality Monitoring (5195)

Longitude: 120.392700

Latitude: 22.413756

Location: Gaoping river estuary outwards 4 nautical miles

Organisation: Environmental Protection Administration, Executive Yuan

Property: Manual monitoring

Monitoring items: Temperature, Salinity, pH, Chlorophyll a, Ammonia, Nitrate, Nitrite, Orthophosphate, Silicate, SS, DO, Heavy Metal

Table 3-16: Water quality sampling near with Liuqiuyu; Year: 2012 (Depth: 1 m)

Date	Temp.	Water temp.	Salinity	pH	Chl-a	Ammonia	Nitrate	Nitrite	Ortho-phosphate	Silicate
	℃	℃	psu		μg/l	mg/l	mg/l	mg/l	mg/l	mg/l
02/21	18.4	22.9	33.1	8.2	0.3	<0.01	0.01	0.002	0.014	0.197
05/14	30.2	28.8	32.9	8.2	1.0	0.03	0.01	0.002	0.012	0.151
08/13	32.3	30.2	28.8	8.1	0.6	0.02	0.15	0.011	0.038	1.410
10/08	27.9	28.1	34.2	8.3	1.0	<0.01	0.04	<0.001	0.009	0.041

Date	Suspended solids	Dissolved O_2 (electrode)	Dissolved O_2 saturation	Cadmium	Chrome	Copper	Zinc	Lead	Mercury
	mg/l	mg/l	%	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
02/21	<2	6.9	98.0	0.00003	<0.001	0.0014	0.0039	0.0003	<0.0003
05/14	8.4	7.5	116.9	0.00001	<0.001	0.0003	0.0048	<0.0001	<0.0003
08/13	2.2	6.9	107.2	0.00002	<0.001	0.0012	0.0022	<0.0001	<0.0003

10/08	3.6	6.6	102.2	0.00002	<0.001	0.0006	0.0012	<0.0001	<0.0003

Reference: EPA 2014

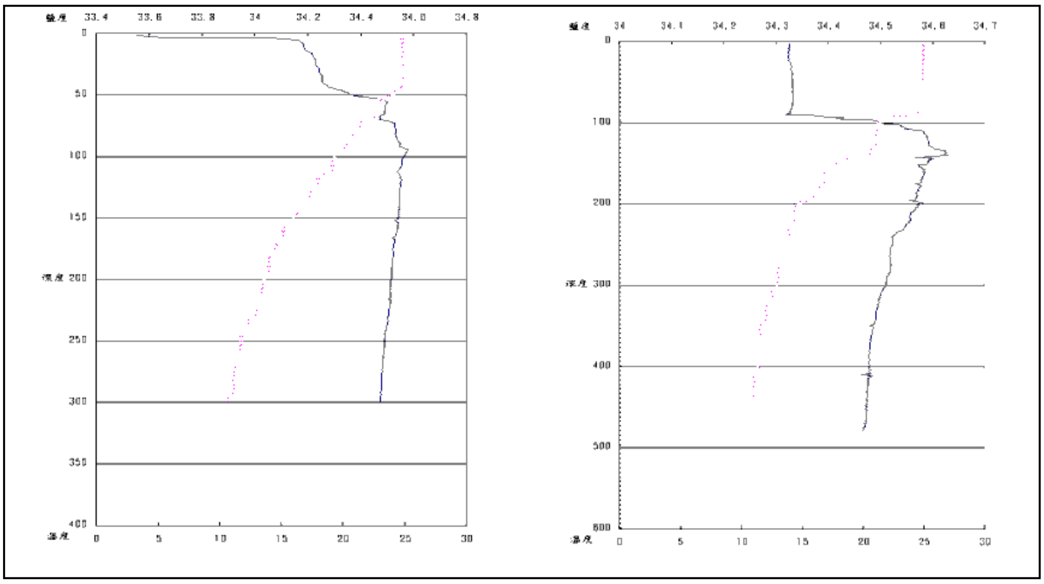


Figure 3-22: CTD profile in December at 300m depth (left) and 500m depth (right) of the Canyon

Due to the biological consumption, the nutrient concentration in the surface water will be smaller than in deep water. With the increasing depth, nutrient concentration is also increased. Nutrient distribution in in this area is roughly the same during different period of time. Closer to the estuary, the nutrient concentration is higher (Yang, 2006).

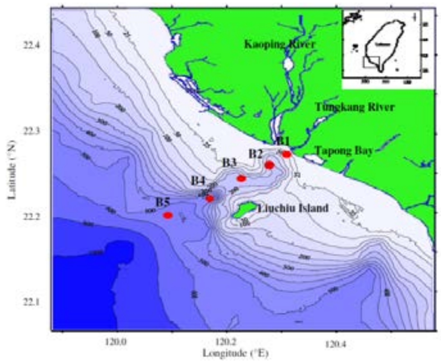
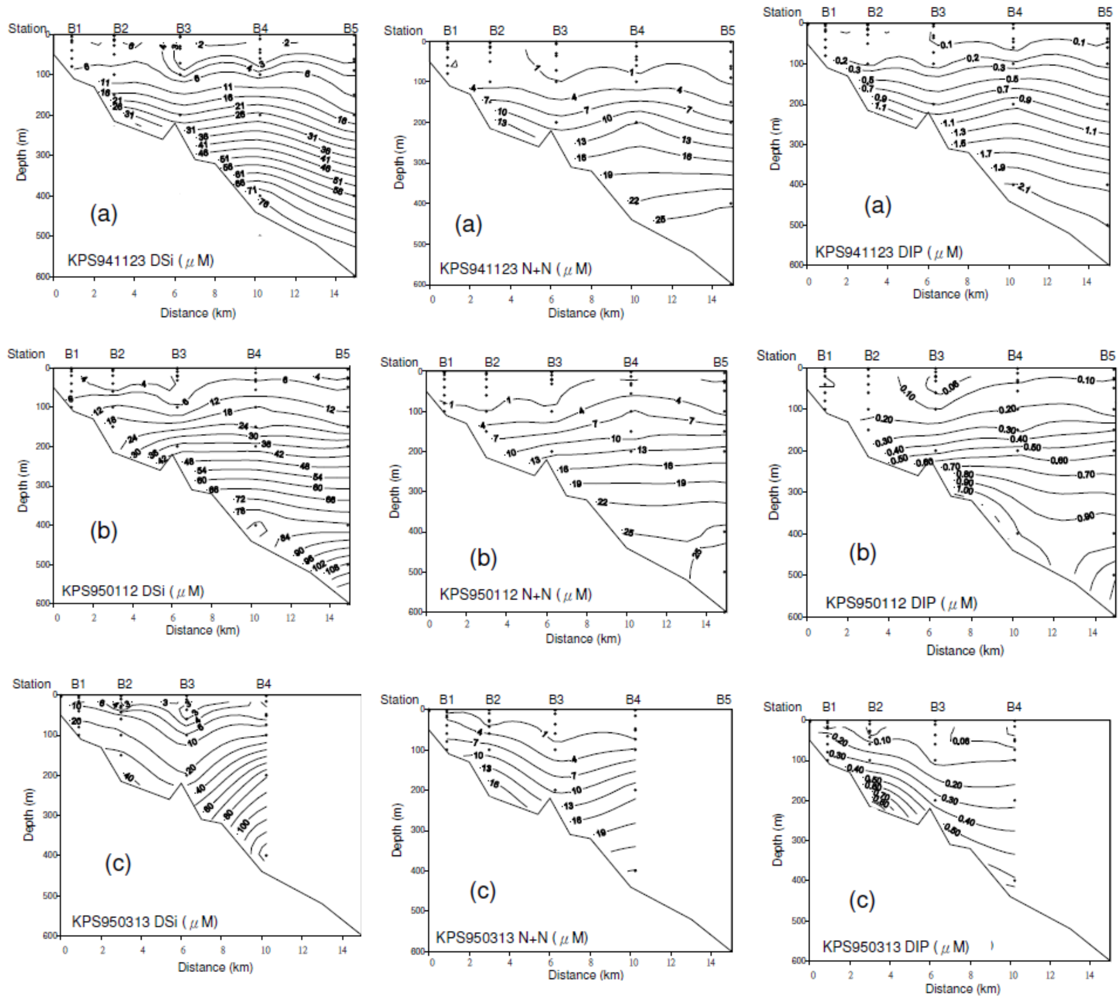


Figure 3-23: Nutrient sampling points in the Kaoping canyon



DSi DIN DIP

Figure 3-24: Nutrient concentrations (Dsi, DIN and DIP) in the Kaoping canyon

(a) Nov, 2005 (b) Jan, 2006 (c) Mar, 2006

3.3 NATURAL HAZARDS

Earthquake

The Seismological Bulletin, Taiwan summarised the information of earthquakes quarterly observed by the CWBSN24. Figure 5.3.1 shows the seismicity map of the events detected in this quarter around Liuqiu island. Table 5.3.1 shows the parameters and related information from the Liuqiu island recording station (primary and secondary seismic waves' arrivals, intensities and peak ground acceleration, etc.). The earthquake happened about 9,453 times in this quarter. The earthquake monitoring station in Liuqiu island recorded about 44 earthquakes, and only two earthquakes could be classified as the intensity scales. The result represented that the impact from earthquake is related low in Liuqiu island.

Figure 3-25: Earthquakes in July to September around Liuqiu island in 2013

Figure 3-26: Earthquake monitoring station

Longitude: 120.369100

Latitude: 22.346700

Organisation: Central Weather Bureau

Property: Automatic Stations

Monitoring items: Depth, ML, STA., PHASE, P_time, S_time, I, PGA, DIS.

Table 3-17: Felt earthquakes at Liuqiu Island

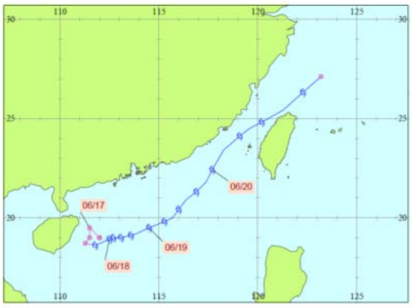
No.	date	time	LAT(°N)	LON(°E)	Depth	ML	STA.	PHASE	P_time	S_time	I	PGA	DIS.
26145	2013/7/6	04:17:12	22.84	121.33	21.2	4.09	WLC	EP	93.41	107.57			112
26942	2013/7/14	19:24:29	22.98	120.91	6.8	4.63	WLC	EP	47.13				89
26987	2013/7/14	22:01:07	22.98	120.91	4.5	3.35	WLC	EP	86.50				89
27038	2013/7/15	13:41:40	23.76	122.84	39.9	5.67	WLC	EPD	83.82	117.29			296
27043	2013/7/15	15:01:29	23.96	121.05	19.0	4.00	WLC	EP	60.50				191
27124	2013/7/16	10:11:35	24.28	121.5	4.9	5.45	WLC	EP	75.17				242
27497	2013/7/18	00:28:23	22.97	120.91	4.2	3.53	WLC	EP	42.52				88
27823	2013/7/20	19:19:45	24.28	121.49	5.1	4.32	WLC	EP	87.35				243
28132	2013/7/23	02:24:03	22.99	121.37	34.7	3.43	WLCH	EP	26.43				123
28316	2013/7/24	14:47:06	23.91	121.53	9.1	4.77	WLC	EP	159.98				209
28324	2013/7/24	15:32:15	23.91	121.53	10.5	5.03	WLC	EP	169.29				209
28328	2013/7/24	15:41:13	23.90	121.52	10.9	4.34	WLC	EP	106.17				208
28420	2013/7/25	09:12:52	23.15	121.2	10.6	3.85	WLCH	EP	76.19				122
29375	2013/8/2	23:18:43	22.91	121.39	21.1	3.65	WLCH	EP	125.98				121
30637	2013/8/14	01:11:19	23.12	121.37	21.8	3.75	WLCH	EP	43.37				132
30877	2013/8/16	12:36:02	22.09	121.38	18.4	3.92	WLC	EP	21.23				107

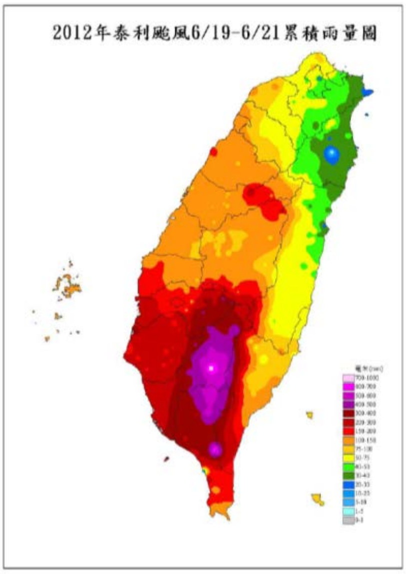
30940	2013/8/17	00:58:54	22.10	121.39	21.0	3.61	WLC	EP	72.84				107
31124	2013/8/18	14:57:02	23.95	122.48	28.0	4.76	WLC	EP	44.28				279
31235	2013/8/19	14:54:09	23.58	121.57	33.1	3.92	WLCH	EP	39.16				182
31860	2013/8/27	07:05:33	22.93	121.4	22.4	3.03	WLCH	EP	55.82				121
31957	2013/8/28	11:55:46	24.15	121.76	43.6	4.32	WLCH	EP	84.71				243
32213	2013/9/1	02:28:07	23.29	120.74	13.5	3.99	WLC	EP	27.85				111
32218	2013/9/1	02:45:04	23.29	120.74	14.2	3.26	WLCH	EP	84.55				109
32232	2013/9/1	05:54:13	23.21	120.95	3.9	2.92	WLCH	EP	96.43				111
32236	2013/9/1	06:54:56	23.29	120.74	13.4	3.88	WLC	EP	76.12				111
32389	2013/9/3	06:24:06	24.22	121.62	20.0	3.80	WLCH	EP	43.58				242
32406	2013/9/3	09:54:59	21.89	120.55	40.4	4.34	WLC	PD	70.82	79.39			53
32456	2013/9/3	19:24:14	22.82	121.39	23.9	4.06	WLC	EP	35.69				116
32466	2013/9/3	22:23:26	25.64	118.76	14.7	5.27	WLCH	EP	84.68				398
32590	2013/9/5	08:48:02	22.92	121.53	18.4	4.28	WLC	EP	25.98				134
32748	2013/9/6	11:33:51	20.05	122.28	6.1	6.76	WLC	EPC	102.42	138.61	1	2.1	323
33135	2013/9/10	23:15:22	22.73	121.37	29.2	4.33	WLC	EP	43.04				110
33213	2013/9/11	22:34:37	24.15	121.67	28.4	4.01	WLCH	EP	75.66				238
33490	2013/9/14	04:13:15	23.18	120.91	7.9	3.06	WLCH	EP	96.81				107
33632	2013/9/16	00:46:14	22.97	120.88	4.2	3.90	WLC	EP	32.44				86
33849	2013/9/18	03:33:17	24.64	122.09	15.0	4.54	WLC	EP	66.08				309
33994	2013/9/19	12:18:37	22.88	121.12	16.0	3.98	WLC	EP	116.72				96
34112	2013/9/21	14:34:08	22.96	120.86	6.3	3.78	WLC	EP	86.54				84
34403	2013/9/25	15:54:10	23.10	120.69	7.1	3.74	WLCH	EPD	89.16	103.62			88
34424	2013/9/25	20:50:55	23.50	121.6	41.4	3.58	WLCH	EP	84.13				178
34587	2013/9/28	06:14:08	22.59	120.95	10.8	3.07	WLC	EP	81.57				65
34747	2013/9/29	19:50:39	22.07	120.37	45.6	4.18	WLC	P	108.56	115.90	1	1.1	30
34783	2013/9/30	08:23:31	23.09	120.36	16.4	3.04	WLC	EP	47.39				82
34797	2013/9/30	12:05:20	23.85	120.96	11.1	4.66	WLC	EP	109.36				176

