Open Sea Aquaculture in the Eastern Mediterranean

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Disclaimer

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Executive Summary

Sea aquaculture is an activity that requires the use of extensive marine space as well as coastal infrastructure and therefore competes for space with other marine activities such as tourism, fisheries, marine navigation, energy, sea recreational activities and coastal activities. The location of the aquaculture placement needs to be in a considerable distance from sensitive and protected areas such as areas of the "Natura 2000" network, *Posidonia oceanica* meadows, artificial reefs, shipwrecks, swimming areas, etc. to avoid negative impacts to the environment or commercial activity.

Allocating farming activities offshore in the open sea, has positive and negative impacts. In the positive side, there is the advantage of water with less nutrient load and the significant decrease of the environmental impact on near shore ecosystems and the interaction with the competitive activities. On the negative side, Open Sea (OS) Aquaculture means that a) the facilities face a number of challenges, as they are venturing into environmental conditions that are far more exposed to strong currents and adverse weather conditions compared to their near-shore technology counterparts and b) the units are in bigger distance to the required land facilities, such as port areas and supporting land infrastructure.

The objective of this deliverable is to identify areas for potential OS aquaculture, through the utilisation of Geographical Information System (GIS) approach and by considering the prediction of the environmental impact effort, while staying within the framework of national and European legislation and directives.

A Marine Spatial Study (MSP) specific to OS aquaculture was executed in three phases, first by identifying the available areas suitable for OS Aquaculture by adopting exclusion criteria related to conflict with other activities and high impact to the natural environment, considering the weather (wind/waves), water depth, and proximity to harbor facilities. The selection of the optimal candidate areas for further investigation was, finally, made after taking into consideration the opinions of relevant Governmental Departments and Services as well as the involved partners and stakeholders.

The outcome of the MSP was the selection of four (4) candidate areas suitable for the establishment of Allocated Zones for Aquaculture (AZAs), and Aquaculture Management Areas (AMAs) within an AZA:

- Point 2 - Xylofagou West
- Point 3 - Larnaka
- Point 6 - Governor's Beach Center East
- Point 7 - Aphrodite Hills

The theoretical "carrying capacity" that refers to the production level (production size or density of the cultured stock) that does not cause "adverse effects on the wider environment" in the selected areas was calculated based on the work of Karakassis (2013) and Karakassis et al (2013) and if the max park area is for 100 thousand m^2, then the "carrying capacity" is for 8,700 tonnes per OS AZA. However, in the scenarios to be analysed, a maximum of 5,000 tonnes will be considered in each AZA/AMA and therefore this safeguards the sustainability of the OS Aqua project from an environmental point of view.

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1 INTRODUCTION

1.1 Background

One of the major constraints for the aquaculture production sector is the availability of, and access to space. In many coastal areas, competition with other marine activities is already high, mainly because the majority of the aquaculture farms is located close to the shore. At the same time, the location of the aquaculture farms is limited by environmental objectives, such as the protection of areas of the “Natura 2000” network, *Posidonia oceanica* meadows, artificial reefs, swimming areas, etc.

The area in which the units are located can also have a significant impact on their functionality and sustainability. Units are significantly affected by environmental conditions such as currents, waves, etc., parameters that should be seriously considered when determining areas suitable for fish farming. Moreover, it is important that the units are located in proximity to harbour infrastructure to reduce transportation costs.

Marine Spatial Planning (MSP), using a Geographical Information System (GIS) approach, seeks to reduce conflicts and environmental impacts, promote sustainable use of marine ecosystems and to determine how to achieve target levels of marine area for particular uses while minimizing costs and impacts.

Therefore, management of marine aquaculture should be ecosystem-based, balancing ecological, economical, and social objectives for sustainable development. The Directive on Maritime Spatial Planning (MSP) (Directive 2014/89/EU) aims to promote sustainable development and use of marine resources, including for aquaculture, through the establishment of maritime spatial plans in each Member State by 2021.

1.2 Purpose of the Project

The Objective of this work package is to propose a ***National Marine Spatial Plan*** having as main objective to designate zones of Open Sea (OS) aquaculture areas, through the utilisation of Geographical Information System (GIS) approach and by taking into account the model output from WP3, while staying within the framework of national and European legislation and directives.

To determine suitable areas for the establishment of Allocated Zones for Aquaculture (AZAs) and Aquaculture Management Areas (AMAs) within an AZA, the present spatial study was carried out in three phases of identification and evaluation of alternative areas:

1. In the first phase, the available areas around the coastline of Cyprus and up to a certain depth identified, based on excluding criteria. Areas based on their distance from sensitive habitats (*Posidonia oceanica* meadows), “Natura 2000” areas, Marine Protected Areas (MPAs), shipwrecks, artificial reefs, desalination plants, sewage disposal points, pipes, ship routes, anchorage areas, areas for military/defence use etc. were excluded.

2. In the second phase, a series of candidate OS AZAs within the areas defined in phase 1, were selected based on proximity criteria to port areas, land infrastructure, etc. and based on weather conditions.
3. In the final third phase, potential candidate areas were narrowed down to the ones that are better suited for a further investigation (see D11-Identification of sites with less sensitive/important/rare habitats where the impact of the aquaculture at the environment can be minimized & D14- Social and environmental impact description of optimal sites for aquaculture development). The selection in this phase took under consideration the opinions of relevant departments and services as well as the involved partners and other users of maritime space.

2 Spatial Planning Methodology

2.1 Introduction

To determine suitable areas for the establishment of the Allocated Zones for Aquaculture (AZAs), the proposed MSP methodology is carried out in three phases:

1. Application of exclusion criteria to define the available maritime space
2. Application of proximity and weather conditions criteria to define a series of more specific candidate OS AZAs
3. Selection of the optimal candidate areas for further investigation by taking into consideration the opinions of relevant stakeholders and partners.

The geographical data used for this study include data form sources such as:

a) The Department of Land and Surveys (DLS), Ministry of Interior.
b) The cartographical database of T.C. Geomatic Ltd, Geomatic Maps™ (Geomatic).
c) Department of Environment, Ministry of Agriculture, Rural Development and Environment (DoE).

2.2 The related EU Directives

2.2.1 MSP Directive

Competition for maritime space – for renewable energy equipment, aquaculture, and other uses – has highlighted the need to manage waters more coherently. Maritime spatial planning (MSP) works across borders and sectors to ensure human activities at sea take place in an efficient, safe, and sustainable way. That is why the European Parliament and the Council have adopted legislation to create a common framework for maritime spatial planning in Europe. (Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning: http://data.europa.eu/eli/dir/2014/89/oj)

MSP is a process by which the relevant Member State's authorities analyse and organise human activities in marine areas to achieve ecological, economic and social objectives' (European Commission's Directive on Maritime Spatial Planning – MSP Directive). The Assistance Mechanism for MSP was launched in 2016 to provide administrative and technical support to EU countries in implementing the MSP legislation.

Recently the EU published a report regarding the progress made and targets fulfilled in regard to MSP. The basic tasks were that the directive was translated into national law to develop MSP plan that is inline with the directive. Five countries, including Cyprus did not succeed to develop MSP on time and they were sent formal letters. For that reason, Cyprus authorities have now made the strategic project "ΘΑΛ-ΧΩΡ - Cross-border Cooperation for Maritime Spatial Planning Development" (THAL-CHOR) a priority. This strategic project aims at the development of a MSP methodology and its pilot implementation in selected area of Cyprus and Greece, as well as at supporting the preparation of both countries for the implementation of the EU Directive on MSP.

2.2.2 WFD and MSFD Directives

In 2013 the Commission issued a Communication on strategic guidelines for the sustainable development of EU aquaculture, with the aim of helping Member States and stakeholders overcome the challenges facing the sector (COM, 2013), while in 2016 Commission also issued a Communication on the application of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) in relation to aquaculture (COM, 2016). The overall aim of this document was to offer practical guidance which will facilitate the implementation of the WFD and MSFD in the context of the development of sustainable aquaculture. More specifically:

- to provide regulatory good practice and suggestions to national authorities about the requirements of the Directives in relation to aquaculture, to facilitate their implementation;
- to provide industry good practice and suggestions to aquaculture producers on what is expected of them and what they can expect from the implementation of the Directives;
- to provide information about the sustainability of EU aquaculture production and its compliance with relevant EU environmental legislation (COM, 2016).

2.2.2.1 EU Policy and legal framework

The WFD aims to improve and protect the chemical and ecological status of surface waters and the chemical and quantitative status of groundwater bodies throughout a river basin catchment. For ecological status, coastal waters extend to one nautical mile out to sea. Chemical status, however, applies also to territorial waters extending out to 12 nautical miles. Article 4 of the WFD requires Member States to prevent deterioration of the ecological and chemical status of surface waters, and to restore polluted surface waters and the ecological conditions necessary to achieve good status in all surface waters. Article 4 also requires Member States to take all the necessary measures to progressively reduce pollution from priority substances and to cease or phase out the emissions, discharges and losses of priority hazardous substances (COM, 2016).

The MSFD aims to achieve good environmental status in marine waters by 2020. Its scope of application extends to coastal waters on aspects of environmental status which are not already addressed by the WFD or other Community legislation, as well as the full extent of Member States territorial waters over which they have or exercise jurisdictional rights (MSFD, Article 3.1). To help achieve GES-MSFD, eleven descriptors of the state of the environment have been defined: biodiversity, non-indigenous species, commercial fish, food webs, eutrophication, sea-floor integrity, hydrographical conditions, contaminants, contaminants in fish and seafood, litter, and underwater energy such as noise (COM, 2016).

Good environmental status (MSFD) is not exactly equivalent to good ecological/chemical status (WFD). The criteria associated with the Directives differ due to the geographical scale to which the Directives apply. As the ultimate objective of the Directives is the protection of the environment, they are designed to have similar criteria insofar as possible. Chemical quality, the effects of nutrient enrichment, and aspects of ecological quality and hydro morphological quality in both Directives are closely related (COM, 2016).

The main differences between the WFD and the MSFD are that the scope of good (environmental) status within the latter is broader, covering a wider range of biodiversity components and pressures; and that assessment scales for the MSFD are larger, requiring assessment of environmental status at the scale of the relevant sub-regions (e.g. Greater North Sea, Celtic Seas) or subdivisions of these rather than at WFD individual water body scales. The boundaries for MSFD and WFD assessments overlap in coastal waters, where the MSFD is intended only to apply to those aspects of good environmental status which are not covered by the WFD (e.g. noise, litter, aspects of biodiversity) (COM, 2016).

2.2.2.2 Directives and Aquaculture

As far as aquaculture is concerned, the WFD and the MSFD do not contain explicit obligations for aquaculture. The aquaculture industry has to comply with the requirements of the national legislation that implements those Directives in each Member State. Annex II, section 1.4 of the WFD requires Member States to collect and maintain information on the type and magnitude of significant anthropogenic pressures on surface waters in each River Basin District.

The Environmental impact assessment (EIA) and strategic environmental assessment (SEA) Directives are cross-cutting and cover a wide scope of environmental issues, including aquaculture related plans, programmes or projects. They set procedures aiming at implementation of certain plans, programmes and projects with due account taken of their likely significant environmental effect, before their adoption. Both directives ensure that environmental concerns are taken into account in the decision making through access to information, public participation and consultation.

The D14. “Social and environmental impact description of optimal sites for aquaculture development” aims to describe the social and environmental impacts at the areas selected by the MSP described in this deliverable, taking into account the pressures and impacts exerted from aquaculture activities (increased nutrient load from concentrations of faecal matter and uneaten feed, from dispersal of cleaning agents and medicines, eutrophication, introduction of non-indigenous species (NIS), nutrients, organic matter, contaminants including pesticides and litter, the disturbance to wildlife, and the possibility for escape of farmed fish, etc.) as imposed by the two EU Directives

2.3 GFCM guidelines on Allocated Zones for Aquaculture (AZA)

In 2012, the General Fisheries Commission for the Mediterranean (GFCM) adopted, at its thirty-sixth session, Resolution GFCM/36/2012/1 aiming at promoting the sustainable development of aquaculture at the national and regional levels and while avoiding conflicts over competing uses of the coastal space and resources, preserving the environment and rationalizing investments. Part of this section has been directly copied and pasted from the original sources cited above to preserve the information contained therein.

This resolution constitutes a major benchmark as it provides the first normative framework for the establishment of **allocated zones for aquaculture (AZA)** in the Mediterranean. **The GFCM:**

"Recognizing that aquaculture plays an important role in terms of contribution to economic development and it represents an important source of food and employment for coastal communities of GFCM Members;

Consistent with the 1995 FAO Code of Conduct for Responsible Fisheries, in particular Article 9 which calls upon States, inter alia, to produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities;

Taking into account relevant provisions in the Johannesburg Declaration on Sustainable Development of 2002 and the 1995 Convention for the Protection of the Marine Environment and Coastal Region of the Mediterranean and its Protocols as amended, in particular, the Protocol on Integrated Coastal Zone Management (ICZM);

Noting that aquaculture activities are rapidly expanding in the GFCM Area, thus calling for an ICZM consistent planning and management at regional level;

Acknowledging that aquaculture activities affect and are affected by other human activities to the extent that their relative contribution to environmental degradation needs to be controlled and adverse social and environmental interactions with aquaculture activities have to be reduced;

Considering the implementation of a regional strategy for the creation of Allocated Zones for Aquaculture (AZA) as an immediate priority for the responsible development and management of aquaculture activities in the Mediterranean and Black Sea;

Further considering that the creation of AZAs may facilitate the integration of aquaculture activities into coastal zone areas exploited by other users and contribute to the enhancement of coordination between the different public agencies involved in aquaculture licensing and monitoring processes;

Acknowledging conflicts between aquaculture activities and other users of the coastal zone in addition to the main variables and factors affecting the development of aquaculture activities,

Stressing in particular the need for the definition of common criteria for the selection of sites for aquaculture activities,

Bearing in mind that the sustainable development of aquaculture can be significantly facilitated by a clear vision of Allocation Zones for Aquaculture (AZAs);

Desiring to promote in the GFCM area of competence the establishment of AZAs as a management tool for marine spatial planning;

ADOPTS, in conformity with Articles 5 and 8 of the Agreement for the establishment of GFCM the following resolution:

1. Contracting Parties and Cooperating non-contracting Parties of the GFCM (hereafter referred to as CPCs) shall include in their national marine spatial planning strategy of aquaculture development and management schemes for the identification and allocation of specific zones reserved for aquaculture activities.

2. AZAs shall comprise specific areas dedicated to aquaculture activities, and any future development thereof and their identification shall be based on the best social, economic and environmental information available in order to prevent conflicts among different users for increased competitiveness, sharing costs and services and to assure investments.
3. AZAs shall be established within the remit of local or national aquaculture plans of CPCs with the aim of ensuring the sustainability of aquaculture development and of promoting equity and resilience of interlinked social and ecological systems.
4. AZAs shall be established within the framework of ICZM, with regulations and/or restrictions being assigned to each zone in accordance with their degree of suitability for aquaculture activities and carrying capacity limit.
5. The zoning process for the establishment of AZAs shall follow a participatory approach, be transparent, coordinated by the main authority responsible for marine planning at local level and carried out in cooperation with the different authorities involved in the aquaculture licensing and leasing procedures and monitoring. The coordination of competences among the different public authorities involved in aquaculture licensing and leasing procedures and monitoring shall be ensured at national level.
6. Zones to be allocated to aquaculture activities shall be classified, inter alia, as, “areas suitable for aquaculture activities”, “areas unsuitable for aquaculture activities” and “areas for aquaculture activities with particular regulation and/or restriction”; guidelines shall be developed to this end;
7. AZAs, once established, shall be based on legal and regulatory provisions integrated into the national legislation or other adequate national administration level and on interministerial coordination in order to ensure their effective implementation.
8. For every AZA, an allowable zone of effect of aquaculture activities could be defined in the close vicinity of each farm. Such zone shall be accompanied by an Environmental Monitoring Programme.
9. The Environmental Monitoring Programme shall be flexible and adaptable, taking into account scale (time and space) approach, and monitoring shall be mandatory.

2.3.1 The AZA environmental monitoring programme

The **Environmental Monitoring Programme (EMP)** is a tool which, when associated to AZA, enables to monitoring each step of aquaculture production. It helps aquaculture farmers take the necessary measures to ensure that their production takes place in a healthy environment and safeguards biodiversity.