No.: the accumulated earthquake number of the year; Dep.: the focal depth of earthquake in km; M_L: the local magnitude, following Richter's original definition, and the local attenuation factor is used (Shin,1993); I: Central Weather Bureau seismic intensity scale; PGA: peak ground acceleration in gal (cm/sec^2); Reference: Seismological bulletin vol. 60 no.3 (2013.07-09), Central Weather Bureau

Typhoon

The climatological data is collected from the annual report of 2012, and showed the typhoon impact and path near Liuqiu island.





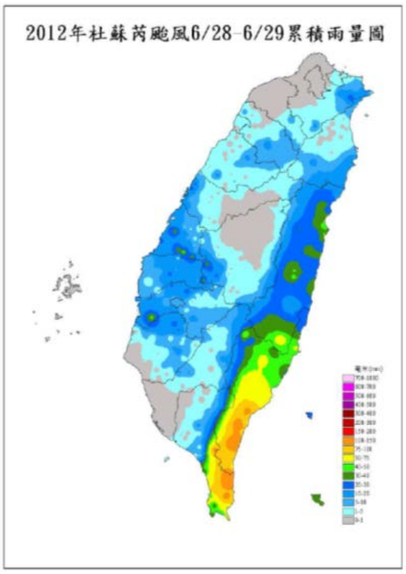
Date: 2012/06/19-06/21

The wind speed near the typhoon center is 25 m/s.

The radius of the typhoon is 150 km.

The type of typhoon path is 9.

Figure 3-27: Typhoon path and Cumulative rainfall of TALIM



Date: 2012/06/28-06/29

The wind speed near the typhoon center is 23 m/s.

The radius of the typhoon is 120 km.

Figure 3-28: Typhoon path and Cumulative rainfall of DOKSURI

Date: 2012/07/30-08/03

The wind speed near the typhoon center is 38 m/s.

The radius of the typhoon is 220 km.

The type of typhoon path is 2.

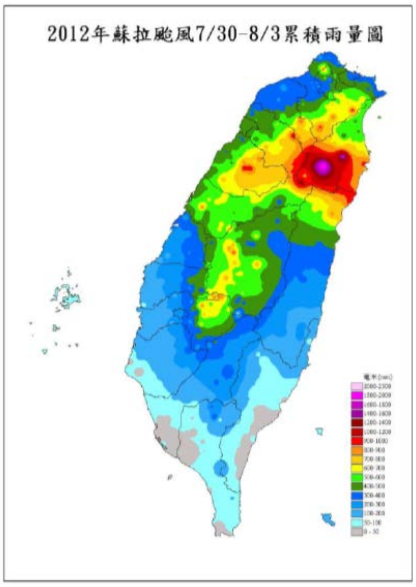
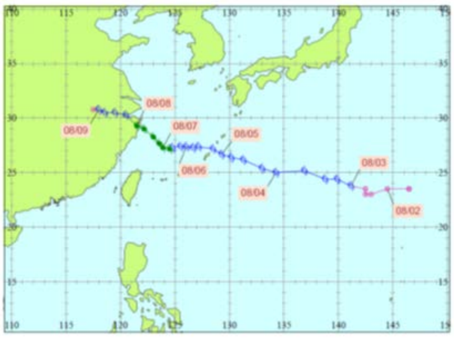


Figure 3-29: Typhoon path and Cumulative rainfall of SAOLA



Date: 2012/08/06-08/07

The wind speed near the typhoon center is 35 m/s.

The radius of the typhoon is 180 km.

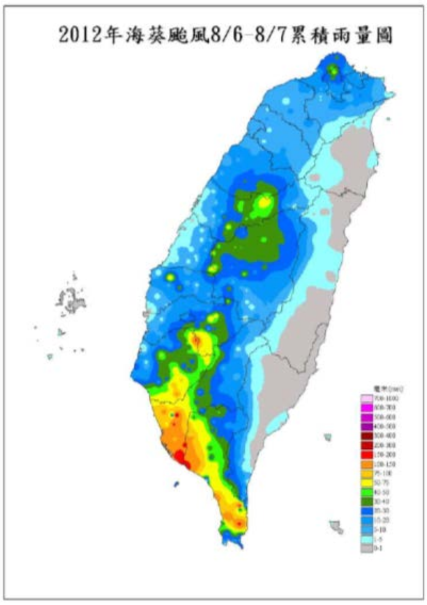


Figure 3-30: Typhoon path and Cumulative rainfall of HAIKUI

Date: 2012/08/14-08/15

The wind speed near the typhoon center is 20 m/s.

The radius of the typhoon is 150 km.

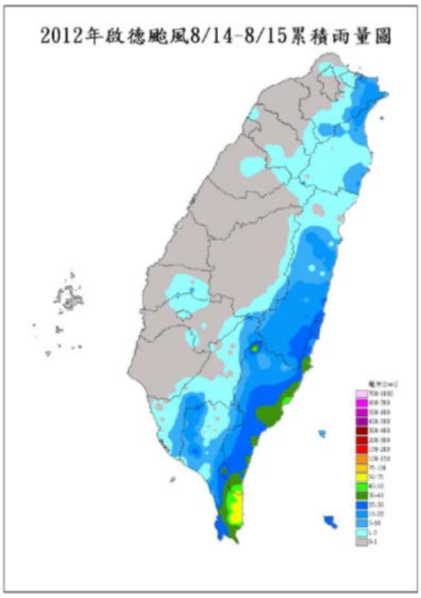


Figure 3-31: Typhoon path and Cumulative rainfall of KAI-TAK

Date: 2012/08/21-08/28

The wind speed near the typhoon center is 45 m/s.

The radius of the typhoon is 180 km.

The type of typhoon path is 10.

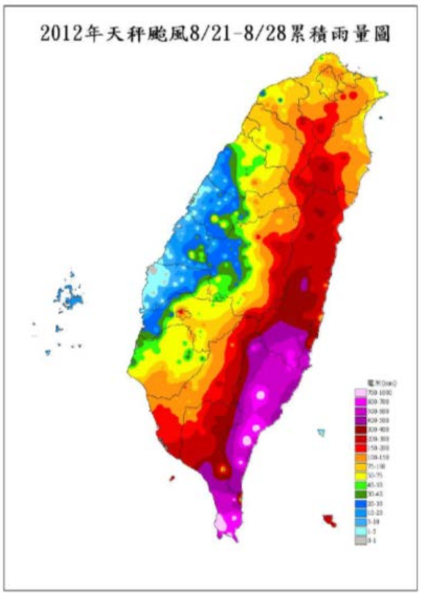
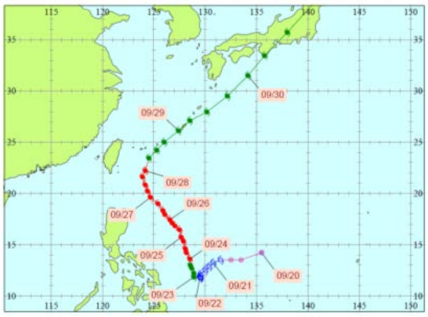


Figure 3-32: Typhoon path and Cumulative rainfall of TEMBIN



Date: 2012/09/27-09/28

The wind speed near the typhoon center is 55 m/s.

The radius of the typhoon is 250 km.

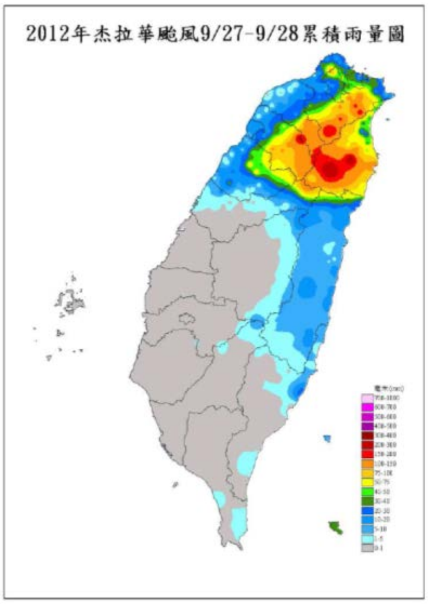


Figure 3-33: Typhoon path and Cumulative rainfall of JELAWAT

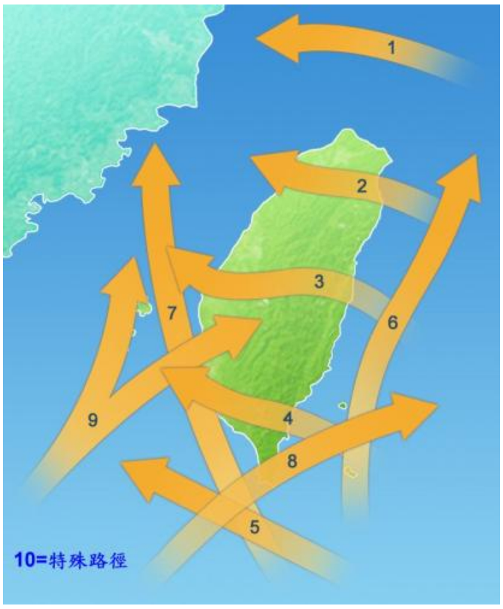


Figure 3-34: The type of typhoon path

In 2012, Liuqiu island received heavy rain because typhoon passed through route 9. According to the record from 2001 to 2013, there are 85 typhoon alerts, which include 7 typhoons through path 9.

The probability of typhoon hit the Liuqiu island in the past 10 years is about 14.12%.

(Reference: Climatological data annual report 2012 Part I – surface data, Central Weather Bureau)

3.4 NOISE CONDITIONS

In spring and summer, the noise peak of average is 5 dB to 10 dB higher than autumn around Liuqiu island offshore area (Wei et al., 2008). Figure 3-35 shows the average noise per hour, and figure 3-36 shows the average value in four seasons. The average peak of noise can reached to 500 Hz in spring and summer. Compared to other seasons, that value was 7 dB to 10 dB higher.

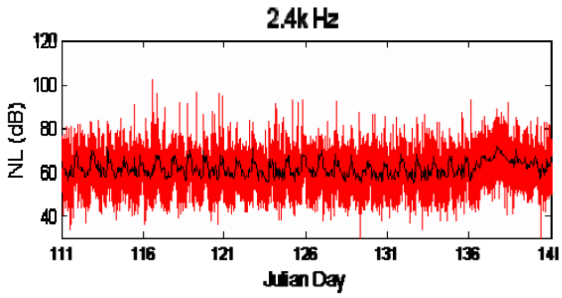


Figure 3-35: Noise average of each hour in Liuqiu island (Wei et al., 2008)

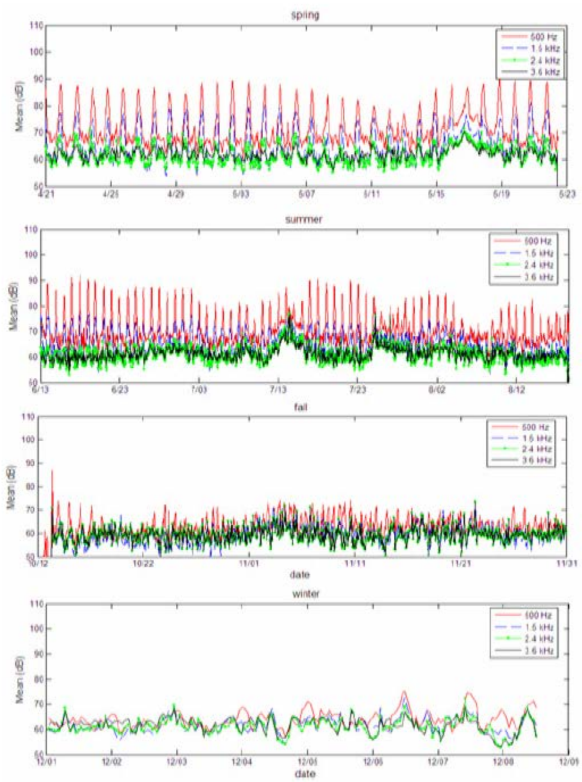


Figure 3-36: Average value of each hour in four seasons around Liuqiu island offshore (Wei et al., 2008)

3.5 ECOSYSTEMS, COMMUNITIES AND HABITATS

3.5.1 INTRODUCTION

This section will describe ecology, communities, relative protected areas, important habitats, and analyse existing distribution and conservation status of the species. It can be as a follow-up EIA assessment of the platform reference information in Liuqiu Island.