More specifically, EMP is a framework to monitor a series of parameters inside and outside the **allowable zone of effect (AZE)**. The AZE is a determined area of the seabed or volume of the receiving water body where the use of specific environment quality standards for aquaculture is allowed. EMP is a crucial component of aquaculture management within AZA as it enables to make sure that parameters remain within the limits that define acceptable aquaculture-environment interactions.

2.3.1.1 Which information?

Monitored parameters mainly concern:

- **Farms:** location, cage characteristics, cultured species, production capacity, estimated feed conversion ratio, potential maximum cultured biomass, feed quantity per year, etc.
- **Oceanographic conditions:** water conditions, water depth, currents, weather-related events, water column, etc.
- **Seabed:** characteristics, organisms living on the seabed, habitats, etc.
- **Potentially negative aquaculture–environment interactions:** escapee incidents, disease, disasters (e.g. mortalities caused by exogenous pollution), etc.
- **Monitoring stations:** location.

These parameters can also be adapted to each local context.

2.3.1.2 When?

Ideally, sampling is carried out twice a year, during opposite seasons. Performing annual sampling when maximum biomass is found in the cages can also be an alternative.

2.3.1.3 Where?

EMP monitoring activities are undertaken in various locations to compare the initial state of the environment with areas that may be affected by aquaculture activities, namely:

- In the immediate vicinity of the farms (inside the AZE), and
- Far from the farms (outside the AZE).

2.3.1.4 Who?

Setting up and implementing an EMP requires the cooperation of the different authorities in charge of granting maritime concessions, of environmental monitoring and aquaculture management as well as other potentially competent authorities.

The participation of farmers in EMP data collection and dissemination activities can enhance responsibility sharing and stewardship.

Ensuring that EMP data are easily accessible and understandable to the general public would help strengthen the image of aquaculture and aquaculture products among society at large. It would also increase transparency, as well as social acceptability and responsibility of aquaculture itself.

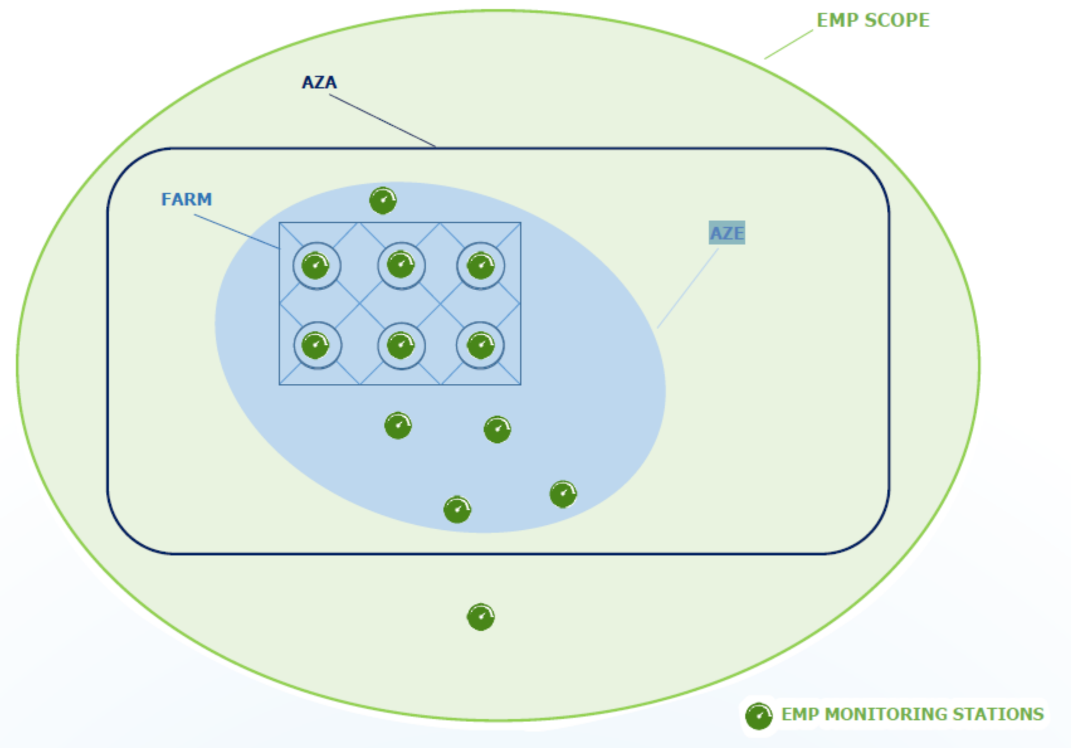

Figure 2.1. Schematic illustration of an EMP implementation in an AZA. ***Source: AZA toolkit Factsheet#6, based on FAO GFCM (2017) Guidelines on a harmonized environmental monitoring programme (EMP) for marine finfish cage farming in the Mediterranean and the Black Sea*.**

2.4 Phase 1 – Application of Exclusion Criteria

For the purpose of identifying eligible areas in which the OS AZA could potentially be established and operating, a study was initially conducted to identify and exclude areas that do not meet basic environmental and techno-economic eligibility criteria. All areas within or in proximity with the following area categories are excluded.

The Exclusion Criteria used in this study are presented in the following table (Table **1**).

STEPS	AREAS / INFRASTRUCTURES	CRITERIA	STEPS	AREAS / INFRASTRUCTURES	CRITERIA
1	Areas not controlled by the Republic of Cyprus		**10**	*Posidonia oceanica* meadows	500m dist.
2	Areas over 200m deep		**11**	Shipwrecks	500m dist.
3	Swimming Areas (Polygon)	1 km dist.	**12**	Desalination Stations	2 km dist.
4	Natura 2000 Network	1 km dist.	**13**	Artificial Reefs	1 km dist.
5	Port Infrastructure Areas • Ports • Port Works (Licensed-License Stage) • Port Facilities)	1 km dist.	**14**	Existing Aquacultures	1 km dist.

6	Anchorages (Polygon)	1 km dist.	**15**	Military Material Depot Areas	2 km dist.
7	Ship Routes	1 km dist.	**16**	Sewage disposal points	2 km dist.
8	Disposal Pipes	1 km dist.	**17**	Protected Areas from Fishing	
9	Sea Shooting Ranges	1 km dist.	**18**	Airports	3.7 km dist.

Table 1. The criteria for the multi-criteria spatial analysis

2.4.1 Exclusion of Areas not controlled by the Republic of Cyprus

As a first given we have is that AZAs should not be located within maritime space of Cyprus not controlled by the Republic of Cyprus (areas of the Republic of Cyprus occupied by Turkish forces) (Figure 2.2).

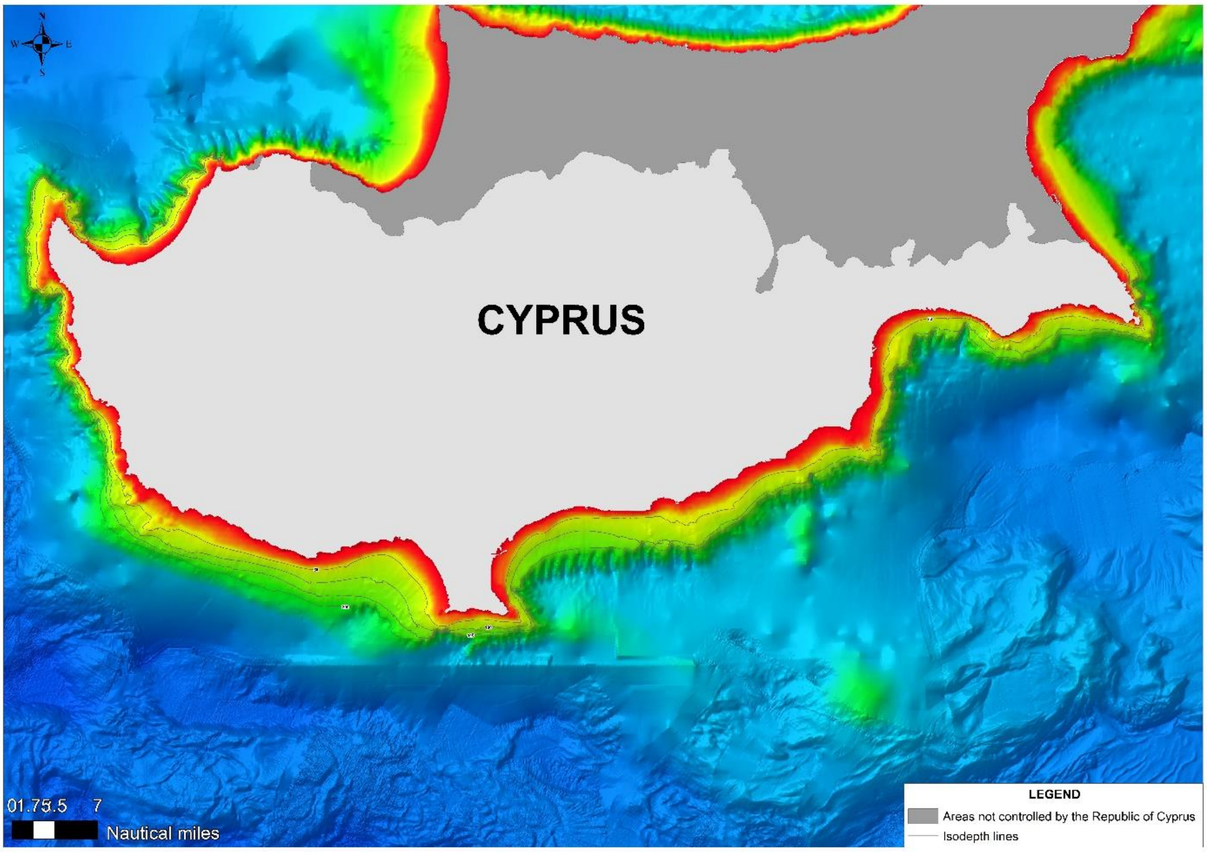

Figure 2.2. Exclusion of areas not controlled by the Republic of Cyprus (Source: Geomatic)

2.4.2 Bathymetry - Exclusion of Areas over 200m deep

To avoid environmental conditions such as currents, waves, etc., in magnitudes that will make aquaculture units very costly to maintain and protect, and at the same time more exposed to unwanted conditions (stronger currents and wind, higher waves, etc), areas over a certain depth must be excluded. For technical reasons and following discussions with the technology providers, it was decided to set a limit to a 200 m depth (Figure 2.3).

2.4.3 Exclusion of Swimming Areas (1 km Buffer)

Swimming Areas, especially the Blue Flag beaches, a major contributor to Cyprus tourist product, must be protected from the impacts of aquaculture, which are the following:

- Visual impact of aquaculture sites (in the sea or land by supporting facilities)
- Spatial restrictions for recreational fishing and boating
- Decreased access to safe anchorage areas
- Accidental damage to boats and aquaculture installations
- Impact of aquaculture on water quality
- Impact of waste on aquaculture.

A buffer zone of 1 km around the swimming areas is applied (Figure 2.4).

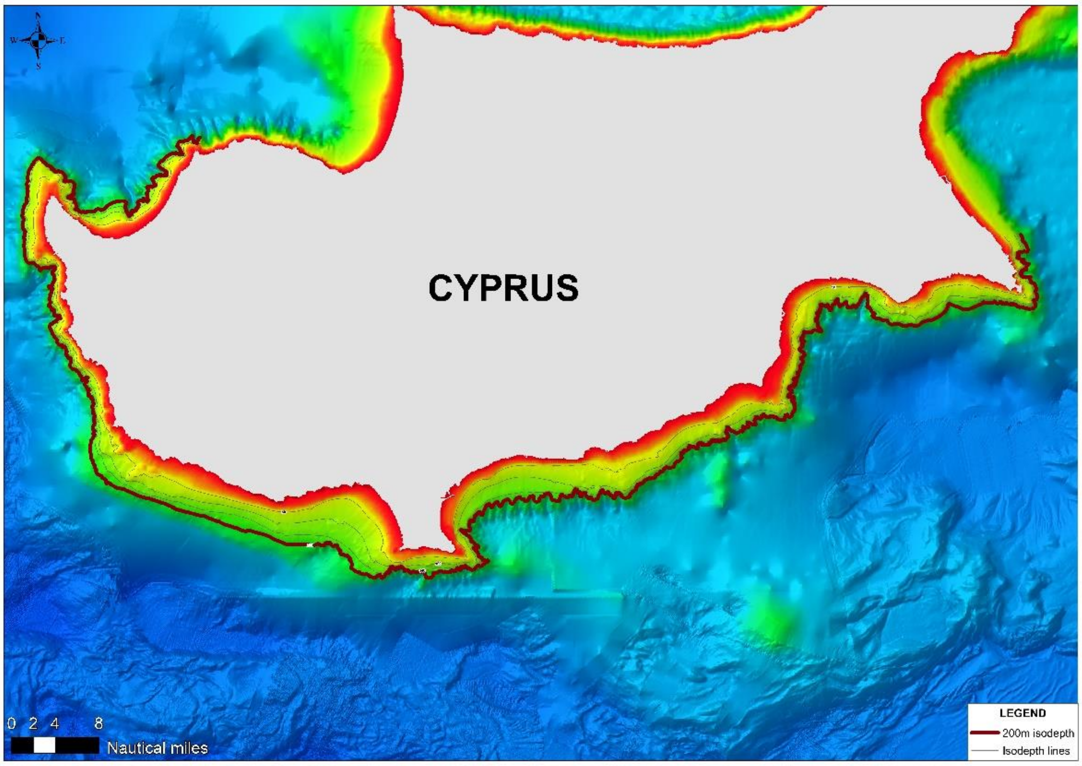

Figure 2.3. Bathymetry Criterion 1: The isobath of 200 meters (Source: DLS)

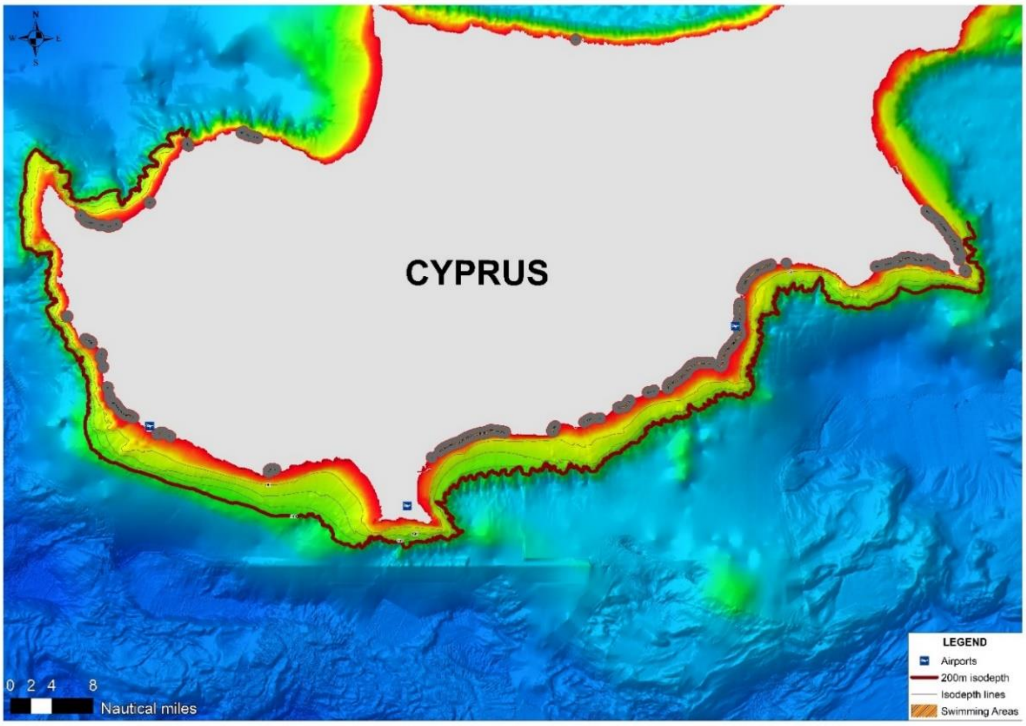

Figure 2.4. Swimming Areas Criterion: 1 km buffer zone (Source: DLS)

2.4.4 Exclusion of "Natura 2000" Network Areas (1 km Buffer zone)

"Natura 2000" is a network of protected areas covering Europe's most valuable and threatened species and habitats. It is the largest coordinated network of protected areas in the world, extending across all 28 EU countries, both on land and at sea. The sites within Natura 2000 are designated under the Birds and the Habitats Directives.