3.5.1 PELAGIC COMMUNITIES

3.5.1.1 Ichthyofauna

Due to the fact that a major part of Liuqiu island catches are transactions in Donggang fish market, this section adopted statistical data of adjacent field Donggang. Table 3-18 shows the major fish species and fishing areas. The geographical distribution of various fish species can be determined according to the above data and map of fishery method area (Figure 3-38). Statistics from the trading volume of economic transactions shows that major species around Liuqiu island are *Makaira nigricans, Thunnus albacares, Coryphaena hippurus, Xiphias gladius* and *Sergia lucens* (see Figure 3-37).

Table 3-18: Major fish species and fishing area of Donggang trade market

Scientific name	Volume of trade(kg)	Fishing area	Fishing method	Migratory/non-migratory
Thunnus alalunga	580,733	far sea	long line	Migratory
		offshore	long line	
		coastal	spear fishing	
Thunnus obesus	931,343	far sea	long line, Purse seine	Migratory
		offshore	long line	
		coastal	spear fishing	
Thunnus albacares	5,332,783	far sea	long line, Purse seine	Migratory
		offshore	long line	
		coastal	spear fishing	
Xiphias gladius	1,449,757	far sea	long line	Migratory
		offshore	long line	
		coastal	spear fishing	
Kajikia audax	207,817	far sea	long line	Migratory
		offshore	long line	
		coastal	spear fishing	
Makaira nigricans	5,904,142	far sea	long line	Migratory
		offshore	long line	
		coastal	spear fishing	

Makaira indica	268,322	far sea	long line	Migratory
		offshore	long line	
		coastal	spear fishing	
Istiophorus platypterus	371,119	far sea	long line	Migratory
		offshore	long line	
		coastal	spear fishing	
Acanthocybium solandri	537,981	far sea	long line	Migratory
		offshore	long line	
		coastal	Set net	
Coryphaena hippurus	2,866,158	far sea	long line	Migratory
		coastal	long line	
Thyrsitoides marleyi	87,286	offshore	pole and lines boots	Migratory
		coastal	set net, pole and lines boots	
Lepidocybium flavobrunneum	984,828	far sea	long line	Migratory
		offshore	long line	
Sergia lucens	1,141,560	coastal	drag net	Migratory
Mene maculata	24,995	offshore	purse seine for mackerel,	Non-migratory
			drag net, long line,	
			pole and lines boots,	
			Taiwanese seine	
Katsuwonus pelamis	164,181	far sea	long line, purse seine	Migratory
		offshore	drag net, long line	
		coastal	set net, torch light net	
Carcharhinus limbatus	26,683	far sea	long line	Non-migratory
		offshore	long line	
Isurus oxyrinchus	28,640	far sea	otter trawling, long line	Non-migratory
Thunnus orientalis	190,336	far sea	long line	Migratory
		offshore	long line	
Acetes intermedius Omori	352,746	coastal	others	Non-migratory

Source: Re-arrangement from Fisheries Agency, 2012, 2013；Biodiversity Research Center, 2014.

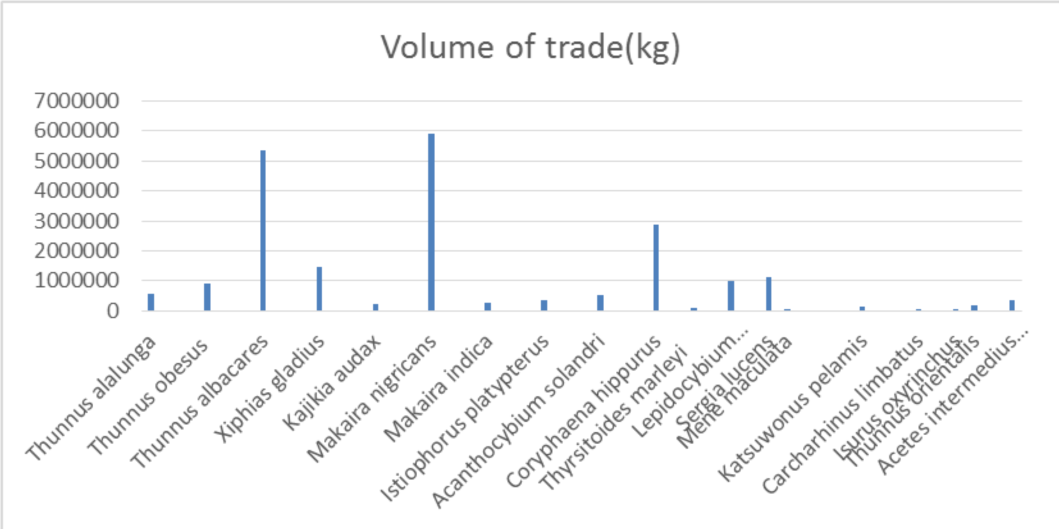


Figure 3-37: Volume of fish trade in Donggang Market (Source: Fisheries Agency, 2012)

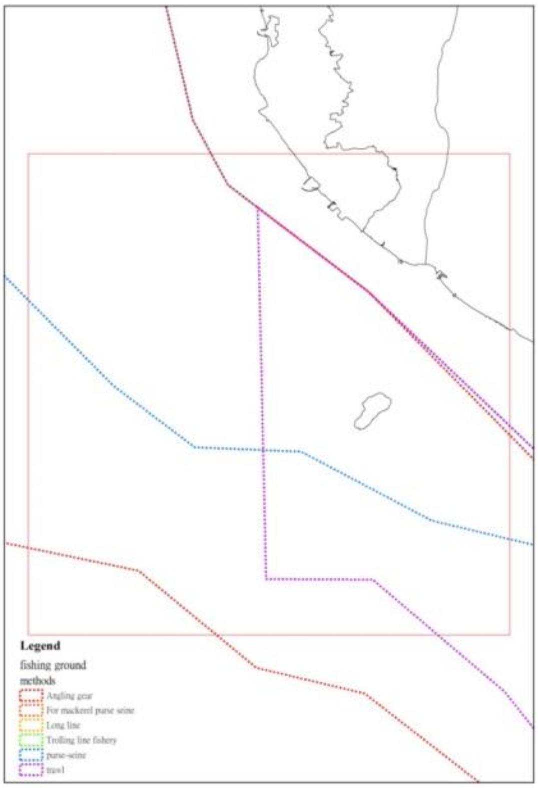


Figure 3-38: Fishing grounds around Liuqiu island

3.5.1.2 Marine Mammals

Fewer marine mammal species are found surrounding Liuqiu waters. The major cetacean species is Delphinidae which distribute in the deep water around Liuqiu (Taiwan Cetacean Society, 2008). The major species are shown in Table 3-19.

Table 3-19: Major marine mammals species around Liuqiu Island

Scientific Name	English Name
Stenella coeruleoalba	Striped dolphin
Orcinus orca	Killer whale
Pseudorca crassidens	False killer whale
Feresa attenuata	Pygmy killer whale
Peponocephala electra	Melon-headed whale

Source: Re-arrangement from Taiwan Cetacean Society, 2008.

3.5.1.3 Marine Reptiles

In addition to fish and birds, another important migratory animal is green turtles (*Chelonia mydas*) in Liuqiu island. Green Turtle is an endangered species of marine reptiles and has been listed as one of the highest level of conservation species in Taiwan. Liuqiu island is one of the few coral islands in Taiwan, where is the place that green turtles come ashore to lay eggs from May to October each year. From 2011 to 2012, about 20 to 30 nest eggs has found in Liuqiu island. The average number of each female turtle have 4 to 8 ness, and contains 81 to 100 eggs per nest. The spawning locations are throughout beaches in the islands (Pingtung County Government, 2014).

3.5.2 BENTHIC COMMUNITIES

According to the data from bottom trawling (2001), near Liuqiu Island, species of benthic communities in each season are listed in Appendix 1-4. Figure 3-39 to 3-41 are routs for benthic sampling near Liuqiu Island.

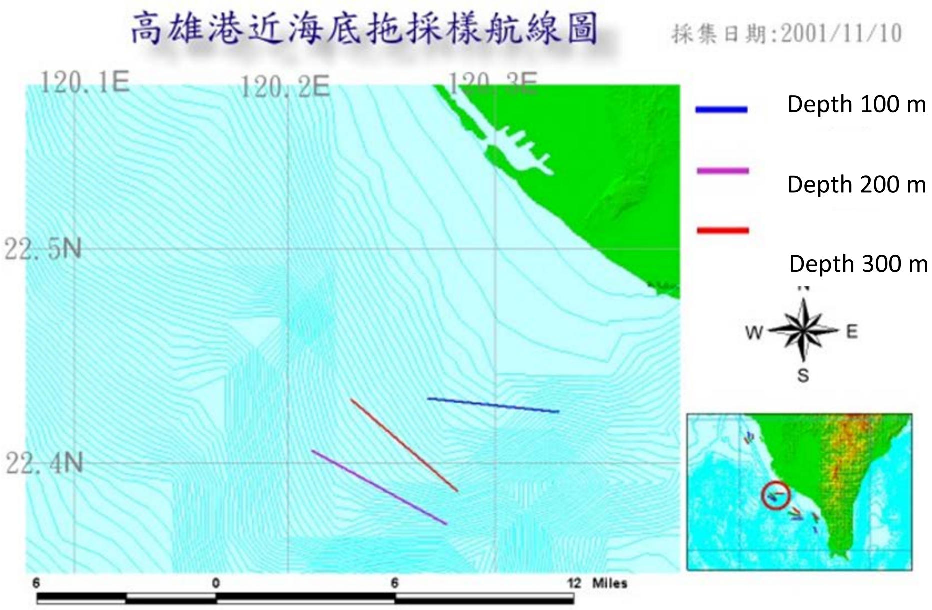


Figure 3-39: The trawl rout lines of sampling at Kaohsiung Harbor site

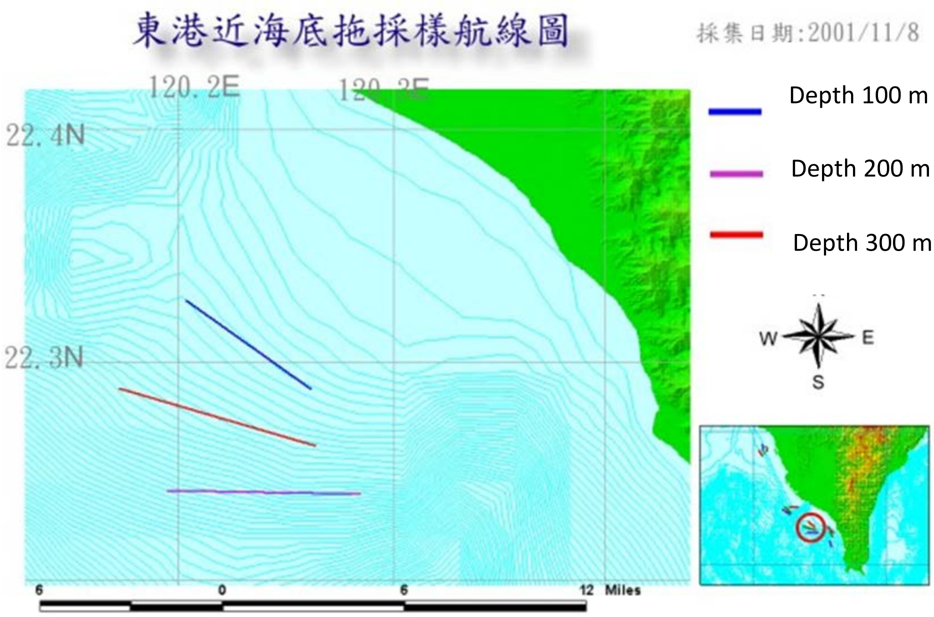


Figure 3-40: The trawl rout lines of sampling at Donggang site

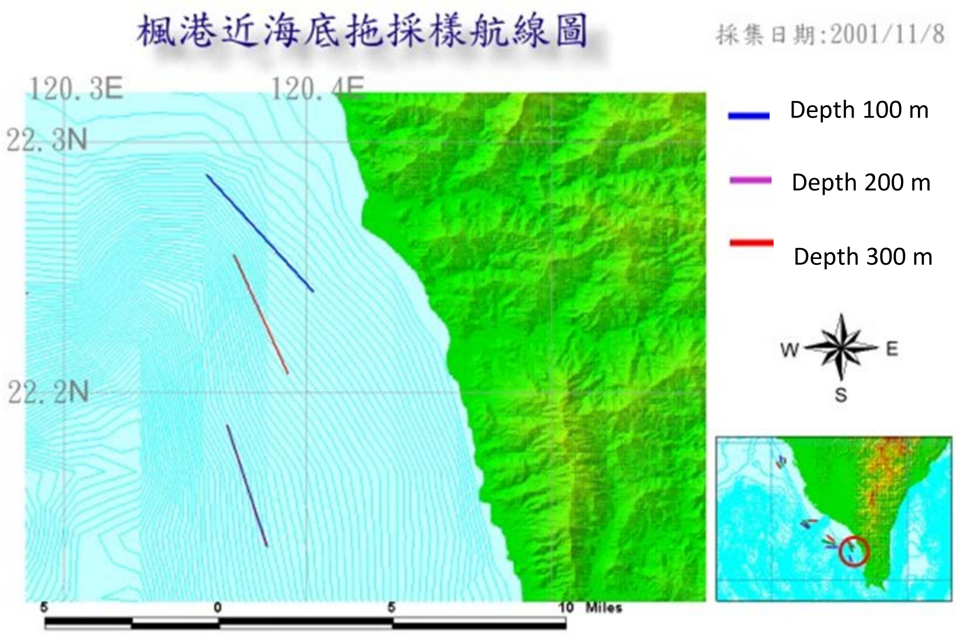


Figure 3-41: The trawl rout lines of sampling at Fengkang site

3.5.3 SEABIRDS

There are 38 kinds of birds recorded in Liuqiu island listed in Table 5.5.3 (Dapeng Bay National Scenic Area Administration A, 2005). Most of these species are non-migratory birds and only 9 species are migratory species. The major protected species are all migratory species, including *Accipiter soloensis, Sterna albifrons, Sterna sumatrana, Lanius cristatus.*

Table 3-20: Common bird species in Liuqiu Island

Scientific name	Migratory/non-migratory	Protection Animals	Activity season	distribution
Egretta garzetta	Non-migratory	N	Four seasons	1, 3, 4, 5, 8, 9, 12, 17
Egretta sacra	Non-migratory	N	Four seasons	8, 10, 15, 16
Accipiter soloensis	Migratory	Y	Spring and autumn	14, 16
Actitis hypoleucos	Migratory	N	Autumn and winter	1, 3, 4, 8, 10, 14, 16
Calidris alpina	Migratory	N	Autumn and winter	1, 3, 4, 8

Sterna albifrons	Migratory	Y	Spring and summer	3, 4
Sterna sumatrana	Migratory	Y	Spring and summer	2, 3
Columba rupestris	Non-migratory	N	Four seasons	3, 5, 7, 11, 12, 13, 14, 15, 17
Streptopelia chinensis	Non-migratory	N	Four seasons	1to 17
Apus affinis	Non-migratory	N	Four seasons	7, 10, 11, 12, 13, 14, 15
Hirundo rustica	Non-migratory	N	Four seasons	2, 3, 4, 7, 9, 10, 11, 13, 14,
Hirundo tahitica	Non-migratory	N	Four seasons	2, 3, 7, 9, 10, 11, 13, 14
Motacilla alba	Non-migratory	N	Four seasons	3, 9, 11, 14
Motacilla flava	Migratory	N	Autumn and winter	4, 13, 14
Pycnonotus sinensis	Non-migratory	N	Four seasons	1 to 17
Lanius cristatus	Migratory	Y	Spring, autumn and winter	2, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 16, 17
Lanius schach	Non-migratory	N	Four seasons	7, 14
Monticola solitarius	Migratory	N	Spring, autumn and winter	2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 15, 17
Saxicola torquata	Migratory	N	Autumn and winter	4
Prinia subflava	Non-migratory	N	Four seasons	13, 14
Hypothymis azurea	Non-migratory	N	Four seasons	2, 7, 13
Zosterops japonica	Non-migratory	N	Four seasons	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17
Passer montanus	Non-migratory	N	Four seasons	1 to 17
Acridotheres cristatellus	Non-migratory	N	Four seasons	1, 8, 13, 14

Source: Re-arrangement from Dapeng Bay National Scenic Area Administration A, 2005.

Figure 3-42: The distribution of common bird species in Liuqiu island. Source: Re-draw from Dapeng Bay National Scenic Area Administration A, 2005

3.5.4 SPECIAL HABITATS

About 90% of the coastal area around Liuqiu island is composed by coral reefs and rest is sandy beach. There are several conservation areas and critical habitats listed in the following.

Sanfu intertidal conservation zone

There exists rich ecological resources in Liuqiu intertidal zone. Recently, increased tourism industry has negative impacts on the shore, and begins to damage the ecological environment. Therefore, the Pingtung County Government designated the most critical and damaged intertidal area as Sanfu Conservation Zone. Table 3-21 listed common fauna species in intertidal zone.

Table 3-21: Common fauna species in intertidal zones of Liuqiu Island

Fauna species	Family Name	Scientific Name
Fish	Atherinidae	*Atherion elymus*
	Kuhliidae	*Kuhlia mugil*
	Pomacentridae	*Abudefduf sordidus*
		Abudefduf vaigiensis
	Mugilidae	*Oedalechilus sp.*
	Blenniidae	*Istiblennius edentulus*
		Istiblennius lineatus
		Istiblennius interuptus

		Entomacrodus striatus
	Gobiidae	*Bathygobius padangensis*
		Bathygobius cyclopterus
		Bathygobius cocosensis
	Acanthuridae	*Acanthurus triostegus*
Crustacean	Tetraclitidae	*Tetraclita squamosa*
	Ligiidae	*Ligia exotica*
	Talitridae	*Orchestia platensis*
	Gonodactylidae	*Gonodactylus chiragra*
	Hippolytidae	*Saron marmoratus*
	Alpheidae	*Alpheus strenuus*
	Diogenidae	*Dardanus guttatus*
		Dardanus pedunculatus
		Calcinus gaimardii
		Calcinus laevimanus
		Calcinus latens
		Clibanarius corallinus
		Clibanarius eurysternus
	Coenobitidae	*Coenobita rugosus*
		Birgus latro
	Portunidae	*Thalamita prymna*
		Thalamita spinimana
		Thalamita gloriensis
	Menippidae	*Erip scabricula*
		Eriphia sebana
	Xanthidae	*Leptodius sanguineus*
		Zosymus aeneus
	Grapsidae	*Grapsus albolineatus*
		Percnon plannissimum
	Ocypodidae	*Ocypode stimpsoni*
Mollusca	Chitonidae	*Acanthopleura spinosa*
	Patellidae	*Cellana toreuma*
	Turbinidae	*Turbo chrysostomus*
		Turbo petholatus

	Neritidae	*Nerita polita*
		Nerita albicilla
	Littorinidae	*Nodilittorina pyramidalis*
		Nodilittorina vidua
	Cypraeidae	*Cypraea annulus*
		Cypraea moneta
		Cypraea arabica
		Cypraea caputserpentis
	Muricidae	*Drupa morum*
		Drupa ricina
		Tenguella granulata
	Mitridae	*Strigatella litterata*
	Conidae	*Conus ebraeus*
		Conus flavidus
		Conus coronatus
		Conus textile
	Aplysiidae	*Aplysia dactylomela*
		Dolabrifera dolabrifera
		Dolabella auricularia
	Hexabranchidae	*Hexabranchus sanguineus*
	Mytilidae	*Modiolus auricularis*
	Ostreidae	*Saccostrea mordax*
Echinodermata	Ophidiasteridae	*Linckia laevigata*
	Ophiocomidae	*Ophiocomas scolopendrina*
	Echinometridae	*Echinometra mathaei*
	Stomopneustidae	*Stomopneustes variolaris*
	Toxopneustidae	*Tripneustes gratilla*
	Diadematidae	*Diadema setosum*
	Holothuriidae	*Actinopyga mauritiana*
		Holothuria atra
		Holothuria cinerascens

Source: Re-arrangement from Dapeng Bay National Scenic Area Administration A, 2005.

Green turtle spawning sites

Almost all beaches in Liuqiu island are green turtles spawning sites.

Coral reefs

Liuqiu island is one of the important coral islands, which is composed of reefs and limestone throughout the island. In addition, coral reef ecosystem is quite rich surrounding the island, there are at least 631 kinds of fish, about 468 kinds of mollusks, 400 species of crustaceans, 50 species of echinoderms, and 200 kinds of Scleractinia species (Dapeng Bay National Scenic Area Administration A,2005).

Table 3-22: Major coral species in Liuqiu Island

Family Name	Scientific Name
Milleporidae	*Millipore platyphlla*
Heliporoidae	*Heliopora coerulea*
Thamnasteriidae	*Psammocora contigua*
Acroporidae	*Pocillopora damicornis*
	Pocillopora verrucosa
Agariciidae	*Pavona decussata*
Poritidae	*Porites lutea*
Faviidae	*Favia favus*
	Leptoria phrygia

Source: Re-arrangement from Dapeng Bay National Scenic Area Administration A, 2005.

Sergestid shrimp fishing ground

The phytoplankton is very rich during winter, spring and summer in Kaoping canyon because of upswell. However, the water from the Kaoping river impacts the phytoplankton habitat and reduces the biomass. The habitat of Sergestid shrimp is in the depth about 50–230 m and the richest production is in March, April and December each year.

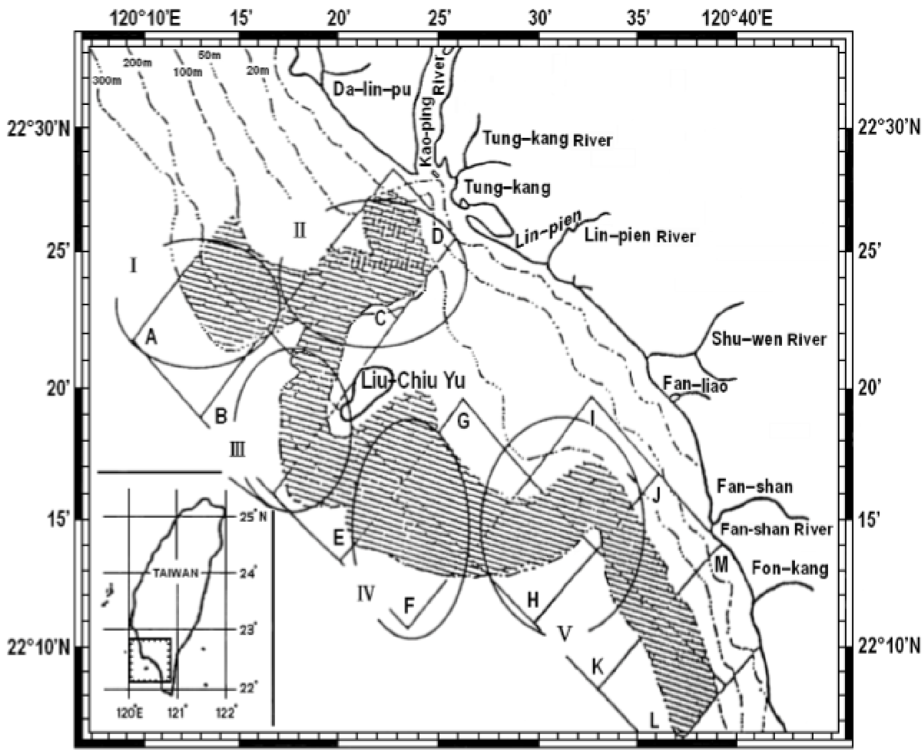


Figure 3-43: *Sergestid shrimp fishing ground (shadow area) in the coastal waters off southwestern Taiwan (Chen,1999)*

3.6 ENVIRONMENTAL PROTECTED AREAS AND SPECIES

To address the overuse of fisheries resource, launching of artificial reefs has been used worldwide for rebuilding of fishing grounds and enhancement of their environment. Artificial reefs can be diverted to multifunctional developments as angling sites and marine tourism attractions. Also, artificial reefs launched in reef protection zones form a barrier along the coast to protect taking of fisheries resources by illegal trawl fishing and thus safeguarding the environment of coastal habitats (Fisheries Agency, 2009). Liuqiu island has built five artificial reefs and those surrounding areas are announced as no-take marine protected area by Fisheries Agency. Pingtung County Government has established "Liuqiu Fisheries Resource Conservation Area" in 2000 and announced tht harvesting abalone, lobster, seaweed and agar is strict prohibited 200 meters seaward from the low tide.

Table 3-23: Relative protected areas in Liuqiu Island

Protected Area	Coordination	Water depth	Announced time
Yufu Village Artificial Reef Zones	N22°20'00",E120°22'20"	40 m	2000/1/5
Sanfu Village Artificial Reef Zones	N22°21'00",E120°19'00"	42 m	2000/1/5
Haikou Village Artificial Reef Zones	N22°06'24",E120°41'12"	35 m	2000/1/6
Nanfu Village Artificial Reef Zones	N22°19'05",E120°21'25"	35 m	2001/11/27
Lobster Cave Artificial Reef Zones	N22°20.700',E120°23.480'		2012/12/19
Liuqiu Fishery Conservation Zone	22°21.323'N 120°22.862'E	1 m to 12 m	2012/7/25
	22°20.520'N 120°21.772'E		

Source: Re-arrangement from Fisheries Agency, 2009.

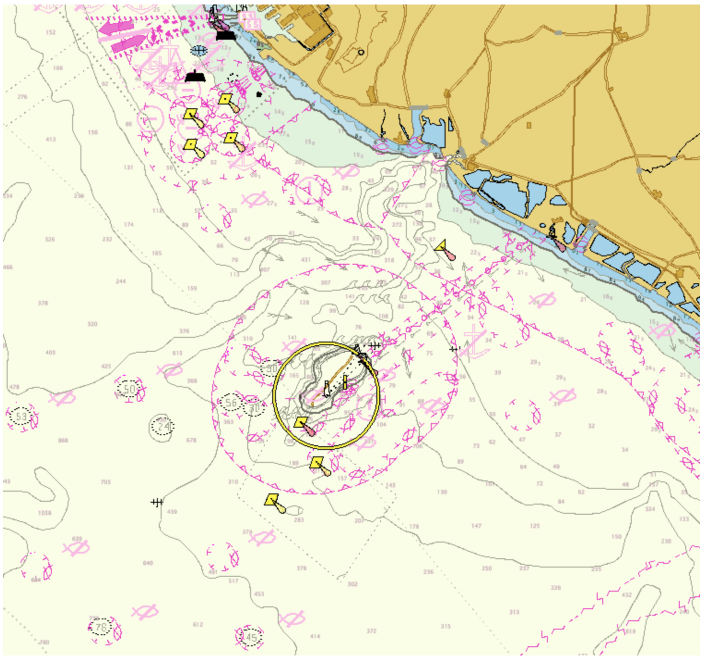


Figure 3-44: Protected areas in Liuqiu Island

3.7 KEY FLORA AND FAUNA SPECIES

Table 3-24 shows the protection level of major fish species, sea birds, crustacean, marine mammals and reptiles of Liuqiu island based on IUCN Red List. The related laws in Taiwan are also listed in the table.

Table 3-24: Liuqiu island fauna species with special protection status in IUCN and Taiwanese Law

Scientific name	Protection level	
Fish fauna	IUCN Red List[1]	Wildlife Conservation Act of Taiwan[2]
Thunnus alalunga	NT	No regulation
Thunnus obesus	VU	No regulation
Thunnus albacares	NT	No regulation
Xiphias gladius	LC	No regulation
Carcharhinus limbatus	NT	No regulation
Isurus oxyrinchus	VU	No regulation
Sea birds		
Accipiter soloensis	LC	II
Sterna albifrons	LC	II
Sterna sumatrana	LC	II
Lanius cristatus	LC	III
Crustacean		
Birgus latro	DD	I
Marine mammals		
Stenella coeruleoalba	LC	II
Orcinus orca	DD	II
Pseudorca crassidens	DD	II
Feresa attenuata	DD	II
Peponocephala electra	LC	II
Reptiles		
Chelonia mydas	EN	I

Source: Search and re-arrangement from Biodiversity Research Center B, 2014.