The network is comprised by the following categories of areas:

- Special Protection Areas (SPA)
- Sites of Community Importance (SCI)
- Special Areas of Conservation (SAC)

To protect these areas a buffer zone of 1 km distance is applied (Figure 2.5).

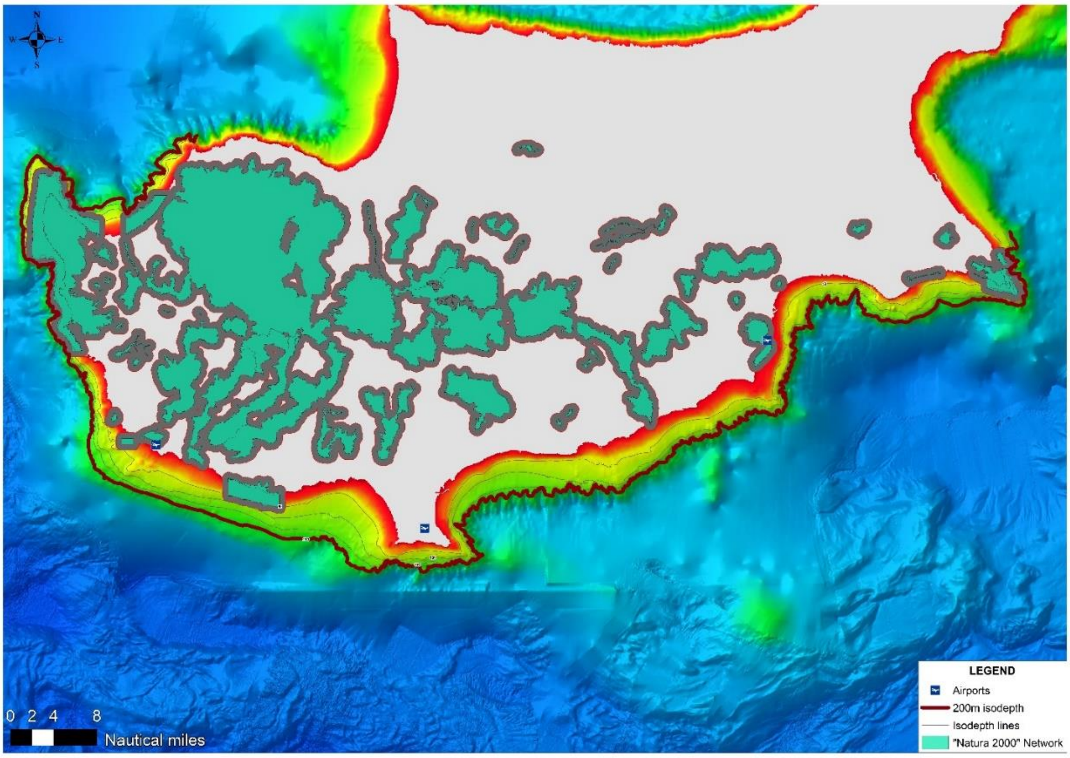

Figure 2.5. "Natura 2000" Criterion: 1 km buffer zone (Source: DoE)

2.4.5 Exclusion of Port Infrastructure Areas (1 km Buffer zone)

The AZAs cannot be in near proximity with the port infrastructure. Therefore, a buffer zone of 1 km distance is set around the following (Figure 2.6):

- Ports
- Port Works (Licensed-License Stage)
- Port facilities

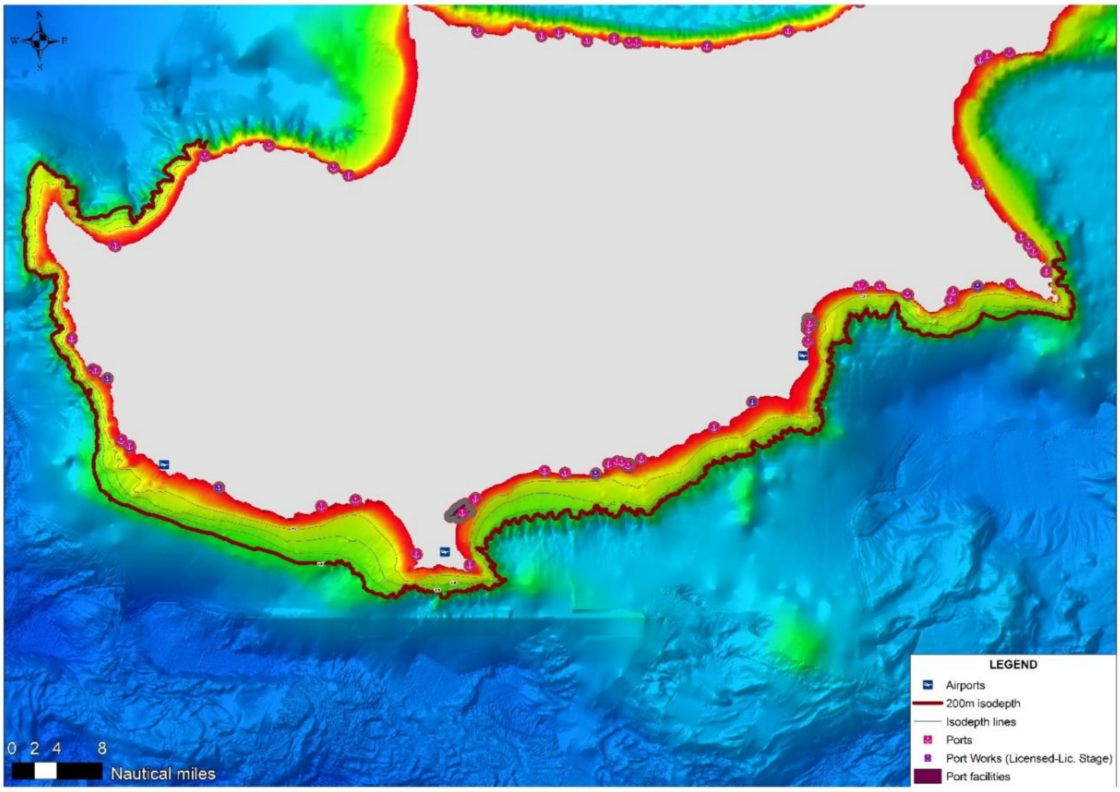

Figure 2.6. Port Infrastructure Criterion: 1 km buffer zone (Source: DLS)

2.4.6 Exclusion of Anchorages Areas (1 km Buffer zone)

The AZAs cannot be in near proximity with the anchorages. Therefore, a buffer zone of 1 km distance from anchorages is set (Figure 2.7):

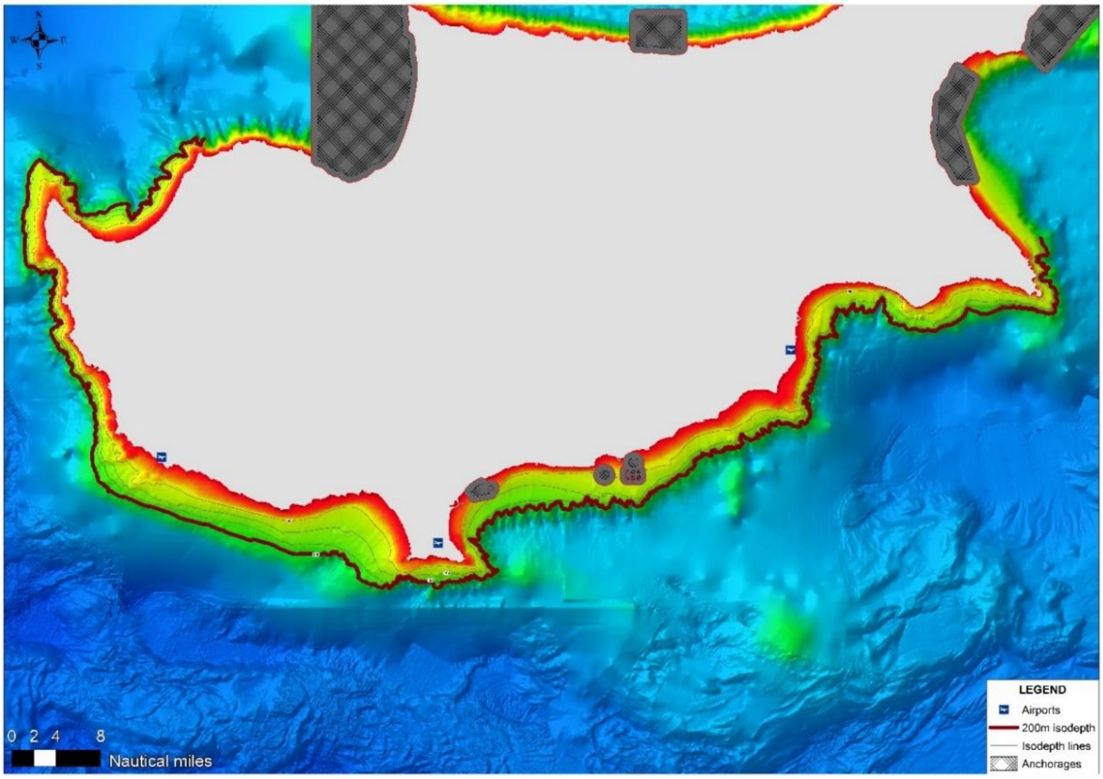

Figure 2.7. Anchorages Criterion: 1 km buffer zone (Source: DLS)

2.4.7 Exclusion of areas along Ship Routes (1 km Buffer zone)

Due to the rising number of aquaculture farms, the damage caused to farms by vessels is growing, and the morale of aquaculture farmers is decreasing due to damages costing more than several million dollars per incident. In addition, accidents in aquaculture farms may lead to secondary problems such as vessel propeller failure accidents and damage to the property of fishers (Yoo, 2017). Therefore, the placement of aquaculture farms is essential in ensuring the operational efficiency of fisheries, the protection of farm property, and the safe navigation of vessels.

Maritime New Zealand (2005) provides guidelines for establishing aquaculture farms in New Zealand. According to the guidelines, offshore aquaculture farms shall not be located within 1000 m of any recognized navigational traffic route. However, these criteria do not provide any statistical basis to address the above-mentioned issues. The United Arab Emirates (UAE) Aquaculture Guide, states that farming sites should be located at a ‘safe’ distance from a navigational path (UAE, 2017). Yet, specific distance measures were not provided. Furthermore, the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) guidelines on navigational safety within marine spatial planning, IALA (2017), encourage the use of geographic information systems and shipping route information to analyze possible conflicts between area uses, including the distance between wind farm areas and shipping routes. The guideline states that the sites of aquaculture farms should be deployed at a ‘safe’ distance from traffic routes. Nonetheless, the specific distance measures were not offered in this case as well. Finally, the Tenerife model applied a 200-400m buffer zone for ship routes.

Taking all the above under consideration a buffer zone of 1 km (Figure 2.8) is set around shipping routes, however the weight of this specific criteria will be examined specifically in each candidate area.

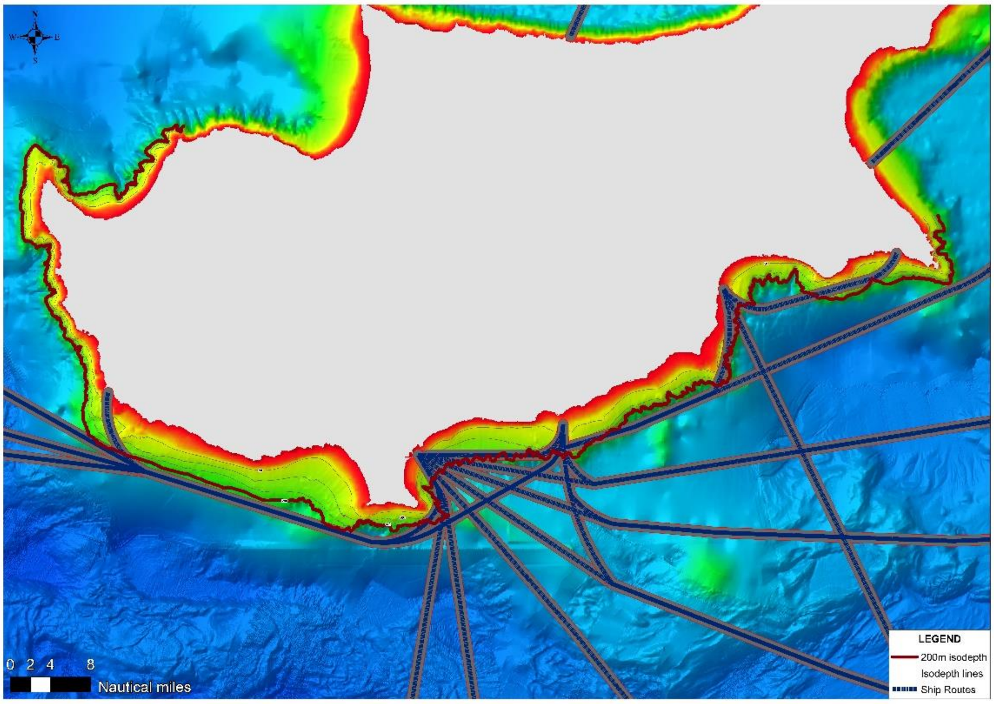

Figure 2.8. Ship Routes Criterion: 1 km buffer zone (Source: DLS)

2.4.8 Exclusion of areas around Disposal Pipes (1 km Buffer zone)

To minimize the risk of affecting the quality of water entering the desalination plants, areas located less than 1 km from the disposal pipes are excluded (Figure 2.9).

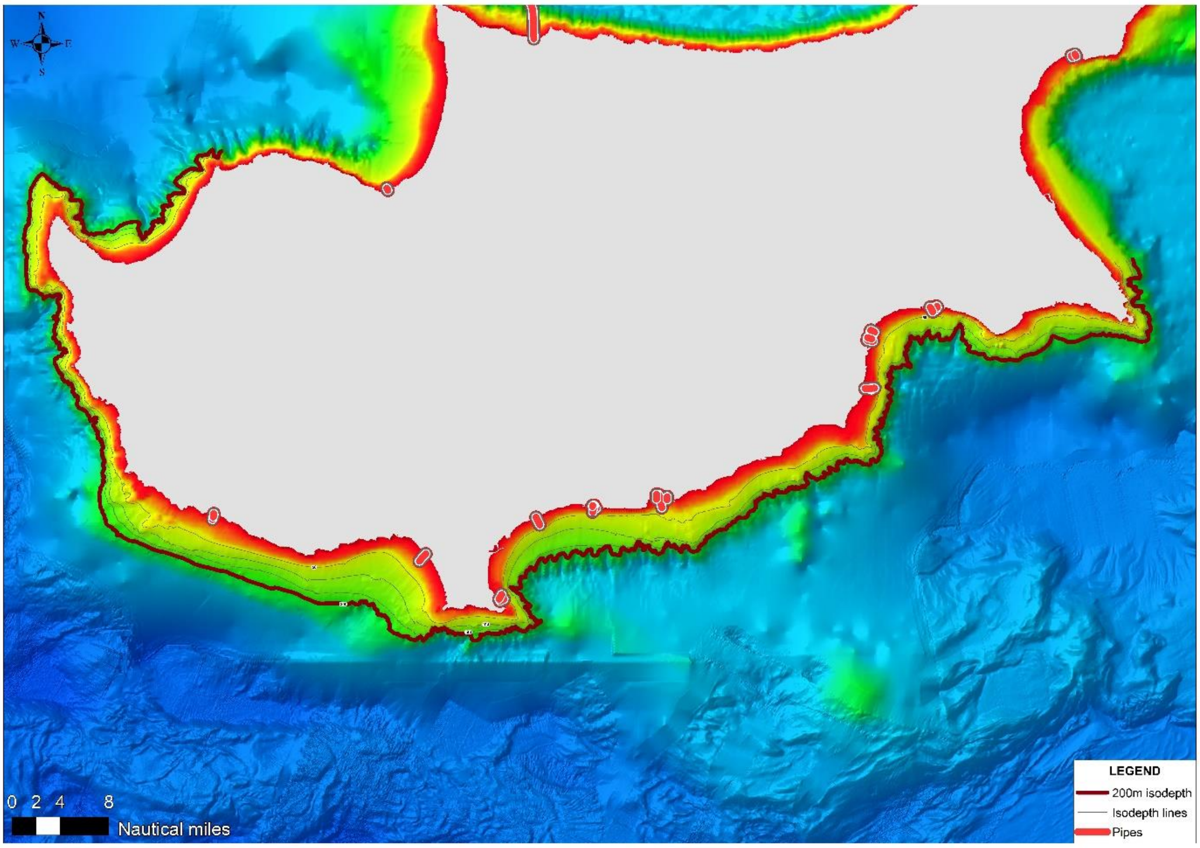

Figure 2.9. Disposal Pipes Criterion: 1 km buffer zone(Source: DLS)

2.4.9 Exclusion of areas along Sea Shooting Range (1 km Buffer zone)

Any area designated as a military zone or military protected area must not be selected as a potential site. To avoid harming the aquaculture farms and the fish, an extra buffer zone of 1 km is set (Figure 2.10).