[1]LC: Least Concern; NT: Near Threatened; VU: Vulnerable; EN: Endangered; CR: Critically Endangered; EW: Extinct in the Wild; EX: Extinct

[2] I: Endangered Species；II: Rare and Valuable Species；III: Other Conservation - Deserving Wildlife

Among fish species, *Thunnus Obesus* is the Vulnerable (VU) species. In sea birds, there are several species listed as Least Concern (LC) in the IUCN list, and as level II to III protection respectively in the Wildlife Protection Act, Taiwan. *Chelonia mydas* is listed in the highest level of protection based on IUCN and Taiwan laws, which is listed as Endangered Species.

There are no flora species listed in IUCN Red List and laws in Taiwan. However, there are some species considered as rare and valuable species from literature (Table 3-25).

Table 3-25: Rare and Valuable Plant Species by other reports in Liuqiu Island

Family Name	Scientific Name
Asclepiadaceae	*Dregea volubilis* (L.F.) Benth.
Celastraceae	*Euonymus spraguei* Hayata
Euphorbiaceae	*Antidesma pentandrum* Merr. var. barbatum (Presl) Merr.
Lythraceae	*Pemphis acidula* J.R. Forst. & G. Forst.
Portulacaceae	*Portulaca*
Rubiaceae	*Guettarda speciosa* L.
	Ixora philippinensis Merr.
	Morinda citrifolia L.
Sapindaceae	*Allophylus timorensis* (DC.) Blume
Araceae	*Amorphophallus paeoniifolius* (Dennst.) Nicolson
Arecaceae	*Phoenix hanceana* Naudin

Source: Re-arrangement from Dapeng Bay National Scenic Area Administration B, 2005.

3.8 INTRODUCED MARINE SPECIES

In Liuqiu island, there are 109 introduced species, of which 30 species are invasive species. *Leucaena leucocephala* is one of the most serious invasion species among all. Within the introduced marine species, only *Saron marmoratus* is recorded to be used as aquarium species frequently. Table 3-26 is the introduced species in Liuqiu Island (TAIBIF 2014).

Table 3-26: Introduced species in Liuqiu Island (TAIBIF 2014)

Scientific name	introduced species		remark
	alien	invasive	
Abelmoschus moschatus	v		
Acacia farnesiana	v		
Achatina fulica	v	v	snail
Acridotheres javanicus	v	v	bird
Acridotheres tristis	v	v	bird
Agave sisalana	v	v	
Ageratum houstonianum	v	v	
Albizia lebbeck	v		
Alocasia macrorrhizos	v		
Alternanthera bettzickiana	v		
Alternanthera sessilis	v		
Alysicarpus rugosus	v	v	
Amaranthus spinosus	v		
Amaranthus viridis	v		
Amorphophallus paeoniifolius	v		
Annona squamosa	v		
Axonopus compressus	v	v	
Bauhinia variegata	v		
Bidens bipinnata	v		
Bidens pilosa var. minor	v		
Blechum pyramidatum	v		
Boehmeria nivea	v		
Cajanus cajan	v		
Capsicum frutescens	v		
Cardiospermum halicacabum	v	v	
Celosia argentea	v		
Chamaecrista mimosoides	v		
Chamaesyce hirta	v		
Chamaesyce hyssopifolia	v		
Chamaesyce serpens	v		
Chloris barbata	v		
Citrus limon	v		
Clitoria ternatea	v		
Conyza bonariensis	v		
Conyza canadensis	v	v	
Corchorus capsularis	v		
Cordia dichotoma	v		
Crotalaria pallida var. obovata	v	v	
Cycas revoluta	v		
Datura metel	v		
Desmodium scorpiurus	v		
Dimocarpus longan	v	v	
Euphorbia cyathophora	v		
Euphorbia heterophylla	v		
Euphorbia tirucalli	v		
Eutropis multifasciata	v	v	skink

Ficus benjamina	v		
Flueggea suffruticosa	v		
Gnaphalium calviceps	v		
Gomphrena celosioides	v	v	
Heliotropium indicum	v		
Hyptis suaveolens	v		
Indoennea bicolor	v	v	snail
Ipomoea batatas	v	v	
Ipomoea cairica	v	v	
Ipomoea indica	v		
Ipomoea obscura	v		
Ipomoea triloba	v		
Lantana camara	v		
Leucaena leucocephala	v	v	
Lycopersicon esculentum	v		
Lygodium japonicum	v	v	
Macrobrachium rosenbergii	v	v	freshwater shrimp
Malvastrum coromandelianum	v		
Malvastrum spicatum	v		
Mangifera indica	v		
Mimosa diplotricha	v		
Mollugo verticillata	v		
Momordica charantia	v		
Muntingia calabura	v	v	
Nicotiana plumbaginifolia	v		
Ocimum basilicum	v		
Ocimum sanctum	v		
Pachyrrhizus erosus	v		
Panicum maximum	v	v	
Panicum repens	v		
Paspalum conjugatum	v		
Passiflora foetidavar. Hispida	v		
Passiflora suberosa	v		
Phyllanthus debilis	v		
Physalis angulata	v		
Piper betle	v		
Pluchea indica	v		
Polygonum plebeium	v		
Pontoscolex corethrurus	v	v	earthworm
Pseudelephantopus spicatus	v		
Psidium guajava	v		
Rhynchelytrum repens	v	v	
Saron marmoratus	v		seawater shrimp
Scoparia dulcis	v	v	
Senna occidentalis	v		
Senna tora	v		
Setaria glauca	v		
Sida acuta	v		
Solanum capsicoides	v		
Solanum diphyllum	v	v	

Solanum erianthum	v		
Sonchus arvensis	v		
Sonchus oleraceus	v		
Stachytarpheta jamaicensis	v	v	
Synedrella nodiflora	v		
Syzygium samarangense	v		
Terminalia catappa	v		
Tridax procumbens	v	v	
Urena lobata	v		
Vaginulus alte	v	v	slug
Vigna radiata	v	v	
Vinca rosea	v		
Xanthium strumarium	v	v	

3.9 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

3.9.1 TOURISM

Liuqiu Island is targeted as one of the major tourism sites in south of Taiwan. The island is famous on its limestone rocks, caves, marine resources and endless sea views. Most visitors make a long day-trip from Kaohsiung or stay overnight. There are plenty of hotels, restaurants and a seaside camping area. Tourist number grows fastly in the past few years. Below are several attractions in the Liuqiu Island.

Table 3-27: Total tourists in Liuqiu island in 2009 to 2013

	2009	2010	2011	2012	2013
Total tourists	190,974	264,232	295,304	362,764	378,791

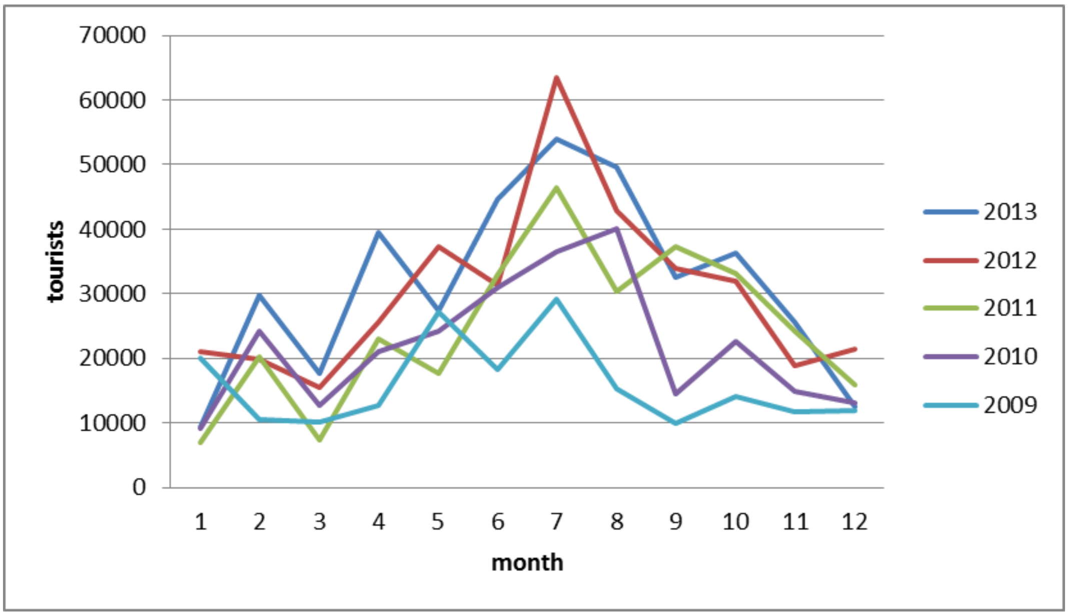


Figure 3-45: Monthly number of tourists in Liuqiu island in 2009 to 2013

Tidal Zone

Tidal area is one of the major attractions for watching fishes around coral reefs, sea cucumbers, sea urchins, starfish, hermit crabs and various fiddler crabs. The best places to observe the tidal areas of Liuqiu are Duozaiping, which is located between Camping Area and Sanfu Ecological Path. Duozaiping is about 1,600 meters long and 200 meters distant from the coast.

Figure 3-46: Duozaiping in Liuqiu island (Source: Liuqiu Tourism 2014)

Marine Activity

Liuqiu is suitable for land activities and water activities. For water activities, swimming, snorkeling, boating, diving, etc. are popular in the island. Baishawei, located on the southeastern shore of the island, has clear water and is suitable for exploring the underwater environment by glass bottom boat.

Figure 3-47: Baishawei in Liuqiu island (Source: Liuqiu Tourism 2014

Special landscape

Liuqiu Island is formed with coral reef and limestone. Distinctive rocks, caves compose unique landscapeattract visitors. Vase Rock is one of the most famous tourist attractions, and is often the first destination for visitors. It was formed by the rising of the coastal coral reefs. As evidenced by the newly-formed coral reefs around Vase Rock, Liuqiu is still under the influence of upward movement of the Earth's crust.

Figure 3-48: Vase Rock in Liuqiu island (Source: Tourism Bureau 2014)

Temples Culture

Fishing is the major livelihood in Liuqiu island and faith is very important to the local fishermen. It brings up the religious and temples in the island. Biyun Temple is one of the famous temples, which situated on the top of the hill at Daliaozhuang between Shangfu Village and Dafu Village. As it is said the Buddha of the Biyun Temple would satisfy people's praying, the temple attracts many worshippers.

Architectural Sites

There are several interest of architecture sites in the island, including lighthouses and local monument. Figure 3-49 illustrates the scenic spots in Liuqiu island.

Figure 3-49: Scenic spots in Liuqiu island (Source: Liuqiu Tourism 2014)

3.9.2 PORTS

There are two major ports in Liuqiu island, Baisha Port and Dafu Port. Baisha Port, which is situated near the beautiful ChungAu Beach, is the main port for tourists to get in or out of Liuqiu. Visitor Information Center at the port provides tourists with ferry service and also with tour boat and glass bottom boat services. In addition, Baisa Port is the best place to enjoy a fascinating night view in summer. Dafu Port is situated southeast of Liuqiu. As the main docking area for many deep-sea fishing boats, Dafu Port has a typical feature of fishery industry. A publicly operated ferry has 10 departures daily between Dafu Port and the main island.

Figure 3-50: All ports in Taiwan

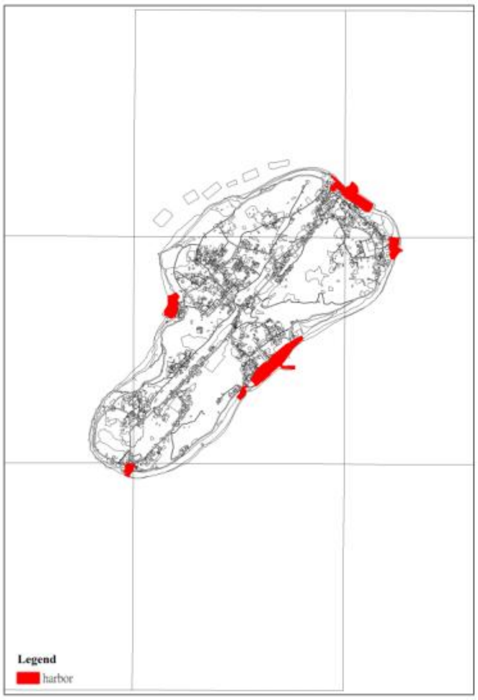


Figure 3-51: All ports in Liuqiu island

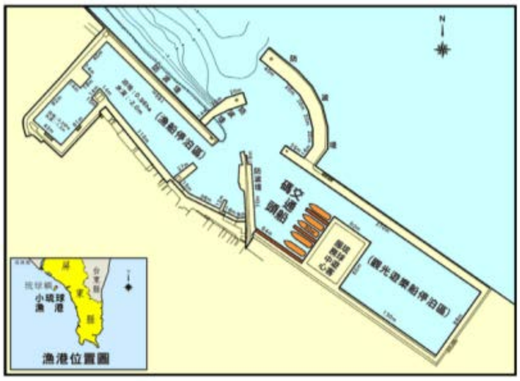


Figure 3-52: The major port in Liuqiu island – Baisa Tourist Port

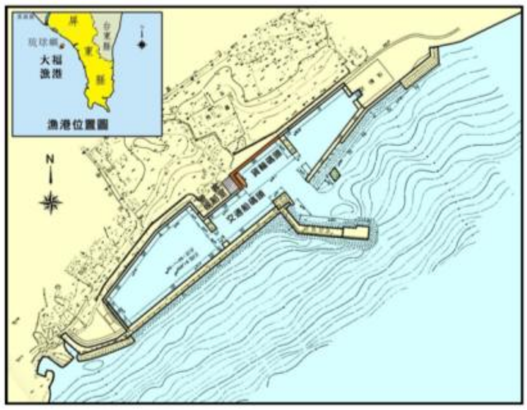


Figure 3-53: The major port in Liuqiu island – Dafu Fishing Port

3.9.3 AQUACULTURE

Every year, the warm Black Tide divides up into two currents flowing along both sides of the island. In addition, the water around the island is clean. Therefore, it is very suitable for net-cage fish farming. For years, the islanders raise grouper, cobia and greater amberjack with net-cage fish farming and export harvests to Japan. Since it is different from the traditional fish farming, the fish farm is one of the most popular tourist attractions on the island.

Figure 3-54: Aquaculture in Liuqiu island

3.9.4 ENERGY SUPPLY INSTALLATIONS

In Liuqiu island, all water and electricity supply is transmitted from the main island of Taiwan. There are six submarine cables between the main island of Taiwan and Liuqiu island, including water pipes, electricity wires and optical fiber.

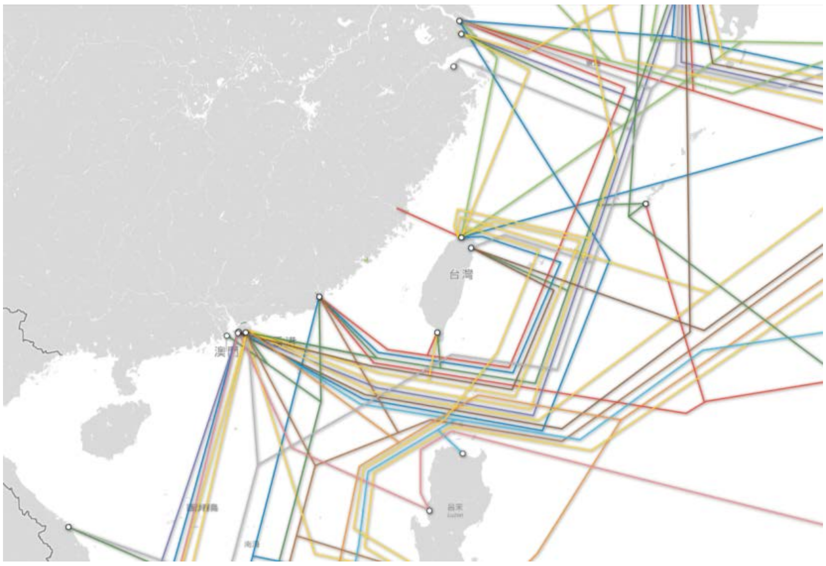


Figure 3-55: Submarine cables of Taiwan (Reference: TeleGeography 2014)

Figure 3-56: Submarine cables around Liuqiu island

3.9.5 MARINE TRAFFIC

The navigation routes and vessel information with live tracking can be found in the automatic vessel identification system in Taiwan.

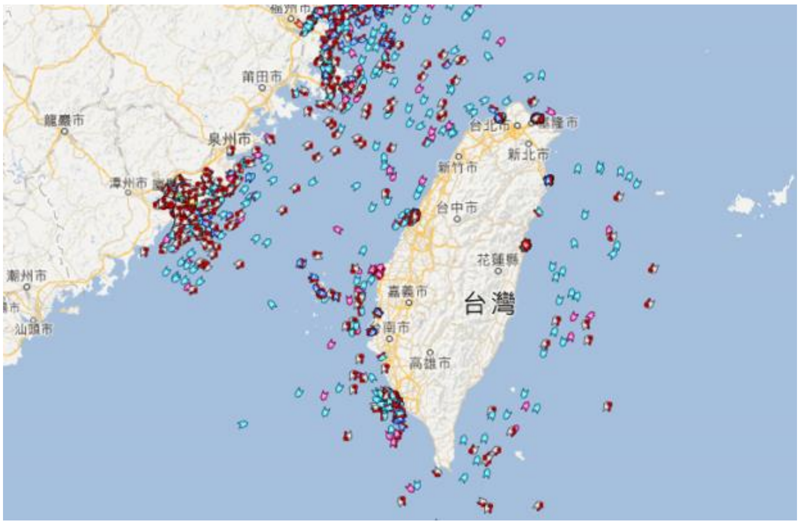
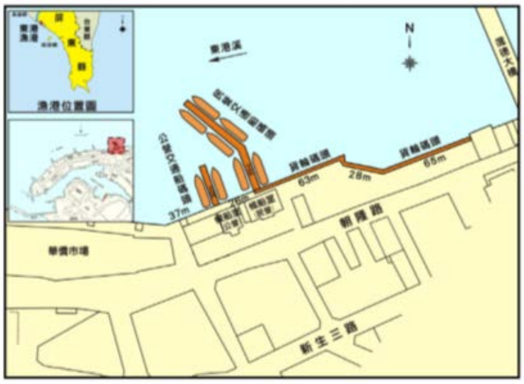


Figure 3-57: The automatic vessel identification system in Taiwan (Source: Harbor & Marine Technology Center I.O.T.,M.O.T.C., Taiwan)



Donggang Port

The major marine traffic is taking ferry from Donggang Port to Liuqiu island. There are two types of ferry in Donggang Port. Privately operated ferry usually arrives Baisha Port and the distance is about 8 nautical miles. Publicly operated ferry usually arrives Dafu Port and the distance is about 8.9 nautical miles.

3.9.6 CULTURAL; ARCHAEOLOGICAL AND SUBAQUATIC PATRIMONY

There are 60 to 70 temples of various sizes in the island. As most of the ancestors of Liuqiu come from Quanzhou and Zhangzhou of Fujian, Mainland China, and the gods worshiped on the island are gods from these places. Although Christianity was brought to Liuqiu by the Dutch (there is still a Presbyterian Church on the island), Catholicism was brought by the Spanish, Shinto (Catholicism and Sikhism) and Buddhism (Tiantai Zong and Zhen Zong) were brought by the Japanese, these religions died out as the political scene changed and the original gods of Liuqiu were restored. The people in the town believe in different gods that the gods can determine everything. They thank Guanyin with elaborate ceremonies and dramas in every single temple of each village, and this festival lasts for 50 to 60 days. This is one of the major events on the island and it has had a great impact on economic development. All the residents of Liuqiu will return to their villages and take part in "Welcoming the God" event which is held once every three years. This is the most important festival in the town.

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3.11 APPENDICES

Appendix 1 Benthic communities by trawing in spring around Liuqiu island offshore area

Kaohsiung site	Donggang site			Fengkang site		
depth(m）	depth(m）			depth(m）		
100 200 300	100	200	300	100	200	300
Fish fauna	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**
no data	*Chiloscyllium indicum*	*Galeus sauteri*	*Chimaera phanthsma*	*Galeus sauteri*	*Hydrolagus ogilbyi*	*Hydrolagus ogilbyi*
	Galeus sauteri	*Eridacnis radcliffei*	*Cirrhoscyllium expolitum*	*Miroscyllium sheikoi*	*Cirrhoscyllium expolitum*	*Cirrhoscyllium expolitum*
Shrimp	*Dasyatis akajei*	*Miroscyllium sheikoi*	*Apristurus macrorhynchus*	*Narke japonica*	*Apristurus macrorhynchus*	*Galeus sauteri*
no data	*Gen. Sp.*	*Gen. Sp.*	*Galeus sauteri*	*Gen. Sp.*	*Cephaloscyllium isabellum*	*Miroscyllium sheikoi*
	Dysomma anguillaris	*Nemichthys scolopaceus*	*Eridacnis radcliffei*	*Ophichthus apicalis*	*Galeus sauteri*	*Raja kwangtungensis*
Cephalopoda	*Gen. Sp.*	*Acromycter nezumi*	*Miroscyllium sheikoi*	*Nemichthys scolopaceus*	*Eridacnis radcliffei*	*Nemichthys scolopaceus*
no data	*Gen. Sp.*	*Bathymyrus simus*	*Etmopterus pusillus*	*Bathymyrus simus*	*Miroscyllium sheikoi*	*Bathycongrus retrotinctus*
Crab and others	*Nemichthys scolopaceus*	*Saurenchelys fierasfer*	*Squaliolus laticaudus*	*Gen. Sp.*	*Squaliolus laticaudus*	*Rhynchoconger brevirostris*
no data	*Bathymyrus simus*	*Maurolicus muelleri*	*Raja tengu*	*Saurenchelys fierasfer*	*Narke japonica*	*Saurenchelys fierasfer*
	Conger myriaster	*Polyipnus sp.*	*Gen. Sp.*	*Gonorynchus abbreviatus*	*Raja tengu*	*Diplophos orientalis*
	Saurenchelys fierasfer	*Harpadon microchir*	*Ophichthus urolophus*	*Polyipnus sp.*	*Gen. Sp.*	*Maurolicus muelleri*
	Polyipnus sp.	*Diaphus nielseni*	*Nemichthys scolopaceus*	*Ateleopus japonicus*	*Ophichthus urolophus*	*Polyipnus sp.*
	Chloropthalmus nigromarginatus	*Diaphus signatus*	*Acromycter nezumi*	*Harpadon microchir*	*Nemichthys scolopaceus*	*Astronesthes lucifer*
	Harpadon microchir	*Lestrolepis japonica*	*Bathymyrus simus*	*Saurida elongata*	*Bathymyrus simus*	*Chauliodus sloani*
	Diaphus signatus	*Neoscopelus microchir*	*Parabathymyrus macrophthalmus*	*Saurida undosquamis*	*Conger japonicus*	*Diaphus bertelseni*
	Saurida undosquamis	*Benthosema ptetotum*	*Rhynchoconger brevirostris*	*Lestrolepis japonica*	*Rhynchoconger brevirostris*	*Lestrolepis japonica*

Benthosema ptetotum	*Pyramodon ventralis*	*Saurenchelys fierasfer*	*Benthosema ptetotum*	*Saurenchelys fierasfer*	*Neoscopelus microchir*
Hoplobrotula armata	*Hoplobrotula armata*	*Dolicholgus longirostris*	*Gadella jordani*	*Gonorynchus abbreviatus*	*Benthosema ptetotum*
Neobythites nigromaculatus	*Neobythites nigromaculatus*	*Alepocephalus bicolor*	*Laemonema sp.*	*Glossanodon semifasciatus*	*Diaphus splendidus*
Bregmaceros japonicus	*Neobythites stigmosus*	*Maurolicus muelleri*	*Bregmaceros japonicus*	*Alepocephalus bicolor*	*Glyptophidium japonicum*
Sargocentron sp.	*Caelorinchus kishinouyei*	*Polyipnus sp.*	*Hoplostethus crassiapinus*	*Argyropelecus aculeatus*	*Hoplobrotula armata*
Minous quincarinatus	*Coryphaenoides liocephalus*	*Polyipnus spinifer*	*Scorpaenodes sp.*	*Polyipnus sp.*	*Neobythites stigmosus*
Scorpaenodes sp.	*Malacocephalus laevis*	*Borostomias elucens*	*Setarches longimanus*	*Astronesthes trifibulatus*	*Caelorinchus asteroides*
Setarches longimanus	*Gadella jordani*	*Ateleopus japonicus*	*Peristedion liorhynchus*	*Chloropthalmus borealis*	*Caelorinchus gilberti*
Lepidotrigla alata	*Bregmaceros japonicus*	*Ijimaia dofleini*	*Peristedion nierstraszi*	*Chloropthalmus nigromarginatus*	*Hymenocephalus longiceps*
Inegocia guttata	*Chaunax abei*	*Chloropthalmus nigromarginatus*	*Ratabulus megacephalus*	*Harpadon microchir*	*Malacocephalus laevis*
Onigocia spinosa	*Hoplostethus crassiapinus*	*Harpadon microchir*	*Acropoma hanedai*	*Lestrolepis japonica*	*Ventrifossa macroptera*
Platycephalus indicus	*Setarches longimanus*	*Diaphus nielseni*	*Acropoma japonicum*	*Neoscopelus microchir*	*Ventrifossa rhipidodorsalis*
Ratabulus megacephalus	*Peristedion orientale*	*Lestrolepis japonica*	*Apogon ellioti*	*Benthosema ptetotum*	*Gadella jordani*
Acropoma japonicum	*Satyrichthys amiscus*	*Neoscopelus microchir*	*Apogon kiensis*	*Diaphus splendidus*	*Bregmaceros japonicus*
Doederleinia berycoides	*Hoplichthys langsdorfii*	*Benthosema ptetotum*	*Apogon lineatus*	*Lampanyctus sp.*	*Hoplostethus crassiapinus*
Anthias sp.	*Apogon kiensis*	*Diaphus splendidus*	*Archamia sp.*	*Polymixia berndti*	*Satyrichthys hians*
Apogon carinatus	*Champsodon guentheri*	*Polymixia berndti*	*Trachurus japonicus*	*Pyramodon ventralis*	*Howella zina*
Apogon kiensis	*Benthodesmus trnuis*	*Glyptophidium japonicum*	*Gazza minuta*	*Hoplobrotula armata*	*Promethichthys prometheus*
Siphamia majimae	*Trichiurus lepturus*	*Hoplobrotula armata*	*Leiognathus bindus*	*Neobythites nigromaculatus*	*Benthodesmus trnuis*

Carangoides hedlandensis	*Aseraggodes kobensis*	*Neobythites nigromaculatus*	*Leiognathus equulus*	*Neobythites stigmosus*	*Chascanopsetta lugubris*
Gazza minuta	*Cynoglossus suyoui*	*Neobythites stigmosus*	*Leiognathus nuchalis*	*Ophidion asiro*	*Symphurus strictus*
Leiognathus splendens	*Symphurus strictus*	*Caelorinchus asteroides*	*Leiognathus splendens*	*Caelorinchus formosanus*	
Dentex tumifrons		*Caelorinchus formosanus*	*Secutor ruconius*	*Antigonia capros*	**Shrimp**
Nemipterus thosaporni	**Shrimp**	*Caelorinchus gilberti*	*Nemipterus thosaporni*	*Caelorinchus kishinouyei*	no data
Upeneus japonicus	no data	*Caelorinchus kishinouyei*	*Argyrosomus argentatus*	*Hymenocephalus longiceps*	
Acanthocepola indica		*Caelorinchus macrochir*	*Upeneus japonicus*	*Malacocephalus laevis*	**Cephalopoda**
Champsodon guentheri	**Cephalopoda**	*Coryphaenoides liocephalus*	*Upeneus vittatus*	*Gadella jordani*	*Austrossia bipapillata*
Parapercis sexfasciata	no data	*Hymenocephalus longiceps*	*Taenioides cirratus*	*Physiculus japonicus*	*Chiroteuthis imperator*
Uranoscopus oligolepis		*Malacocephalus laevis*	*Sphyraena japonica*	*Bregmaceros japonicus*	*Octopus sp.*
Bathycallionymus formosanus	**Crab and others**	*Ventrifossa macroptera*	*Trichiurus lepturus*	*Lophiomus setigerus*	*Pteroctopus sp. TW25*
Taenioides cirratus	no data	*Ventrifossa rhipidodorsalis*	*Psenopsis anomala*	*Lophius litulon*	
Sphyraena japonica		*Gadella jordani*	*Chascanopsetta lugubris*	*Chaunax abei*	**Crab and others**
Trichiurus lepturus		*Bregmaceros japonicus*	*Japonolaeops dentatus*	*Halieutaea fizsmonsi*	no data
Psenopsis anomala		*Lophiomus setigerus*	*Symphurus strictus*	*Malthopsis annulifera*	
Arnoglossus polyspilus		*Diretmus argenteus*		*Malthopsis luteus*	
Crossorhombus azureus		*Hoplostethus crassiapinus*	**Shrimp**	*Hoplostethus crassiapinus*	
Engyprosopon maldivensis		*Setarches longimanus*	no data	*Cyttopsis rosea*	
Japonolaeops dentatus		*Peristedion orientale*		*Neomerinthe procurva*	
Pseudorhombus cinnamoneus		*Satyrichthys amiscus*	**Cephalopoda**	*Ocosia fasciata*	
Pseudorhombus quinquocellatus		*Howella zina*	*Sepia esculenta*	*Plectrogenium nanum*	