2.4.10 Exclusion of areas around *Posidonia oceanica* meadows (500 m Buffer zone)

As this MSP concerns Open Sea Allocated Zones for Aquaculture and the allocation is taken place in depths of about 100m and more, there is no possibility of affecting the *Posidonia oceanica* meadows that grow to depths of no more than 40-50 meters. However, a buffer zone of 500m is applied to exclude the areas around the meadows and to protect them (Figure 2.11).

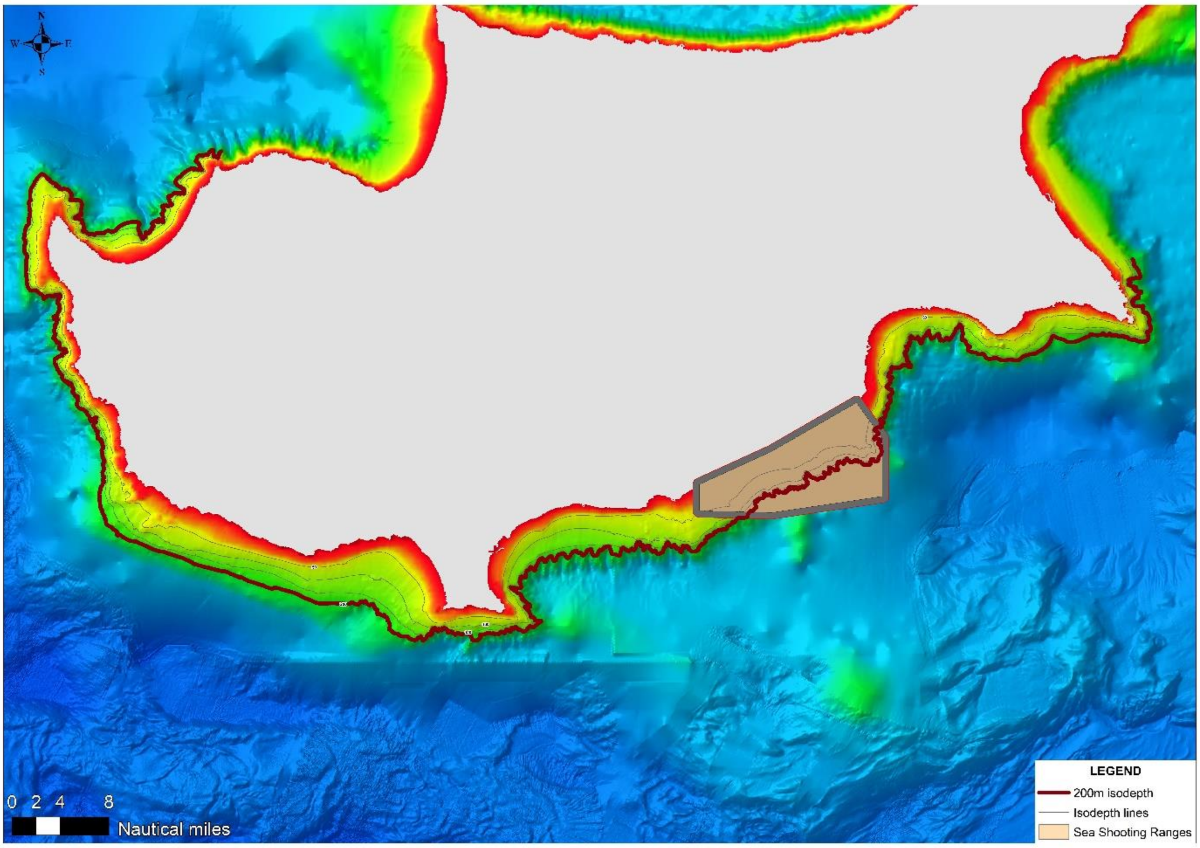

Figure 2.10. Sea Shooting Range Criterion: 1 km buffer zone (Source: DLS)

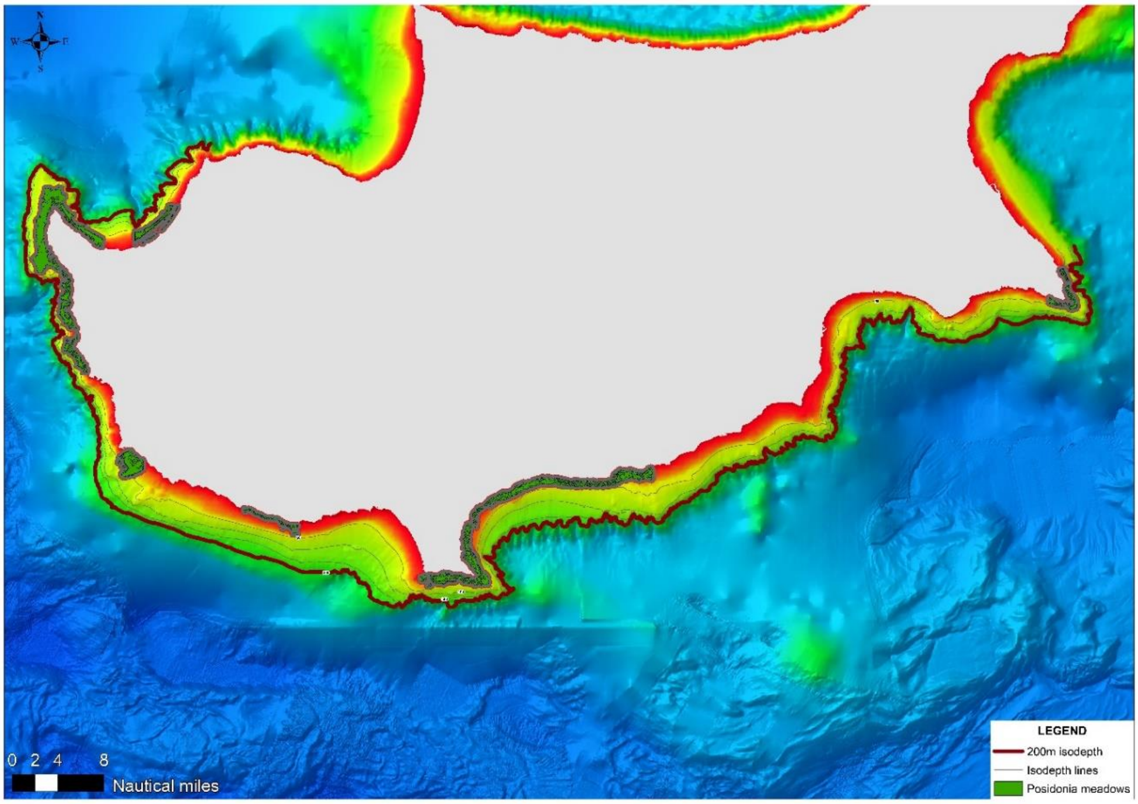

Figure 2.11. *Posidonia oceanica* meadows Criterion: 500 m buffer zone (Source: DLS)

2.4.11 Exclusion of areas along Shipwrecks (500 m Buffer zone)

Shipwrecks are protected zones that produce a positive, synergic effect on the marine resources, on the environment and on the touristic fruition of the coastal sea. To avoid any destruction of the shipwreck by the aquaculture farms, either in the stage of construction or in the stage of operation as well as to protect divers visiting the shipwrecks, a buffer zone of 500m is applied (Figure 2.12).

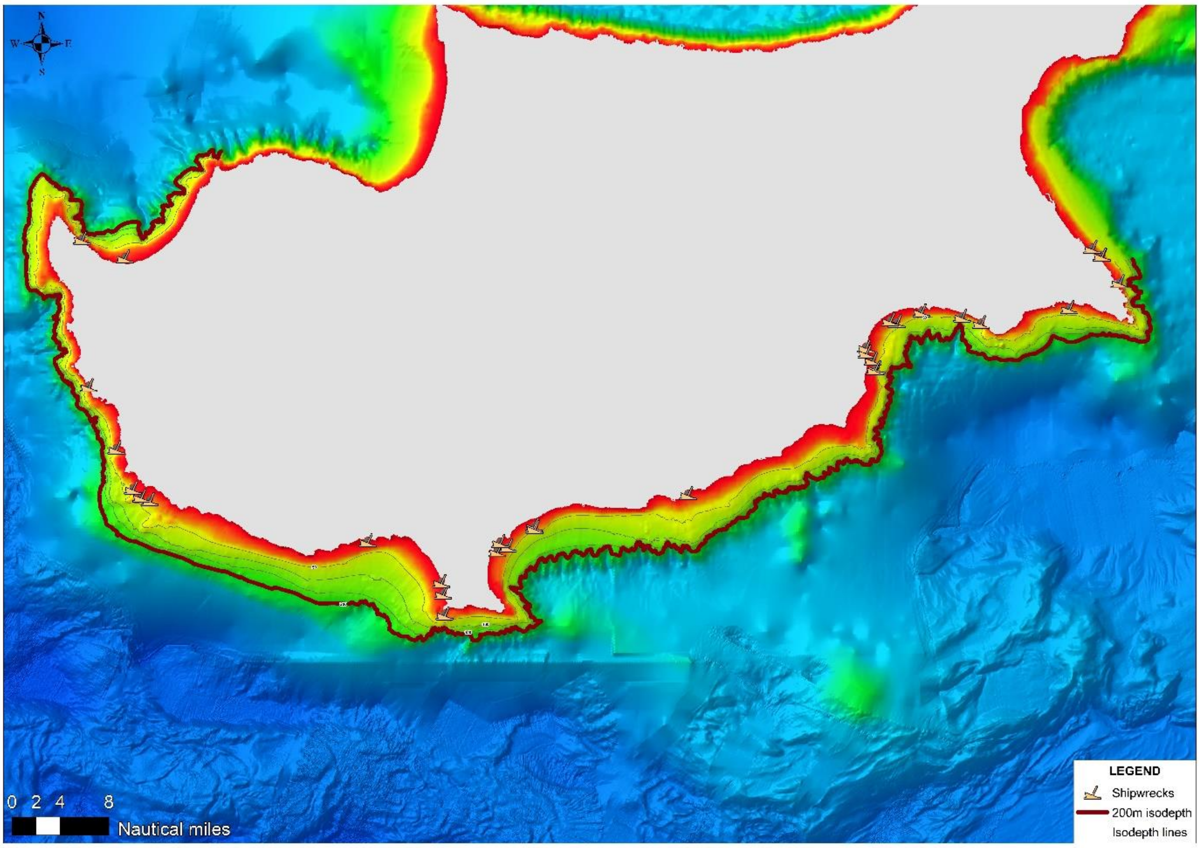

Figure 2.12. Shipwrecks Criterion: 500 m buffer zone (Source: DLS)

2.4.12 Exclusion of areas around Desalination Stations (2 km Buffer zone)

To minimize the risk of affecting the quality of water entering the desalination Stations, areas located less than 2 km from the facilities are excluded. As (Figure 2.13Figure 2.11).

2.4.13 Exclusion of areas around Artificial Reefs (1 km Buffer zone)

Artificial reefs improve fish habitat, enhance coastal erosion protection, and provide marine research opportunities (Claudet & Pelletier, 2004). Because artificial reefs assist in environmental mitigation and enhancement, increased habitat for marine life, benthic and pelagic aquaculture applications, and recreational benefits including swimming, snorkeling, diving, fishing, and surfing, a buffer zone of 1 km is decided. (Figure 2.14).

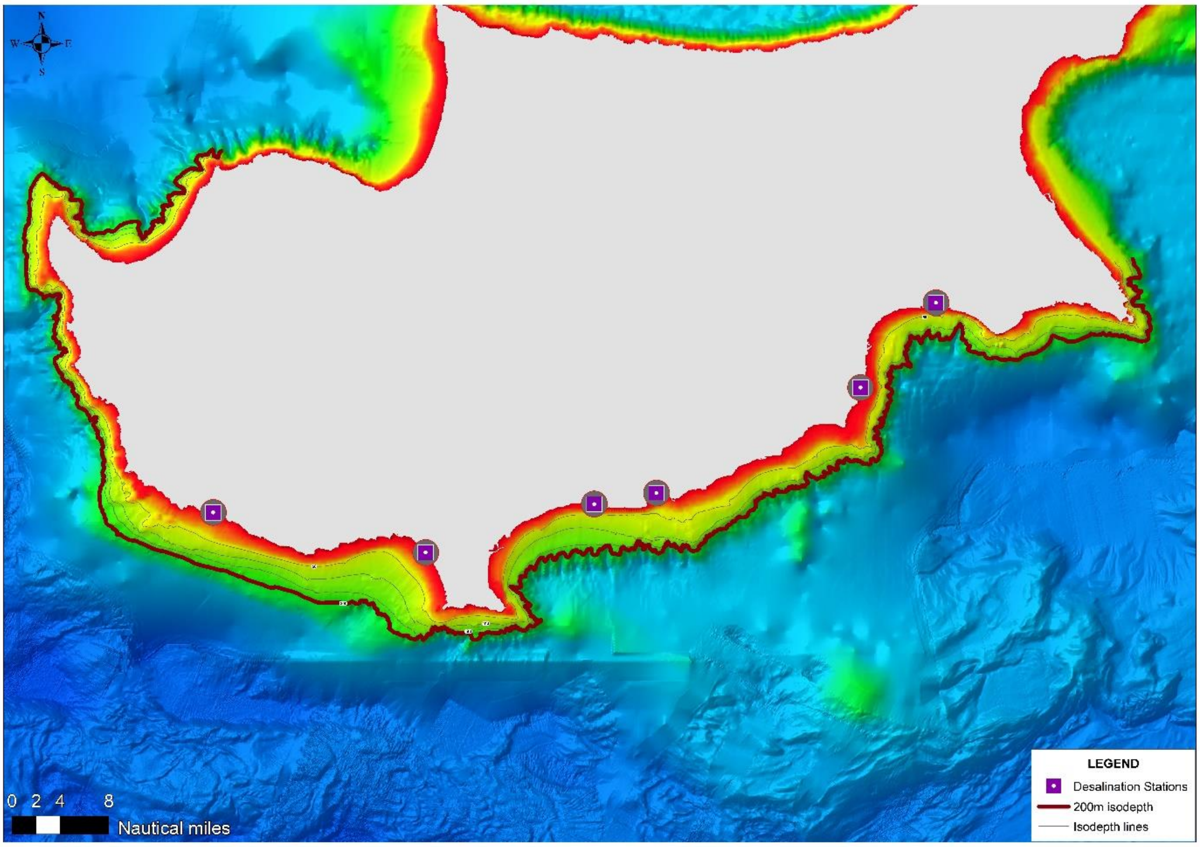

Figure 2.13. Desalination Stations Criterion: 2 km buffer zone (Source: DLS)

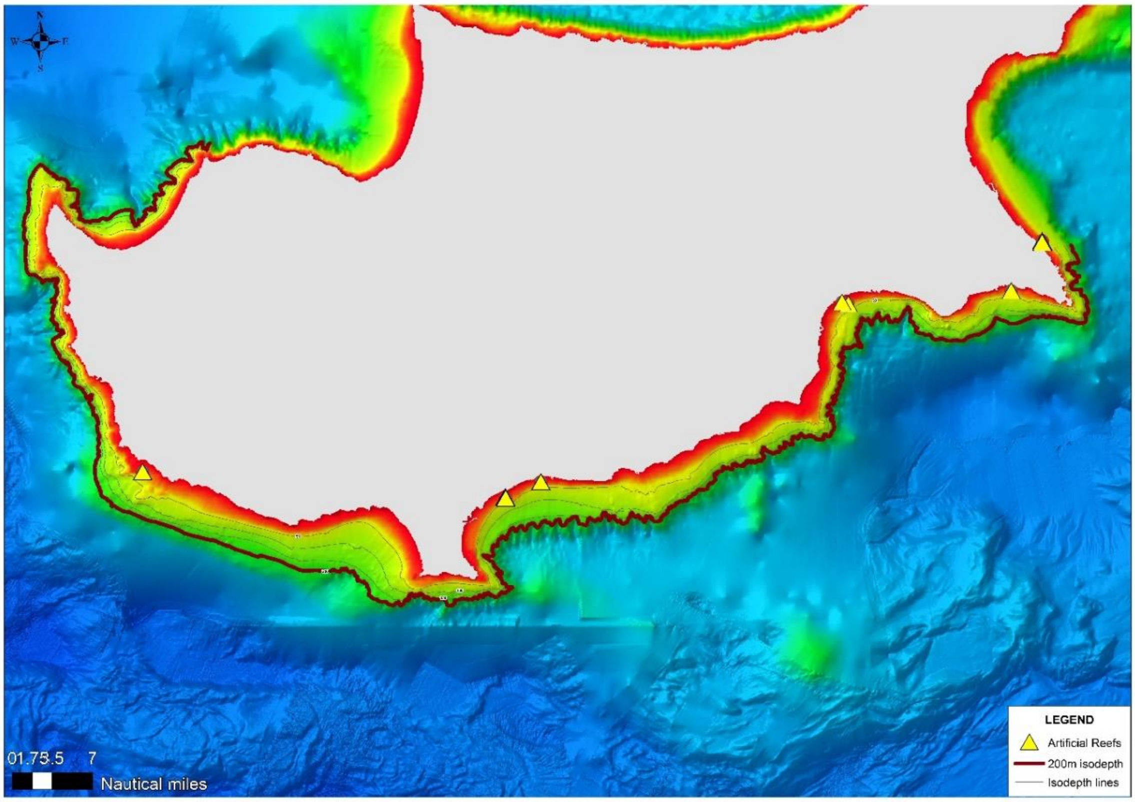

Figure 2.14. Artificial Reefs Criterion: 1 km buffer zone (Source: DLS)

2.4.14 Exclusion of areas around existing aquacultures (1 km Buffer zone)

A buffer zone of 1km is set around existing aquacultures as they constitute areas where the environment is already burdened and placement of new AZAs in near proximity would multiply the environmental impact (Figure 2.15).

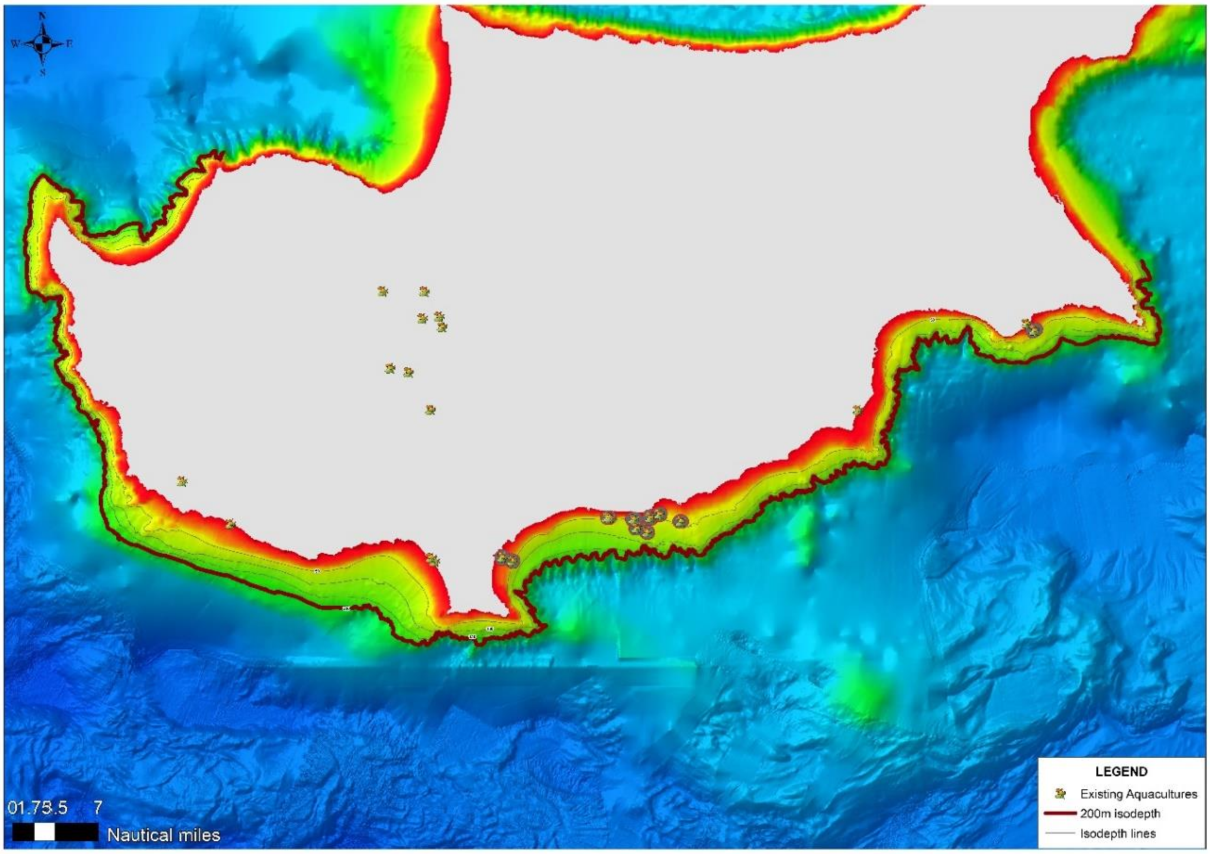

Figure 2.15. Existing Aquaculture Criterion: 1 km buffer zone (Source: DLS)

2.4.15 Exclusion of areas around Military Material Depot Areas (2 km Buffer zone)

A buffer zone of 2km is set around Military Material Depot Areas where the environment is also already burdened, and the biochemical characteristics of the water column are affected (Figure 2.16).

2.4.16 Exclusion of areas around Sewage disposal points (2 km Buffer zone)

Sewage disposal points are a significant source of pollution and a buffer zone of 2km is set to avoid the risk of pollution (Figure 2.17).

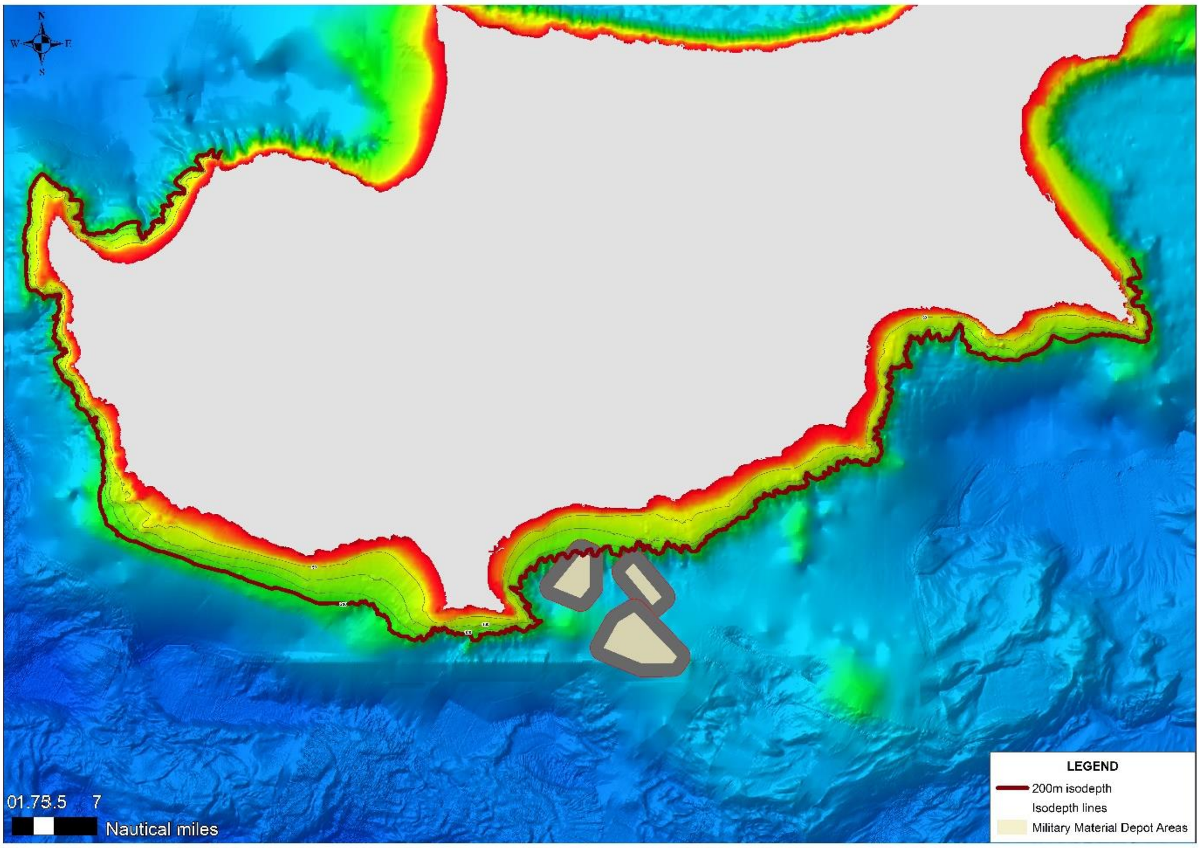

Figure 2.16. Military Material Depot Areas Criterion: 2 km buffer zone (Source: DLS)

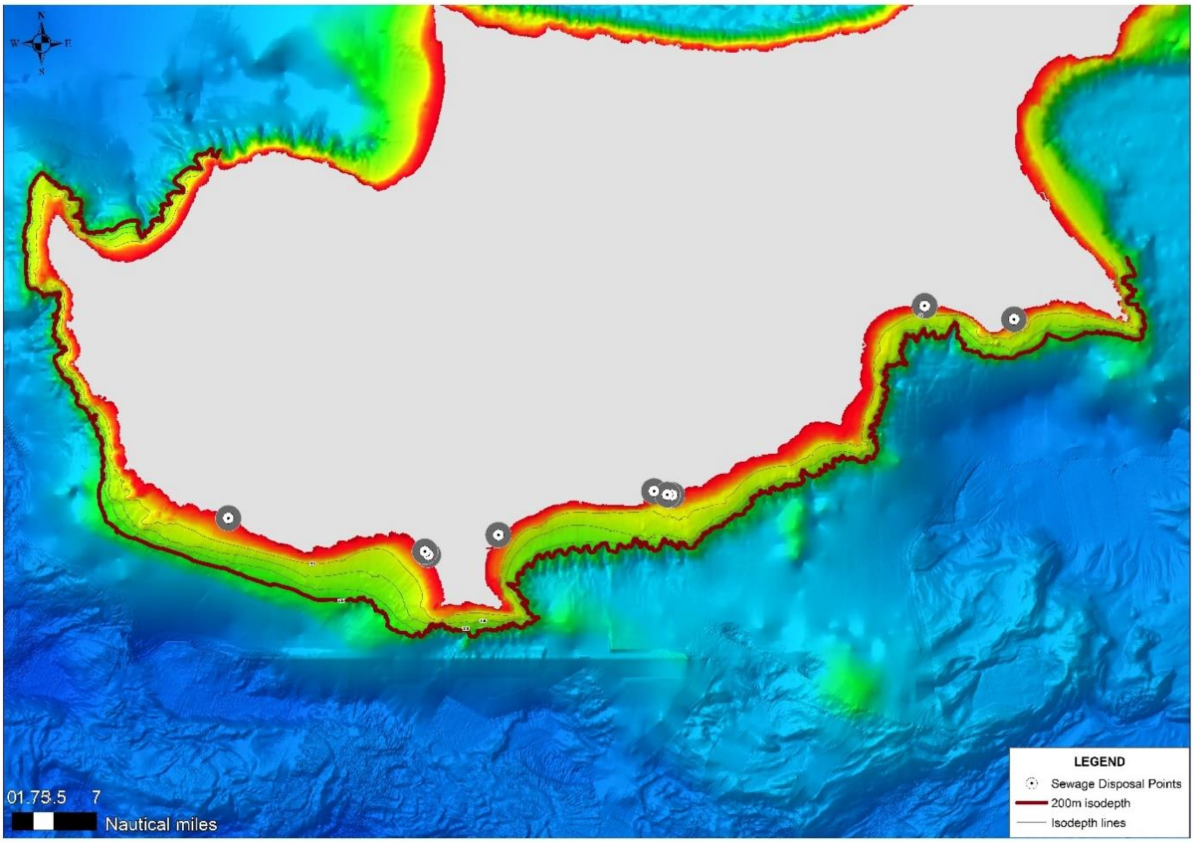

Figure 2.17. Sewage disposal points Criterion: 1 km buffer zone (Source: DLS)

2.4.17 Exclusion of Protected Areas from Fishing

Protected Areas from Fishing should be avoided, thus they are excluded. No buffer distance is set (Figure 2.18).

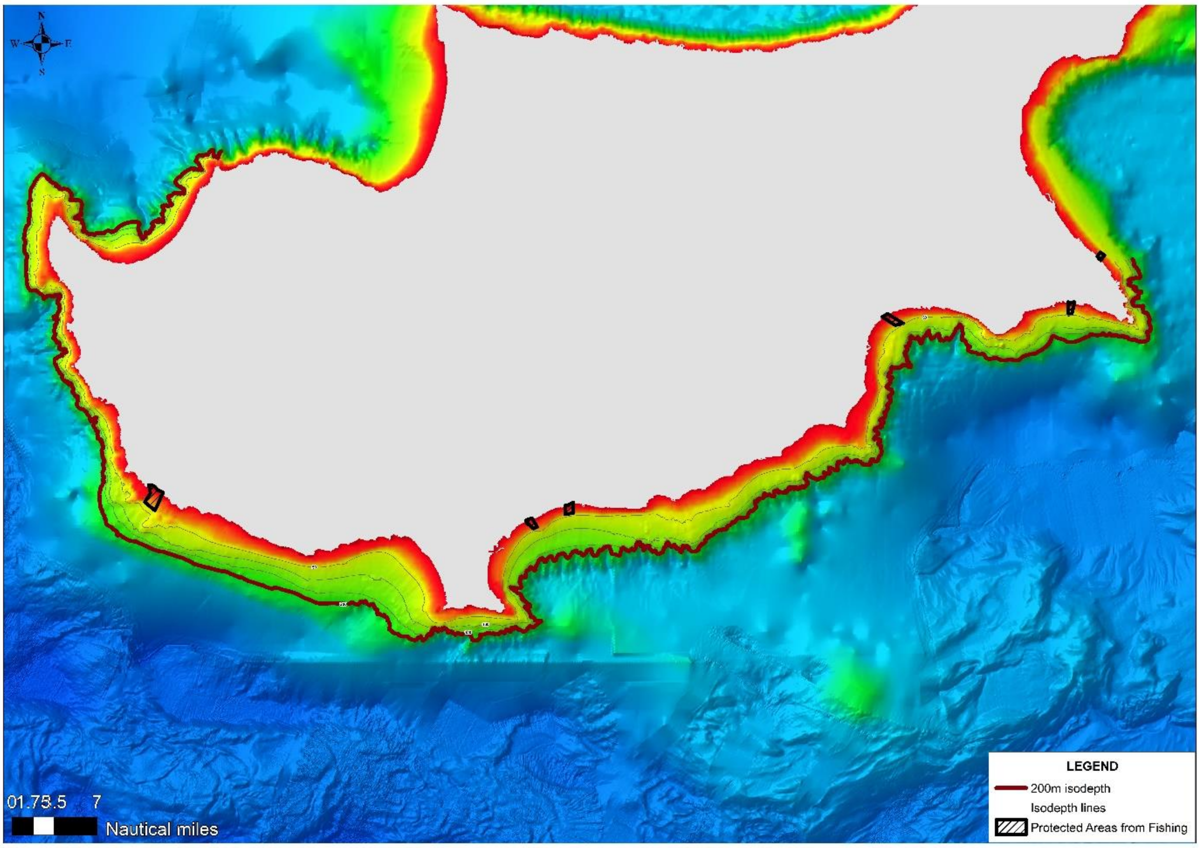

Figure 2.18. Protected Areas from Fishing Criterion (Source: DLS)

2.4.18 Exclusion of Areas Around Airports (3.7 km Buffer zone)

Aquaculture farms attract not only wild fish but also birds. Therefore, aquaculture zones should not be in very close proximity to the airports. A buffer zone of 2 nautical miles (3.7 km) is set based on the Greek directive for aquaculture (https://www.pde.gov.gr/ppxsaa/content/files/plaisia-xsaa/ΦΕΚ%202505%CE%92_11_ΥΔΑΤΟΚΑΛ.pdf – p.20) (Figure 2.19**Error! Reference source not found.**).