Cynoglossus itinus	*Champsodon guentheri*	*Sepia (Platysepia) madokai*	*Setarches longimanus*
Symphurus strictus	*Taenioides cirratus*	*Sepia (Doratosepion) vietnamica*	*Peristedion liorhynchus*
	Promethichthys prometheus	*Sepia (Doratosepion) sp. TW18*	*Peristedion orientale*
Shrimp	*Benthodesmus trnuis*	*Uroteuthis (Photololigo) edulis*	*Pterygotrigla macrorhynchus*
no data	*Trichiurus lepturus*	*Abralia multihamata*	*Bembradium roseum*
	Psenes whiteleggii	*Chiroteuthis imperator*	*Hoplichthys langsdorfii*
Cephalopoda	*Chascanopsetta lugubris*	*Octopus sp. TW33*	*Acropoma japonicum*
Sepia esculenta	*Symphurus strictus*	*Pteroctopus sp. TW25*	*Doederleinia berycoides*
Sepia pharaonis			*Malakichthys wakiyai*
Sepia (Doratosepion) vietnamica	**Shrimp**	**Crab and others**	*Synagrops japonicus*
Sepia (Doratosepion) sp.	no data	no data	*Synagrops philppinensis*
Sepia sp.			*Synagrops serratospinosus*
Metasepia tullbergi	**Cephalopoda**		*Plectranthias sagamiensis*
Austrossia bipapillata	*Uroteuthis (Photololigo) edulis*		*Priacanthus macracanthus*
Euprymna berryi			*Priacanthus tayenus*
Uroteuthis (Photololigo) edulis	**Crab and others**		*Dentex tumifrons*
Abralia multihamata	no data		*Atrobucca nibe*
Cistopus indicus			*Champsodon guentheri*
Octopus marginatus			*Parapercis muronis*
Octopus sp. TW33			*Bembrops curvatura*

Crab and others

no data

Chrionema chlorotaenia

Foetorepus masudai

Promethichthys prometheus

Benthodesmus trnuis

Trichiurus lepturus

Psenopsis anomala

Psenes whiteleggii

Chascanopsetta lugubris

Japonolaeops dentatus

Aseraggodes kaianus

Synaptura annularis

Cynoglossus suyoui

Symphurus strictus

Shrimp

no data

Cephalopoda

Sepia (Doratosepion) sp.

Sepiolina nipponensis

Abralia multihamata

Octopus sp. TW33

	Pteroctopus sp. TW25
	Crab and others
	no data

Appendix 2 Benthic communities by trawing in summer around Liuqiu island offshore area

Kaohsiung site	Donggang site			Fengkang site		
depth(m)	depth(m)			depth(m)		
100 200 300	100	200	300	100	200	300
Fish fauna	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**
no data	*Apristurus macrorhynchus*	*Cirrhoscyllium expolitum*	*Apristurus macrorhynchus*	*Ophichthus urolophus*	*Galeus sauteri*	*Paramyxine sp.*
	Galeus sauteri	*Galeus sauteri*	*Galeus sauteri*	*Bathymyrus simus*	*Eridacnis radcliffei*	*Hydrolagus ogilbyi*
Shrimp	*Squaliolus laticaudus*	*Benthobatis moresbyi*	*Etmopterus pusillus*	*Conger japonicus*	*Ophichthus urolophus*	*Cephaloscyllium isabellum*
no data	*Gymnothorax phaasmatodes*	*Gen. Sp.*	*Squaliolus laticaudus*	*Saurida undosquamis*	*Bathymyrus simus*	*Galeus sauteri*
	Ophichthus urolophus	*Ophichthus urolophus*	*Torpedo nobilina*	*Lestrolepis japonica*	*Parabathymyrus macrophthalmus*	*Eridacnis radcliffei*
Cephalopoda	*Branchysomorphis cirrhocheilos*	*Nemichthys scolopaceus*	*Benthobatis moresbyi*	*Benthosema ptetotum*	*Chloropthalmus borealis*	*Etmopterus splendidus*
no data	*Nemichthys scolopaceus*	*Bathymyrus simus*	*Raja tengu*	*Caelorinchus formosanus*	*Lestrolepis japonica*	*Squatina nebulosa*
Crab and others	*Bathymyrus simus*	*Saurenchelys fierasfer*	*Gen. Sp.*	*Bregmaceros japonicus*	*Benthosema ptetotum*	*Ophichthus urolophus*
no data	*Saurida elongata*	*Diplophos taenia*	*Ophichthus urolophus*	*Lophius litulon*	*Polymixia berndti*	*Bathymyrus simus*

Saurida undosquamis	*Chloropthalmus nigromarginatus*	*Nemichthys scolopaceus*	*Antennarius striatus*	*Hoplobrotula armata*	*Rhynchoconger brevirostris*
Lestrolepis japonica	*Lestrolepis japonica*	*Bathymyrus simus*	*Lepidotrig;a japonica*	*Neobythites stigmosus*	*Chloropthalmus nigromarginatus*
Benthosema ptetotum	*Neoscopelus microchir*	*Saurenchelys fierasfer*	*Onigocia spinosa*	*Caelorinchus formosanus*	*Lestrolepis japonica*
Neobythites nigromaculatus	*Benthosema ptetotum*	*Alepocephalus bicolor*	*Acropoma japonicum*	*Lophiomus setigerus*	*Neoscopelus microchir*
Hippocampus erinaceus	*Diaphus splendidus*	*Polyipnus spinifer*	*Apogon fasciatus*	*Malthopsis annulifera*	*Benthosema ptetotum*
Fistularia petimba	*Polymixia berndti*	*Astronesthes lucifer*	*Apogon kiensis*	*Hoplostethus crassiapinus*	*Diaphus splendidus*
Antennarius striatus	*Hoplobrotula armata*	*Chloropthalmus borealis*	*Apogon striatus*	*Scorpaenodes sp.*	*Polymixia berndti*
Dactyloptena orientalis	*Neobythites nigromaculatus*	*Lestrolepis japonica*	*Trichiurus lepturus*	*Setarches longimanus*	*Hoplobrotula armata*
Neomerinthe procurva	*Neobythites stigmosus*	*Neoscopelus microchir*	*Chascanopsetta lugubris*	*Synagrops japonicus*	*Neobythites nigromaculatus*
Neosebastes entaxis	*Caelorinchus formosanus*	*Diaphus splendidus*	*Symphurus strictus*	*Champsodon guentheri*	*Neobythites stigmosus*
Setarches longimanus	*Caelorinchus kishinouyei*	*Pyramodon ventralis*		*Foetorepus masudai*	*Caelorinchus asteroides*
Pterygotrigla hemistica	*Gadella jordani*	*Glyptophidium japonicum*	**Shrimp**	*Rexea prometheoides*	*Caelorinchus formosanus*
Lepidotrig;a japonica	*Hoplostethus crassiapinus*	*Hoplobrotula armata*	no data	*Trichiurus lepturus*	*Caelorinchus kishinouyei*
Bembras japonicus	*Setarches longimanus*	*Neobythites nigromaculatus*		*Psenes whiteleggii*	*Malacocephalus laevis*
Inegocia japonica	*Pterygotrigla hemistica*	*Neobythites stigmosus*	**Cephalopoda**	*Chascanopsetta lugubris*	*Lophiomus setigerus*
Acropoma hanedai	*Peristedion orientale*	*Caelorinchus kishinouyei*	no data		*Lophius litulon*
Doederleinia berycoides	*Synagrops japonicus*	*Hymenocephalus longiceps*		**Shrimp**	*Chaunax abei*
Synagrops japonicus	*Rexea prometheoides*	*Malacocephalus laevis*	**Crab and others**	no data	*Halieutaea fizsmonsi*

Apogon carinatus	*Trichiurus lepturus*	*Gadella jordani*	no data		*Hoplostethus crassiapinus*
Apogon fasciatus	*Psenes whiteleggii*	*Bregmaceros japonicus*		**Cephalopoda**	*Plectrogenium nanum*
Apogon kiensis	*Chascanopsetta lugubris*	*Hoplostethus crassiapinus*		*Abralia andamanica*	*Setarches longimanus*
Apogon lineatus		*Setarches longimanus*		*Histioteuthis celetaria*	*Pterygotrigla multiocellata*
Decapterus ruselli	**Shrimp**	*Scorpaena ornaria*		*Octopus sp. TW32*	*Peristedion orientale*
Leiognathus bindus	no data	*Peristedion orientale*			*Satyrichthys amiscus*
Leiognathus elongatus		*Acropoma hanedai*		**Crab and others**	*Acropoma japonicum*
Leiognathus splendens	**Cephalopoda**	*Synagrops japonicus*		no data	*Synagrops japonicus*
Dentex tumifrons	no data	*Promethichthys prometheus*			*Foetorepus masudai*
Argyrops bleekeri		*Rexea prometheoides*			*Rexea prometheoides*
Nemipterus japonicus	**Crab and others**	*Neoepinnula orientalis*			*Trichiurus lepturus*
Atrobucca nibe	no data	*Trichiurus lepturus*			*Chascanopsetta lugubris*
Upeneus japonicus		*Psenes whiteleggii*			*Symphurus strictus*
Champsodon guentheri		*Chascanopsetta lugubris*			
Uranoscopus oligolepis		*Symphurus strictus*			**Shrimp**
Repomucenus planus					no data
Trichiurus lepturus		**Shrimp**			
Psenes whiteleggii		no data			**Cephalopoda**
Psettina tosana					*Sepia (Doratosepion) longipes*
Japonolaeops dentatus		**Cephalopoda**			*Austrossia bipapillata*

Pseudorhombus quinquocellatus	no data	*Uroteuthis (Photololigo) edulis*
Symphurus strictus		*Abralia astrosticta*
Amblyrhynchotes hypselogenion	**Crab and others**	*Octopus sp. TW31*
	no data	
Shrimp		**Crab and others**
no data		no data
Cephalopoda		
no data		
Crab and others		
no data		

Appendix 3 Benthic communities by trawing in autumn around Liuqiu island offshore area

Kaohsiung site			Donggang site			Fengkang site		
depth(m)			depth(m)			depth(m)		
100	200	300	100	200	300	100	200	300
Fish fauna	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**
Galeus sauteri	*Chloropthalmus nigromarginatus*	*Chloropthalmus nigromarginatus*	*Ophichthus apicalis*	*Cirrhoscyllium expolitum*	*Muraenesox cinereus*	*Galeus sauteri*	*Chloropthalmus nigromarginatus*	*Chimaera phanthsma*
Gen. Sp.	*Harpadon*	*Harpadon*	*Muraenesox*	*Eridacnis radcliffei*	*Chloropthalmus*	*Etmopterus*	*Hoplobrotula*	*Galeus sauteri*

	microchir	*microchir*	*cinereus*		*nigromarginatus*	*splendidus*	*armata*	
Bathymyrus simus	*Diaphus splendidus*	*Diaphus splendidus*	*Chloropthalmus nigromarginatus*	*Miroscyllium sheikoi*	*Diaphus splendidus*	*Dasyatis akajei*	*Neobythites nigromaculatus*	*Etmopterus splendidus*
Saurenchelys fierasfer	*Hoplobrotula armata*	*Hoplobrotula armata*	*Saurida elongata*	*Gen. Sp.*	*Hoplobrotula armata*	*Gen. Sp.*	*Dactyloptena peterseni*	*Gen. Sp.*
Harpadon microchir	*Neobythites nigromaculatus*	*Doederleinia berycoides*	*Trachinocephalus myops*	*Ophichthus urolophus*	*Neobythites nigromaculatus*	*Bathymyrus simus*	*Pterygotrigla hemistica*	*Ophichthus urolophus*
Saurida undosquamis	*Pterygotrigla hemistica*	*Synagrops japonicus*	*Priacanthus macracanthus*	*Muraenesox cinereus*	*Pterygotrigla hemistica*	*Saurenchelys fierasfer*	*Platycephalus indicus*	*Conger japonicus*
Diaphus splendidus	*Doederleinia berycoides*	*Psenes whiteleggii*	*Branchiostegus auratus*	*Nemichthys scolopaceus*	*Synagrops japonicus*	*Saurida undosquamis*	*Doederleinia berycoides*	*Alepocephalus bicolor*
Neobythites nigromaculatus	*Trichiurus lepturus*		*Trachurus japonicus*	*Bathymyrus simus*	*Decapterus tabl*	*Benthosema ptetotum*	*Synagrops japonicus*	*Polyipnus sp.*
Setarches longimanus			*Leiognathus splendens*	*Rhynchoconger brevirostris*	*Psenes whiteleggii*	*Hoplobrotula armata*	*Priacanthus cruentatus*	*Astronesthes lucifer*
Pterygotrigla hemistica	**Shrimp**	**Shrimp**	*Nemipterus japonicus*	*Polyipnus sp.*		*Neobythites nigromaculatus*	*Branchiostegus auratus*	*Chloropthalmus nigromarginatus*
Acropoma japonicum	no data	no data	*Atrobucca nibe*	*Astronesthes lucifer*	**Shrimp**	*Caelorinchus kishinouyei*	*Decapterus kurroides*	*Lestrolepis japonica*
Synagrops philppinensis	**Cephalopoda**	**Cephalopoda**	*Johnius amblycephalus*	*Chauliodus sloani*	no data	*Bregmaceros japonicus*	*Decapterus tabl*	*Neoscopelus microchir*
Apogon striatus	*Sepia esculenta*	*Nototodarus hawaiiensis*	*Johnius macrorhynus*	*Chloropthalmus nigromarginatus*		*Neomerinthe procurva*	*Atrobucca nibe*	*Diaphus splendidus*
Trachurus japonicus	*Sepia (Doratosepion) sp.*	*Chiroteuthis imperator*	*Terapon jarbua*	*Lestrolepis japonica*	**Cephalopoda**	*Pterygotrigla hemistica*		*Hoplobrotula armata*
Leiognathus splendens	*Sepiolina nipponensis*		*Trichiurus lepturus*	*Neoscopelus microchir*	*Sepia esculenta*	*Onigocia spinosa*	**Shrimp**	*Neobythites stigmosus*
Dentex tumifrons	*Abralia andamanica*	**Crab and others**		*Benthosema ptetotum*	*Metasepia tullbergi*	*Acropoma japonicum*	no data	*Caelorinchus formosanus*
Nemipterus		no data	**Shrimp**	*Diaphus*	*Austrossia*	*Priacanthus*		*Hymenocephalus*