2.4.19 Results of the Application of Exclusion Criteria

Once the criteria have been set and converted to geographical layers, then all layers were merged into a single layer representing all the areas that the OS AZAs should not be located (Figure 2.20).

From the output of Phase 1 as it is represented on the map of Figure 2.20, the area available for the development of new OS AZAs is quite limited.

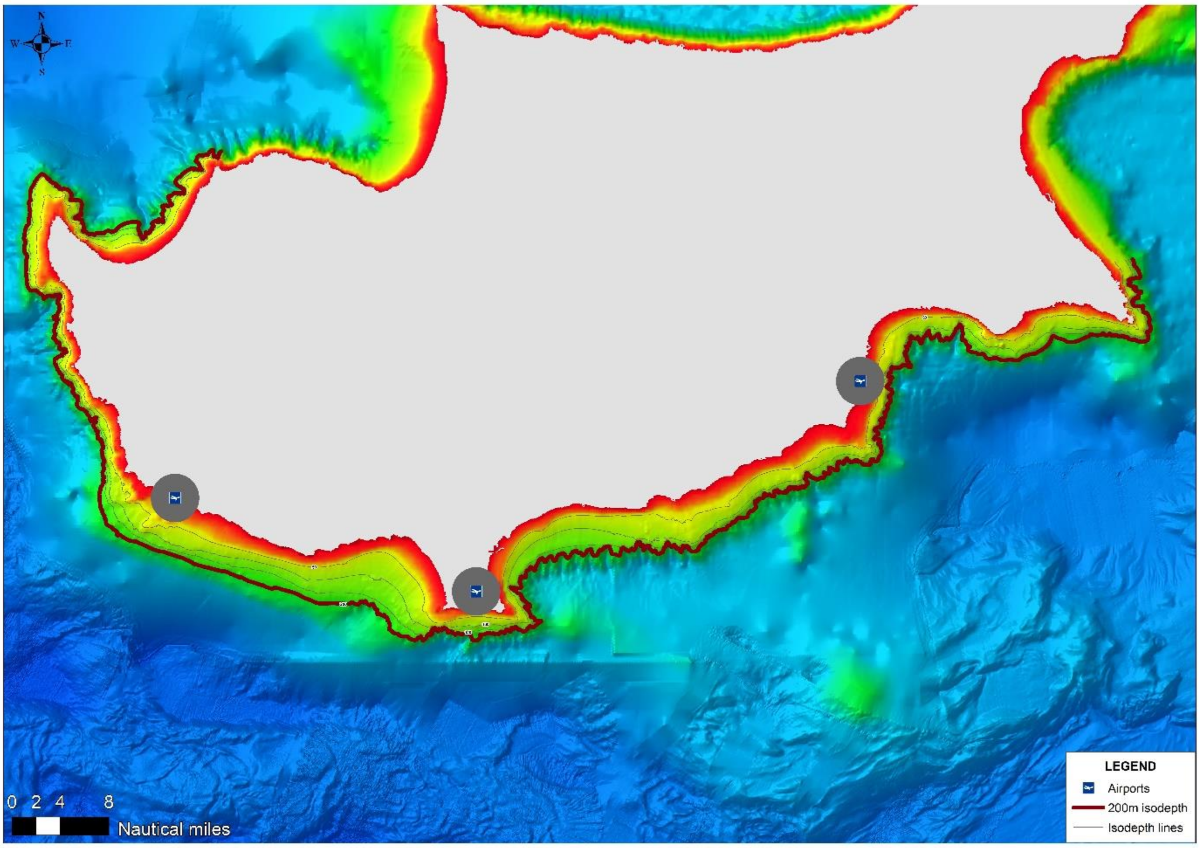

Figure 2.19. Protected Areas from Fishing Criterion (Source: Geomatic)

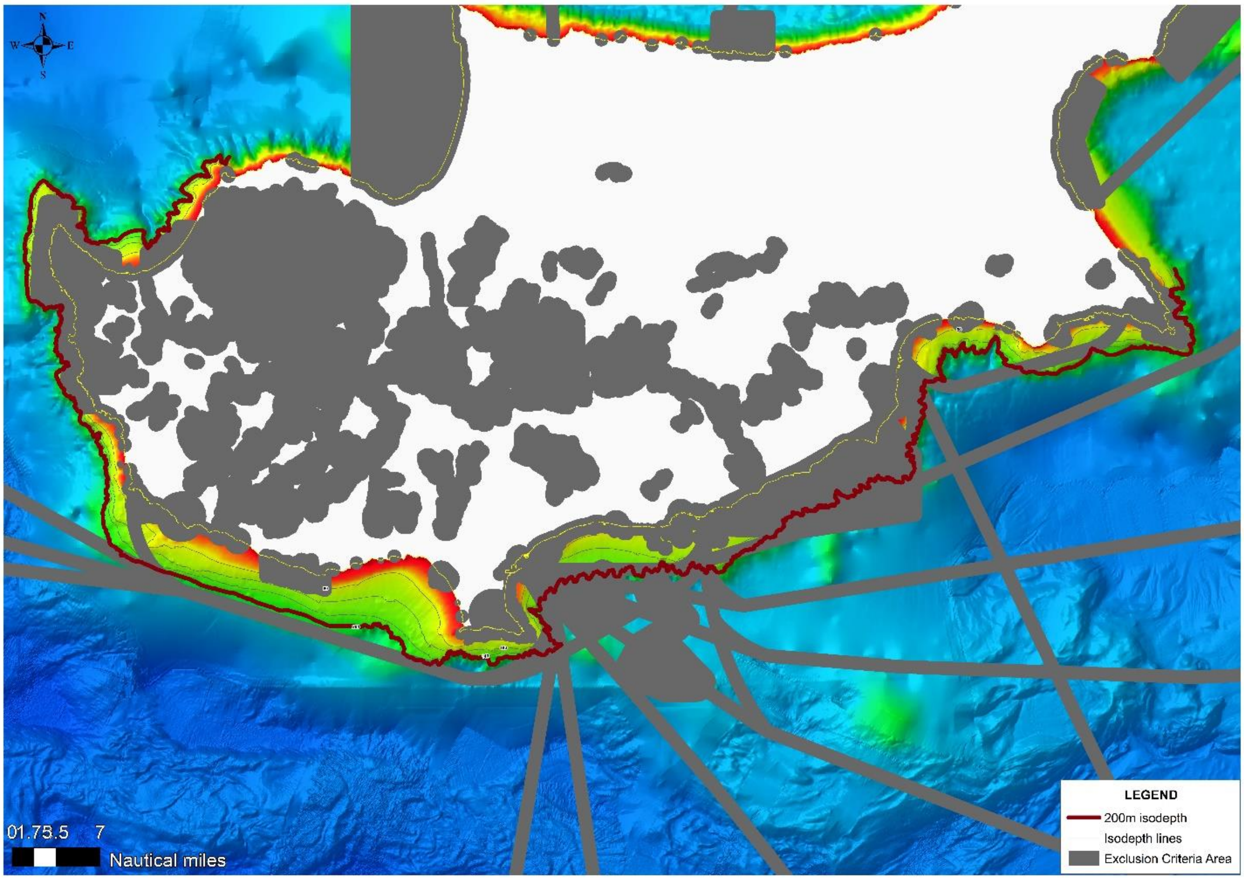

Figure 2.20. Areas excluded during Phase 1.

2.5 Phase 2 – Application of Proximity and Weather Condition Criteria

2.5.1 Weather Condition Criteria

Once the results of Phase 1 were generated, nine (9) locations were selected (see **Error! Reference source not found.**, Figure 2.21) to be investigated in terms of weather conditions, and specifically wind and waves.

NAME	LON	LAT
POINT1	34.05	35.05
POINT2	33.85	34.9
POINT3	33.65	34.85
POINT4	33.6	34.45
POINT5	33.55	34.65
POINT6	33.25	34.65
POINT7	32.65	34.6
POINT8	32.35	34.8
POINT9	32.4	35.1

Table 2. The coordinates of the nine areas investigated for weather conditions.

Figure 2.21. The nine areas investigated for weather conditions.

Wave and wind datasets (Table 3) were calculated by the OC-UCY and data were retrieved by the UCY WAM that runs at the University of Cyprus (see also Annex 1 for the respective graphs). Data used was the 24hourly forecast between 2010 and 2017 averaged over time. For temperature, current and salinity Copernicus reanalysis was used for the years between 2010 and 2015 (max availability at time). For the currents, values extracted was the maximum value over depth averaged over time.

Point	Season	Mean SWH (m)	Max SWH (m)	Mean Wind (m/s)	Max Wind (m/s)
POINT 1	Annual	0.27	3.88	3.41	17.35
	Autumn	0.20	2.37	2.96	15.33
	Spring	0.24	2.62	3.24	14.02
	Summer	0.21	1.13	3.15	9.47
	Winter	0.41	3.88	4.33	17.35
POINT 2	Annual	0.48	5.05	3.85	21.30
	Autumn	0.35	3.48	3.27	15.87
	Spring	0.47	3.03	3.70	14.82
	Summer	0.50	2.00	3.87	12.74
	Winter	0.61	5.05	4.58	21.30
POINT 3	Annual	0.41	4.75	3.79	20.23
	Autumn	0.30	2.77	3.23	15.07
	Spring	0.41	2.55	3.67	13.67
	Summer	0.43	1.61	3.90	11.91
	Winter	0.52	4.75	4.37	20.23
POINT 4	Annual	0.80	6.29	5.21	20.32

	Autumn	0.64	4.78	4.45	18.35
	Spring	0.77	4.42	5.07	17.23
	Summer	0.77	2.66	5.40	13.02
	Winter	1.02	6.29	5.91	20.32
POINT 5	Annual	0.62	5.69	4.87	20.72
	Autumn	0.47	3.52	4.12	17.56
	Spring	0.61	3.62	4.77	16.38
	Summer	0.62	2.12	5.15	13.63
	Winter	0.79	5.69	5.46	20.72
POINT 6	Annual	0.49	5.16	4.44	19.51
	Autumn	0.37	2.89	3.76	16.09
	Spring	0.49	2.98	4.37	15.60
	Summer	0.49	1.59	4.75	12.63
	Winter	0.63	5.16	4.88	19.51
POINT 7	Annual	0.75	6.66	4.93	21.60
	Autumn	0.61	5.09	4.32	17.58
	Spring	0.73	4.45	5.00	15.63
	Summer	0.73	3.23	5.39	11.55
	Winter	0.92	6.66	5.00	21.60
POINT 8	Annual	0.70	6.73	3.45	20.04
	Autumn	0.58	5.14	3.30	16.03
	Spring	0.68	4.35	3.64	14.00
	Summer	0.67	3.59	2.83	9.25
	Winter	0.87	6.73	4.04	20.04
POINT 9	Annual	0.43	5.08	3.15	19.98
	Autumn	0.37	3.32	2.80	14.93
	Spring	0.41	3.17	3.07	16.88
	Summer	0.36	1.78	3.08	10.17
	Winter	0.59	5.08	3.66	19.98

Table 3. Wave and wind values per location and per season (SWH: Significant Wave Height, Wind: Wind speed). (Source: OC-UCY)

From the analysis of the data, it was clear that all the areas west of Lemesos have been assigned as of lower priority as they are more exposed to the weather (waves). Nevertheless, it was decided for research purposes to include an area at Point 7 (Southeast from Pafos) in the subsequent assessment of the areas.

2.5.2 Proximity Criteria

In the second stage, the proximity to the necessary infrastructures was investigated as the existence of infrastructure to support the activity of aquaculture, such as road network and port facilities it is very critical.

The outcome of the application of the proximity criteria was the selection of four (4) candidate areas (Figure 2.22):

1. Xylofagou West (point 2)
2. Larnaca (point 3)
3. Governor's Beach (point 6)
4. Aphrodite Hills (point 7)

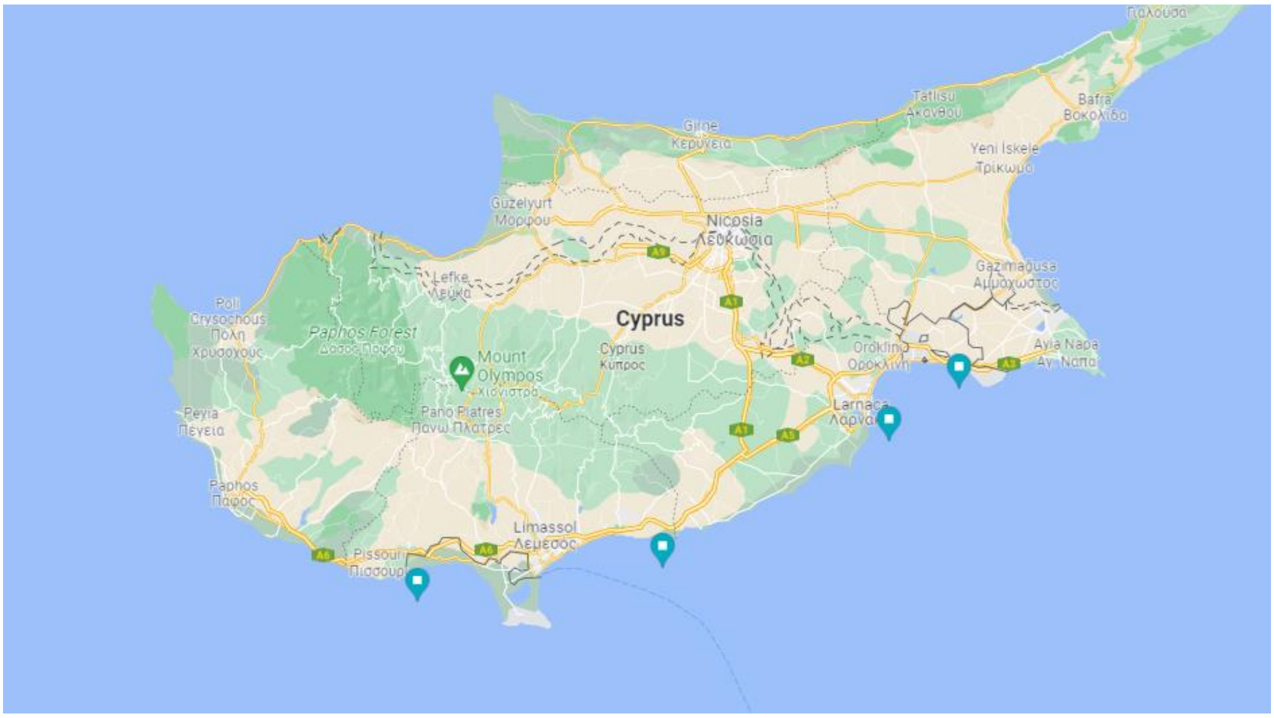

Figure 2.22. The selected four candidate areas

Point 2 - Xylofagou West was selected as to explore and investigate a new area where an aquaculture zone could be allocated. It is not within the exclusion areas, has favorable weather conditions, the currents there are non-zero which will help refresh water, there are no major tourist attractions there, military or industrial activity. It is also very close to a fishing shelter (about 3 km) and to Potamos Liopetriou harbor, however, is needed to be evaluated if the fishing shelter can accommodate the needs of the proposed OS ASA.

Point 3 – Larnaka Area was selected even though it was close to the boundaries of the exclusion area, due to the proximity of the Larnaka International Airport. This area is generally considered very satisfactory both based on environmental and technical criteria that have been set. The main advantage of this zone is the presence of the port of Larnaka as well as the possibility of exploiting the existing infrastructure of the city of Larnaka. However, it should be noted that a basic condition for the development and proper operation of this aquaculture zone is the existence of suitable facilities within the port of Larnaka.

Point 6 - Governor's Beach is situated near-by numerous existing nearshore farms and there are adequate land-based facilities including the construction of the new aquaculture port facility to accommodate the relevant needs for OS Aquaculture.

Point 7 – Aphrodite Hills was selected, as mentioned before, for research purposes.

Within these four areas, and after several meetings and discussions, optimal location for the AZAs were identified. An area of 1 square kilometer was set as reference to create cage configurations that will be later on assessed for the deployment of offshore aquaculture technologies (see D11 “Identification of sites with less sensitive/important/rare habitats where the impact of the aquaculture at the environment can be minimized”).

The above areas have no conflicts with other activities, they are all situated in depths up to 200 m (average depth from 120 to 150 m), and they are relatively close to existing port facilities.

The maps of Figures 23 – 26 show the total of ten (10) candidate zones selected (distance from nearest port facility is also displayed) which are the following (Table 4. The candidate AZAsTable 4):

ID	Name	Lat	Lon
1	Point 2 - Agia Napa	34.942889	34.005029
2	Point 2 - Xylofagou East	34.919164	33.916974
3	Point 2 - Xylofagou West	34.940567	33.810116
4	Point 3 - Larnaka	34.85903	33.676446
5	Point 6 - Governor's Beach Center East	34.659938	33.245334
6	Point 6 - Governor's Beach Center West	34.66132	33.233734
7	Point 6 - Governor's Beach East	34.657745	33.270209
8	Point 6 - Governor's Beach West	34.663632	33.222309
9	Point 7 - Aphrodite Hills	34.633645	32.562276
10	Point 7 Avdimou	34.606562	32.778484

Table 4. The candidate AZAs

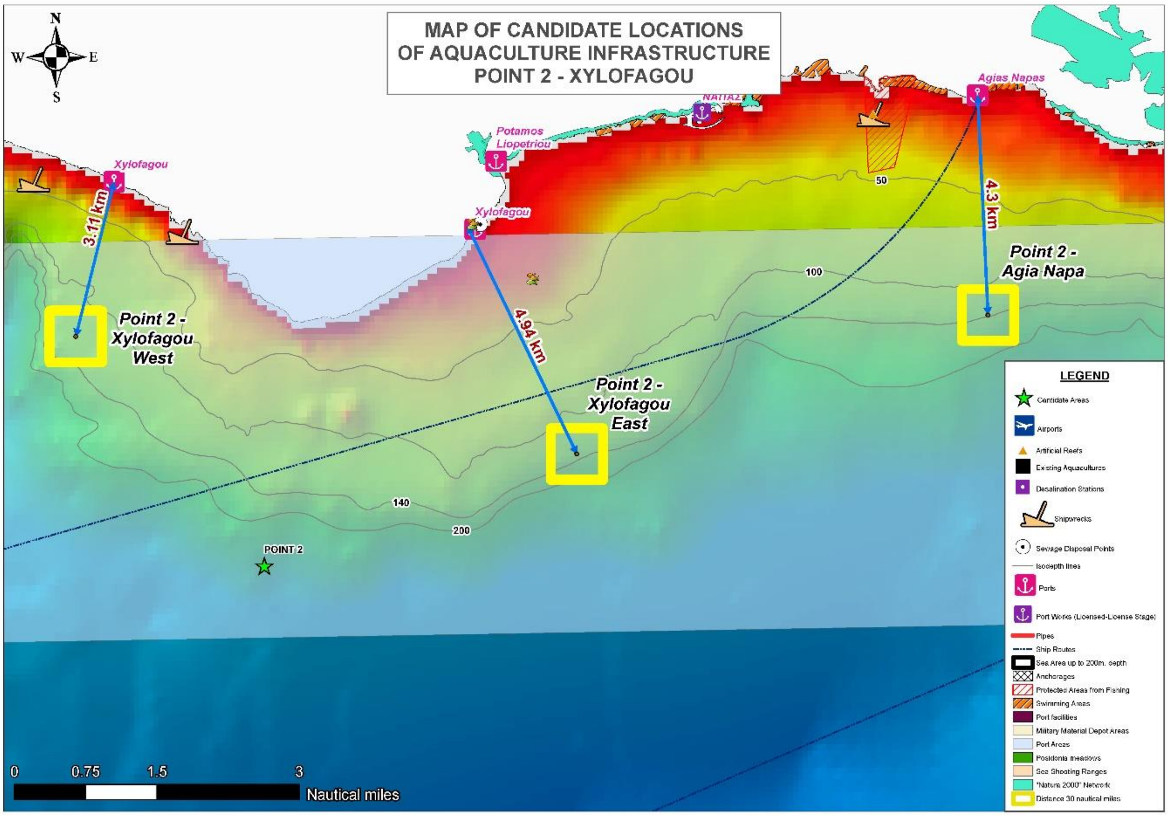

Figure 2.23. Xylofagou AZA and its AMAs (3 locations).

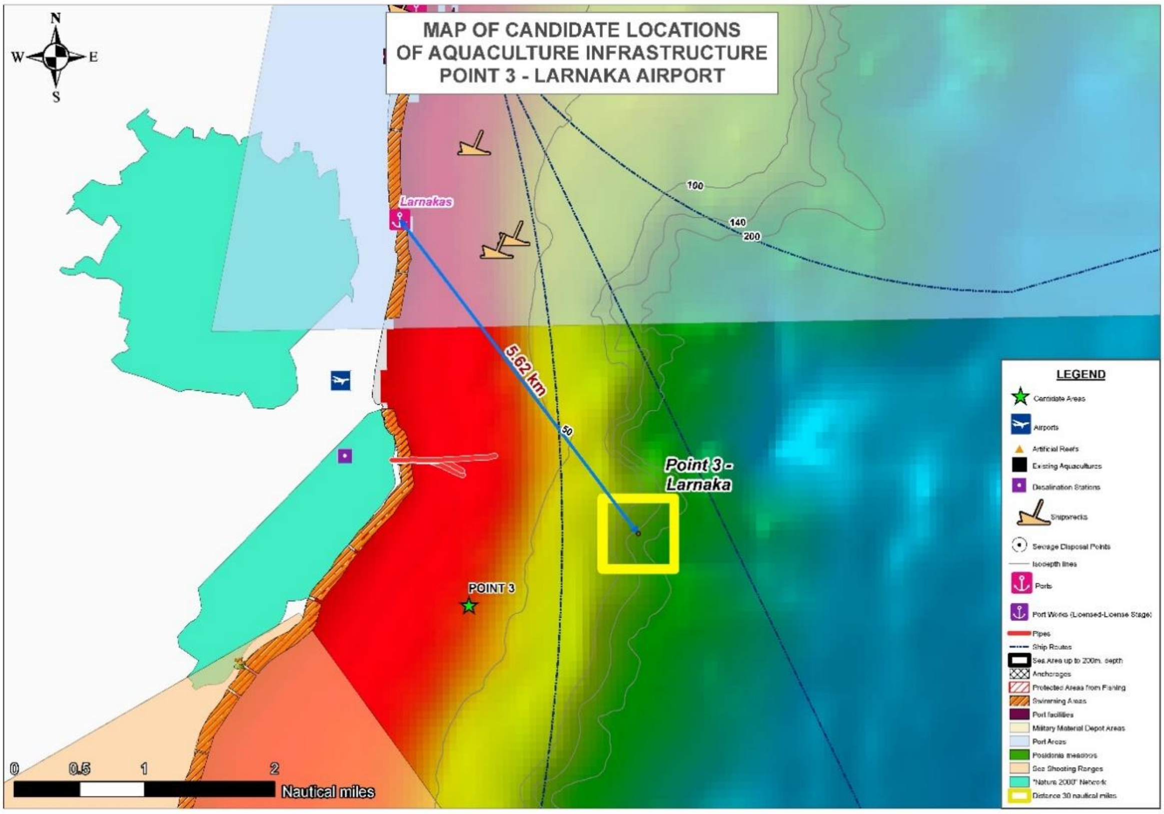

Figure 2.24. Larnaka AZAs (1 location).

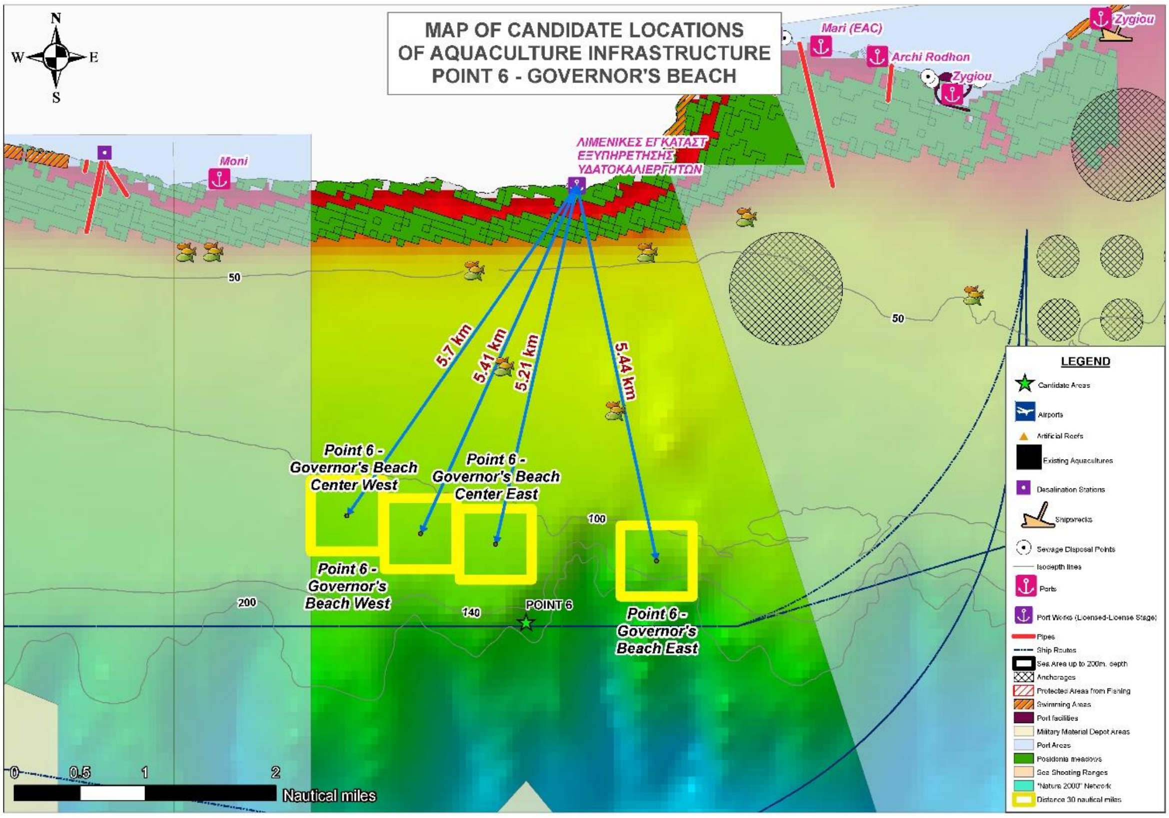

Figure 2.25. Governor's beach AZA and its AMAs (4 AMA locations).

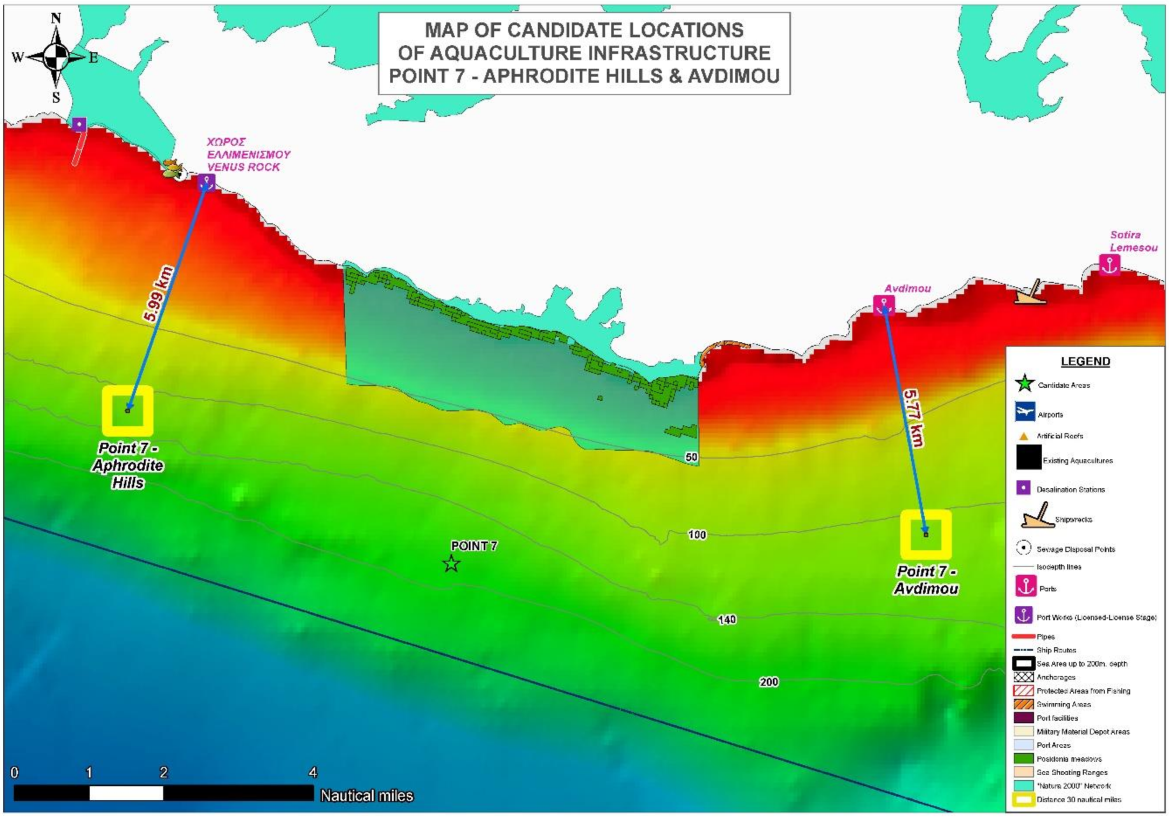

Figure 2.26. Aphrodite Hills & Avdimou AZAs (2 locations).

2.6 Phase 3 - Selection of the optimal candidate areas

In the third and final phase, the ten (10) potential candidate areas needed to be narrowed down to the ones that are best for further investigation (see D11- Identification of sites with less sensitive/important/rare habitats where the impact of the aquaculture at the environment can be minimized & D14- Social and environmental impact description of optimal sites for aquaculture development).

At first, meetings and discussions took place between the partners of the project. Then, the opinion of the Department of Fisheries and Marine Research (DFMR) was requested.

The outcome of the meetings with DFMR regarding the evaluation of the ten areas is shown in Table 5.