japonicus			*splendidus*	*bipapillata*	*macracanthus*		*longiceps*
Atrobucca nibe	**Crab and others**	no data	*Polymixia japonicus*	*Sepiolina nipponensis*	*Apogon kiensis*	**Cephalopoda**	*Malacocephalus laevis*
Upeneus japonicus	no data		*Hoplobrotula armata*	*Abralia andamanica*	*Apogon striatus*	*Sepia (Rhombosepion) vossi*	
Psenopsis anomala		**Cephalopoda**	*Neobythites nigromaculatus*	*Histioteuthis celetaria*	*Trachurus japonicus*	*Sepia (Doratosepion) sp. TW18*	**Shrimp**
Chascanopsetta lugubris		*Sepia esculenta*			*Nemipterus japonicus*	*Sepia (Doratosepion) sp.*	no data
		Sepia pharaonis	**Shrimp**	**Crab and others**	*Atrobucca nibe*	*Abralia andamanica*	
Shrimp		*Sepia recurvirostra*	no data	no data	*Uranoscopus oligolepis*	*Abralia multihamata*	**Cephalopoda**
no data		*Sepia (Doratosepion) vietnamica*			*Rexea prometheoides*	*Psenes whiteleggii*	*Abralia andamanica*
		Sepia (Rhombosepion) vossi	**Cephalopoda**		*Trichiurus lepturus*	*Chascanopsetta lugubris*	*Abralia multihamata*
Cephalopoda		*Sepia (Doratosepion) sp.*	*Sepia (Doratosepion) sp. TW18*		*Psenopsis anomala*	*Symphurus strictus*	*Nototodarus hawaiiensis*
Sepia esculenta		*Metasepia tullbergi*	*Sepiolina nipponensis*				*Chiroteuthis imperator*
Sepia pharaonis		*Uroteuthis (Photololigo) edulis*	*Abralia andamanica*		**Shrimp**	**Crab and others**	*Octopus sp. TW33*
Sepia		*Abralia*	*Octopus sp. TW36*		no data	no data	*Pteroctopus sp.*

recurvirostra	*andamanica*			*TW25*
Sepia (Rhombosepion) vossi	*Octopus marginatus*			
Metasepia tullbergi	*Pteroctopus sp. TW25*	**Crab and others**	**Cephalopoda**	**Crab and others**
Uroteuthis (Photololigo) edulis	*Trichiurus lepturus*	no data	*Sepia esculenta*	no data
Abralia multihamata	*Psenes whiteleggii*		*Sepia pharaonis*	
Chiroteuthis imperator	*Symphurus strictus*		*Sepia recurvirostra*	
Octopus marginatus			*Sepia (Rhombosepion) vossi*	
Octopus cf. marginatus	**Crab and others**		*Metasepia tullbergi*	
	no data		*Euprymna berryi*	
Crab and others			*Uroteuthis (Photololigo) edulis*	
no data			*Abralia andamanica*	
			Abralia multihamata	
			Pteroctopus sp. TW25	

Crab and others

no data

Appendix 4 Benthic communities by trawing in winter around Liuqiu island offshore area

Kaohsiung site			Donggang site			Fengkang site		
depth(m）			depth(m）			depth(m）		
100	200	300	100	200	300	100	200	300
Fish fauna	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**	**Fish fauna**
Paramyxine sp.	*Paramyxine sp.*	*Galeus sauteri*	*Ophichthus macrochir*	*Paramyxine sp.*	*Chimaera phanthsma*	*Eridacnis radcliffei*	*Galeus sauteri*	*Hydrolagus ogilbyi*
Cirrhoscyllium expolitum	*Chimaera phanthsma*	*Etmopterus lucifer*	*Thryssa setirostris*	*Galeus sauteri*	*Cirrhoscyllium expolitum*	*Etmopterus splendidus*	*Etmopterus splendidus*	*Galeus sauteri*
Galeus sauteri	*Galeus sauteri*	*Bathymyrus simus*	*Saurida elongata*	*Eridacnis radcliffei*	*Apristurus macrorhynchus*	*Nemichthys scolopaceus*	*Strophidon sathete*	*Etmopterus lucifer*
Gen. Sp.	*Eridacnis radcliffei*	*Saurenchelys fierasfer*	*Saurida undosquamis*	*Etmopterus splendidus*	*Galeus sauteri*	*Bathymyrus simus*	*Dysomma anguillaris*	*Polyipnus stereope*
Ophichthus apicalis	*Squalus japonicus*	*Alepocephalus bicolor*	*Parapterois heterura*	*Dysomma anguillaris*	*Dysomma anguillaris*	*Thryssa setirostris*	*Ophichthus urolophus*	*Ateleopus purpureus*
Nemichthys scolopaceus	*Etmopterus splendidus*	*Argyropelecus aculeatus*	*Inegocia japonica*	*Ophichthus urolophus*	*Ophichthus urolophus*	*Chloropthalmus nigromarginatus*	*Muraenesox cinereus*	*Ijimaia dofleini*
Bathymyrus simus	*Gen. Sp.*	*Astronesthes lucifer*	*Acropoma japonicum*	*Bathymyrus simus*	*Bascanichthys kirkii*	*Saurida undosquamis*	*Bathymyrus simus*	*Chloropthalmus nigromarginatus*
Saurenchelys fierasfer	*Nemichthys scolopaceus*	*Chauliodus sloani*	*Apogon carinatus*	*Argentina kagoshimae*	*Bathymyrus simus*	*Diaphus splendidus*	*Gonostoma elongatum*	*Neoscopelus microchir*
Chloropthalmus nigromarginatus	*Bathymyrus simus*	*Lestrolepis japonica*	*Apogon kiensis*	*Astronesthes lucifer*	*Glossanodon semifasciatus*	*Bregmaceros japonicus*	*Astronesthes lucifer*	*Diaphus splendidus*

Harpadon microchir *Lestrolepis japonica* *Diaphus splendidus* *Hoplobrotula armata* *Neobythites nigromaculatus* *Monocentris japonicus* *Setarches longimanus* *Pterygotrigla hemistica* *Acropoma hanedai* *Acropoma japonicum* *Synagrops japonicus* *Priacanthus macracanthus* *Branchiostegus auratus* *Trachurus japonicus* *Atrobucca nibe*	*Astronesthes lucifer* *Chauliodus sloani* *Harpadon microchir* *Lestrolepis japonica* *Neoscopelus microchir* *Benthosema ptetotum* *Diaphus splendidus* *Hoplobrotula armata* *Neobythites nigromaculatus* *Caelorinchus formosanus* *Gadella jordani* *Bregmaceros japonicus* *Paratrachichthys prosthemius* *Setarches longimanus* *Lepidotrigla alata*	*Neoscopelus microchir* *Diaphus splendidus* *Myctophum asperum* *Hoplobrotula armata* *Neobythites nigromaculatus* *Gadella jordani* *Lophiomus setigerus* *Setarches longimanus* *Doederleinia berycoides* *Synagrops japonicus* *Rexea prometheoides* *Ruvettus pretiosus* *Benthodesmus trnuis* *Psenes whiteleggii*	*Trachurus japonicus* *Leiognathus bindus* *Leiognathus splendens* *Nemipterus japonicus* *Trichiurus lepturus* *Pseudorhombus quinquocellatus* *Aseraggodes kobensis* *Cynoglossus itinus* **Shrimp** no data **Cephalopoda** no data	*Chloropthalmus nigromarginatus* *Lestrolepis japonica* *Neoscopelus microchir* *Benthosema ptetotum* *Diaphus splendidus* *Polymixia longispina* *Hoplobrotula armata* *Neobythites nigromaculatus* *Caelorinchus formosanus* *Setarches longimanus* *Pterygotrigla hemistica* *Acropoma hanedai* *Synagrops japonicus* *Priacanthus macracanthus* *Atrobucca nibe*	*Polyipnus spinifer* *Chauliodus sloani* *Chloropthalmus nigromarginatus* *Harpadon microchir* *Neoscopelus microchir* *Diaphus splendidus* *Polymixia japonicus* *Glyptophidium japonicum* *Hoplobrotula armata* *Neobythites stigmosus* *Caelorinchus asteroides* *Caelorinchus formosanus* *Caelorinchus kishinouyei* *Hymenocephalus longiceps* *Ventrifossa rhipidodorsalis*	*Erosa erosa* *Ratabulus megacephalus* *Acropoma hanedai* *Acropoma japonicum* *Synagrops japonicus* *Apogon ellioti* *Apogon striatus* *Trachurus japonicus* *Urspis uraspis* *Leiognathus splendens* *Nemipterus japonicus* *Champsodon guentheri* *Rexea prometheoides* *Trichiurus lepturus* *Psenes whiteleggii*	*Chloropthalmus nigromarginatus* *Saurida undosquamis* *Lestrolepis japonica* *Benthosema ptetotum* *Diaphus splendidus* *Polymixia longispina* *Hoplobrotula armata* *Neobythites nigromaculatus* *Caelorinchus formosanus* *Antigonia capros* *Caelorinchus kishinouyei* *Malacocephalus laevis* *Gadella jordani* *Lophiomus setigerus* *Lophius litulon*	*Hoplobrotula armata* *Neobythites nigromaculatus* *Neobythites stigmosus* *Caelorinchus formosanus* *Caelorinchus kishinouyei* *Hymenocephalus longiceps* *Ventrifossa rhipidodorsalis* *Lophiomus setigerus* *Chaunax abei* *Hoplostethus crassiapinus* *Cyttopsis rosea* *Setarches longimanus* *Doederleinia berycoides* *Synagrops japonicus* *Synagrops philppinensis*

Rexea prometheoides	*Acropoma hanedai*	**Shrimp**	**Crab and others**	*Champsodon guentheri*	*Gadella jordani*	*Chascanopsetta lugubris*	*Chaunax abei*	*Pentaceros japonicus*
Trichiurus lepturus	*Doederleinia berycoides*	no data	no data	*Synchiropus altivelis*	*Laemonema palauense*	*Aesopia cornula*	*Halieutaea fizsmonsi*	*Psenes whiteleggii*
Psenopsis anomala	*Howella zina*			*Promethichthys prometheus*	*Bregmaceros japonicus*		*Halieutaea stellata*	
Psenes whiteleggii	*Malakichthys wakiyai*	**Cephalopoda**		*Rexea prometheoides*	*Lophiomus setigerus*	**Shrimp**	*Hoplostethus crassiapinus*	**Shrimp**
	Synagrops japonicus	no data		*Benthodesmus trnuis*	*Hoplostethus crassiapinus*	no data	*Paratrachichthys prosthemius*	no data
Shrimp	*Synagrops philppinensis*			*Trichiurus lepturus*	*Macrorhamphosus scolopax*		*Dactyloptena peterseni*	
no data	*Trachurus japonicus*	**Crab and others**		*Chascanopsetta lugubris*	*Setarches longimanus*	**Cephalopoda**	*Setarches longimanus*	**Cephalopoda**
	Atrobucca nibe	no data		*Symphurus strictus*	*Lepidotrigla alata*	no data	*Pterygotrigla hemistica*	no data
Cephalopoda	*Champsodon guentheri*			*Triacanthodes anomalus*	*Pterygotrigla hemistica*		*Peristedion nierstraszi*	
no data	*Rexea prometheoides*				*Peristedion nierstraszi*	**Crab and others**	*Peristedion orientale*	**Crab and others**
	Trichiurus lepturus			**Shrimp**	*Peristedion orientale*	no data	*Hoplichthys langsdorfii*	no data
Crab and others	*Psenes cyanophrys*			no data	*Satyrichthys hians*		*Acropoma hanedai*	
no data	*Psenes whiteleggii*				*Doederleinia berycoides*		*Doederleinia berycoides*	
	Symphurus strictus			**Cephalopoda**	*Malakichthys wakiyai*		*Synagrops japonicus*	
	Sphoerides pachygaster			no data	*Synagrops japonicus*		*Synagrops philppinensis*	

Shrimp

no data

Cephalopoda

no data

Crab and others

no data

Crab and others

no data

Promethichthys prometheus
Rexea prometheoides
Psenes whiteleggii
Chascanopsetta lugubris

Shrimp

no data

Cephalopoda

no data

Crab and others

no data

Plectranthias japonicus
Branchiostegus auratus
Trachurus japonicus
Dentex tumifrons
Atrobucca nibe
Champsodon guentheri
Bembrops curvatura
Uranoscopus oligolepis
Foetorepus masudai
Promethichthys prometheus
Rexea prometheoides
Trichiurus lepturus
Psenopsis anomala
Psenes whiteleggii
Chascanopsetta lugubris
Symphurus strictus
Triacanthodes

anomalus

Shrimp

no data

Cephalopoda

no data

Crab and others

no data