CANDIDATE AZA	PRIORITY (High, Medium, Low)	DFMR COMMENTS
Point 2- Xylofagou West	VERY LOW / NO	There are no available appropriate infrastructures to accommodate the needs of aquaculture Activity. The existing fishing shelter cannot be used for this purpose
Point 2- Xylofagou East	VERY LOW / NO	The indicated fishing shelter belongs to a private company, therefore it cannot be used for this purpose.
Point 2- Agia Napa	VERY LOW / NO	There are no available appropriate infrastructures to accommodate the needs of aquaculture Activity. The existing fishing shelter cannot be used for this purpose
Point 3- Larnaka	HIGH (Under Conditionality)	This is only an option if the Port Authorities will provide an appropriate area / space within Larnaka Port to accommodate the supporting needs of this activity.
Point 6 - Governor's Beach Center West	HIGH	The construction of the new aquaculture port facility is ideal to accommodate the relevant needs in this area
Point 6 - Governor's Beach West	HIGH	The construction of the new aquaculture port facility is ideal to accommodate the relevant needs in this area
Point 6 - Governor's Beach Center East	HIGH	The construction of the new aquaculture port facility is ideal to accommodate the relevant needs in this area
Point 6 - Governor's Beach East	HIGH	The construction of the new aquaculture port facility is ideal to accommodate the relevant needs in this area
Point 7 - Aphrodite Hills	VERY LOW / NO	In general, all the sites west of Limassol are very exposed to the weather and are of much higher risk for damages due to wave action. Also in the area there in no appropriate fishing shelter to accommodate the needs of aquaculture.

Point 7 - Avdimou	VERY LOW / NO	In general, all the sites west of Limassol are very exposed to the weather and are of much higher risk for damages due to wave action. Also, in the area there in no appropriate fishing shelter to accommodate the needs of aquaculture.

Table 5. The outcome on the discussions with DFMR regarding the assessment of the ten candidate areas.

Other comments received by DFMR were considered as well and are listed below:

- The most prominent location in general is in the wider area between Governor's Beach and Moni Limassol.
- Most of the other proposed areas are not close to appropriate port facilities, except in Larnaka. But even this, it is still difficult because if the development plans for the Larnaka Port, are considered, there are doubts, whether the Port Authority will provide its consent for accommodating aquaculture.
- Also regarding conflicts at these depths, DFMR believes that these include the Maritime traffic and maybe some fishing activities.
- For the establishment of any marine aquaculture activity / unit the submission and examination of an Environmental Impact Assessment Study is required and also an Environmental Approval must be secured. At these depths It is believed that there should not be expected any problems to this respect.
- As regards other criteria, according to the Spatial Study conducted by DFMR, all the areas west of Limassol have been excluded as they are more exposed to the weather (waves).

2.6.1 Final Selection of the optimal candidate OS AZAs

The overall result of the discussions and meetings taken place is the final selection of four (4) optimal locations for OS AZA (Table 6,Figure 2.27 & Figure 2.28):

Name	LAT	LON
Point 2 - Xylofagou West	34.9406	33.8101
Point 3 - Larnaka	34.859	33.6764
Point 6 - Governor's Beach Center East	34.6599	33.2453
Point 7 - Aphrodite Hills	34.6336	32.5623

Table 6. The four selected candidate areas as OS AZA

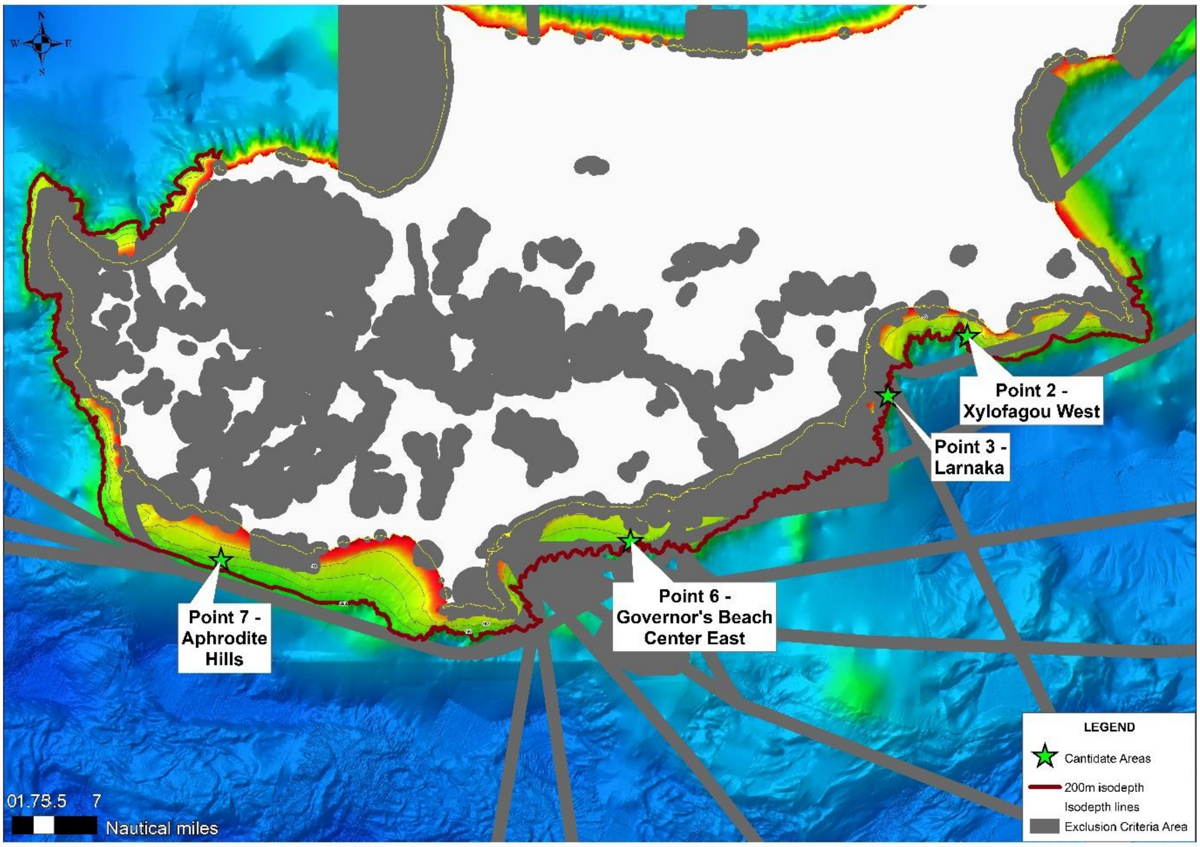

Figure 2.27. The final selection of the four (4) optimal locations for OS AZAs. Exclusion areas are also displayed.

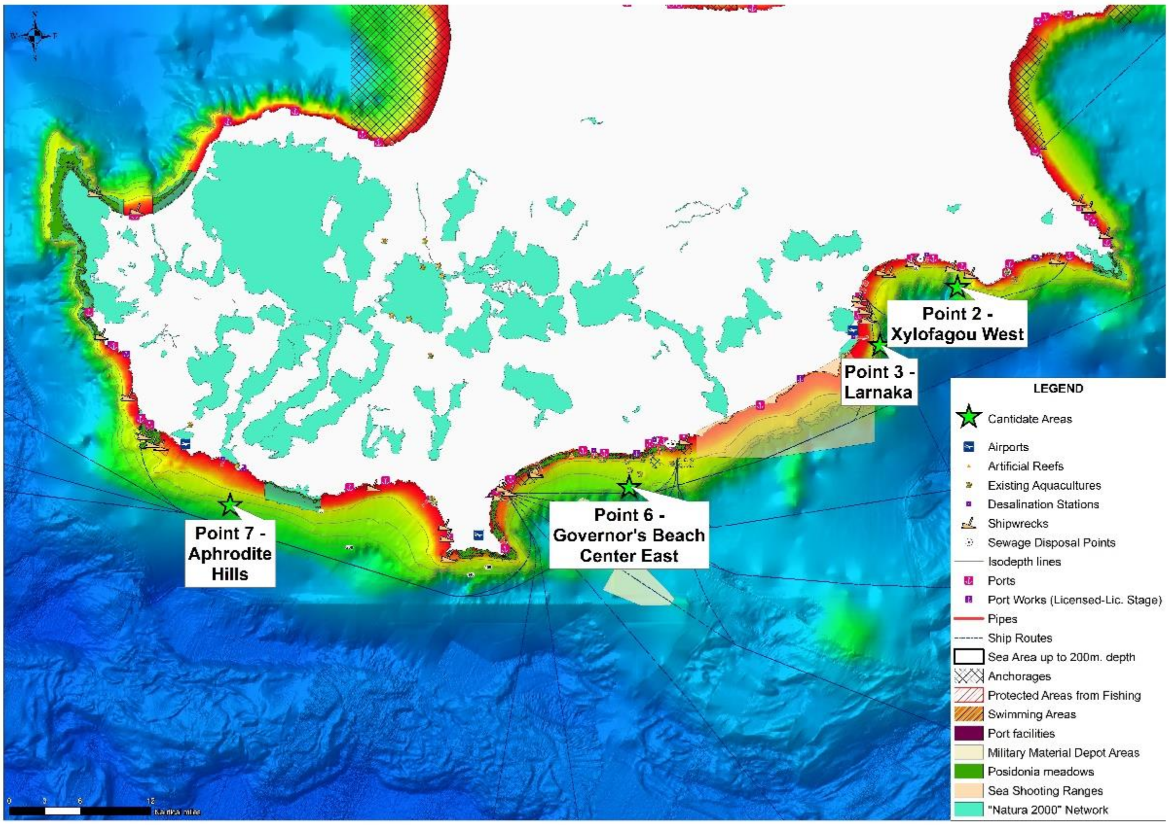

Figure 2.28. The 4 selected Open Sea Allocated Zones for Aquaculture (4 areas).

3 Estimation of carrying capacity

There is no doubt that for the development of sustainable aquaculture it is critical to estimate the "carrying capacity" of the ecosystem. The content of the term and its definition are a subject of debate (McKindsey, et al., 2006). However, it is generally accepted that for all human production activities (and hence for aquaculture), there are limits beyond which adverse effects arise. In the countries with a developed fish farming industry, there is pressure from the administration and the producers to the scientific community to identify the "carrying capacity" for fish farms.

Prominent international Organisations like the FAO and the GFCM have promoted initiatives to assist cooperation for the development of aquaculture, to enhance the dialogue among Mediterranean states and stakeholders regarding three main issues for sustainable aquaculture development (Karakassis, 2013). These include:

- site selection and carrying capacity,
- sustainability indicators and
- marketing of aquaculture products.

In general, carrying capacity is a well-defined concept in Ecology i.e. “the maximum population size a certain environment can support for an extended period of time, for a population of a particular species”. The fact that there is increasing demand for estimating carrying capacity by various stakeholders including regulators and farmers is a positive sign indicating that it has become understood that aquaculture growth (like most other types of development) has an upper limit.

Karakassis (2013) and Karakassis et al (2013) discuss in detail the concept of "carrying capacity”. According to them, the "carrying capacity” is readily applicable in the case of mussel farming where the farmed stock directly depends on the availability of plankton resources in the ambient water, however, in the case of cage fish farming, the farmed stock depends on allochthonous food sources, and therefore the availability of food, as well as that of space and water that may be practically limitless.

The OS Aqua Team adopts the following definition of Karakassis et al. (2013) for the "carrying capacity” in the case of this OS AQUA project.

"Carrying capacity" refers to the production level (production size or density of the cultured stock) that does not cause "adverse effects on the wider environment”.

The physical “carrying capacity” of the selected AZAs was estimated using mathematical formulations provided by Karakassis et al. (2013), as also reported by Macias et al. (2019) and Yigit et al. (2021) as a rapid model that can be applied for estimating the physical carrying capacity in marine sites of the Mediterranean with similar water conditions and production managements of similar fish species such as gilthead seabream or European seabass. Greek (Karakassis et al. 2013; Macias et al. 2019) and Turkish legislations (Yigit et al., 2021) set for fish farming in the Mediterranean follow similar parameters for the estimation of physical or production carrying capacity in allocated aquaculture sites in the Mediterranean Sea. These parameters are water currents, water depth under the cage systems, distance from the shore, the exposure of the farm site, or the current speed along with the total area that allocate for aquaculture in the area with cage farm systems

In order to determine the theoretical carrying capacity of the habitat in the four selected areas, the following formula was used (Karakassis, 2013):

$\boxed{\Delta = [\ 150 + 8 \times (E\text{-}10)\ ] \times fA \times fB \times fK}$

where:

E: marine area of fish farm in 1,000m^2.

fA: coefficient that relates the distance of the park from the coast

fB: coefficient that relates the depth of the sea area

fK: coefficient that relates the offshore nature of the site or the speed of the currents.

The values of the coefficients are selected from the Table below:

Distance from the coast	***≤ 100 m***	***101-400 m***	***401-1000 m***	***>1.000 m***
Value f_A	**1**	**1.25**	**1.5**	**2**
Depth in the center of the park	***≤ 20 m***	***21-40 m***	***41-60 m***	***> 60 m***
Value f_B	**0.9**	**1**	**1.5**	**2**
Open or closed area (gulf)	***Closed (<3cm/sec)***	***Open (3-5 cm/sec)***	***Very exposed (5-10 cm/sec)***	***Fast flow (>10 cm/sec)***
Value f_K	**1**	**1.5**	**2**	**2.5**

The above formula and coefficients have been adopted by the Greek Government in a regulation since 12/06/2009 (Common Ministerial Decision of the Ministry of Environment and Ministry of Agricultural Development and Food) based on a study carried out by the University of Crete (Prof. Karakassis) aiming at providing a means to adapt production levels to the environmental characteristics of the receiving environment. These values were determined through a Delphi exercise after asking 31 experts from 20 countries.

The characteristics of the potential AZAs for Open Sea Aquaculture are as follows:

(α) The distance of the area from the coast more than 1,000 meters.

❖ ***Therefore, the coefficient fA for the distance of the park from the coast, is 2.***

(β) The depth of the sea ranges from 100 m to 200 m and is much deeper than 60m. ***Therefore, the coefficient of the depth*** f_B ***is equal to 2.***

(γ) The position of the marine area can be characterized as very exposed and fast flow **(**f_K**=2.5).**

Also, according to the Greek regulation:

- Distance between farms should be >500m
- The leased marine area should be 10–100 thousand m^2
- Depth >18m and at least 2 times the depth of the nets
- Loading (fish density) per m^3 is provided for different species and size of fish
- Mortality (bream-bass) should be <17 % and for other Med species <30 %
- No new farms on *Posidonia* meadows
- No expansion of the capacity of the ones over *Posidonia* beds
- The existing ones will not be renewed after the expiration of their concession.

Based on the calculations above, the following capacity is estimated for an indicative aquaculture zone of 1Km^2 (1 million m^2).

$\boxed{\Delta = [\ 150 + 8 \times (E-10)\ ] \times fA \times fB \times fK}$ =

$\boxed{\Delta = [\ 150 + 8 \times (1000-10)\ ] \times 2 \times 2 \times 2.5}$ = **80,700 tonnes**.

That means that theoretically more than 80,000 tonnes could be cultivated.

If the max park area is for 100 thousand m^2, then the formula should be

$\boxed{\Delta = [\ 150 + 8 \times (100-10)\ ] \times 2 \times 2 \times 2.5}$ = **8,700 tonnes**.

However, in the scenarios to be analysed, **a maximum of 5,000 tonnes will be considered in each AZA/AMA and therefore this safeguards the sustainability of the OS Aqua project from an environmental point of view.**

4 Conclusions

The Objective of WP4 is to propose a ***National Marine Spatial Plan*** having as main objective to designate zones of Open Sea aquaculture areas, through the utilisation of Geographical Information System (GIS) approach and by taking into account the model output from WP3, while staying within the framework of national and European legislation and directives.

The implementation of the Marine Spatial Study as described in the previous sections had as an outcome the selection of four (4) candidate areas suitable for the establishment of Allocated Zones for Aquaculture (AZAs), and Aquaculture Management Areas (AMAs) within an AZA. The selection was based on an important number of techno-economic, environmental and proximity criteria, all described in spatial terms. The selected AZAs for further investigation and assessment are:

- Point 2 - Xylofagou West
- Point 3 - Larnaka
- Point 6 - Governor's Beach Center East
- Point 7 - Aphrodite Hills

Nevertheless, as the project progresses to completion, candidate areas will be in constant evaluation and alterations are likely to occur, always aiming to provide solid solutions for OS Aquaculture Zone Areas.

5 References

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6 Annexes

Annex 1. Wave Statistics

Wave and wind datasets for the nine areas investigated for weather conditions (see section 2.4.1). The datasets were calculated by the OC-UCY and data were retrieved by the UCY WAM that runs at the University of Cyprus. Data used was the 24hourly forecast between 2010 and 2017 averaged over time.

POINT1 (35.05, 34.05)

Annual

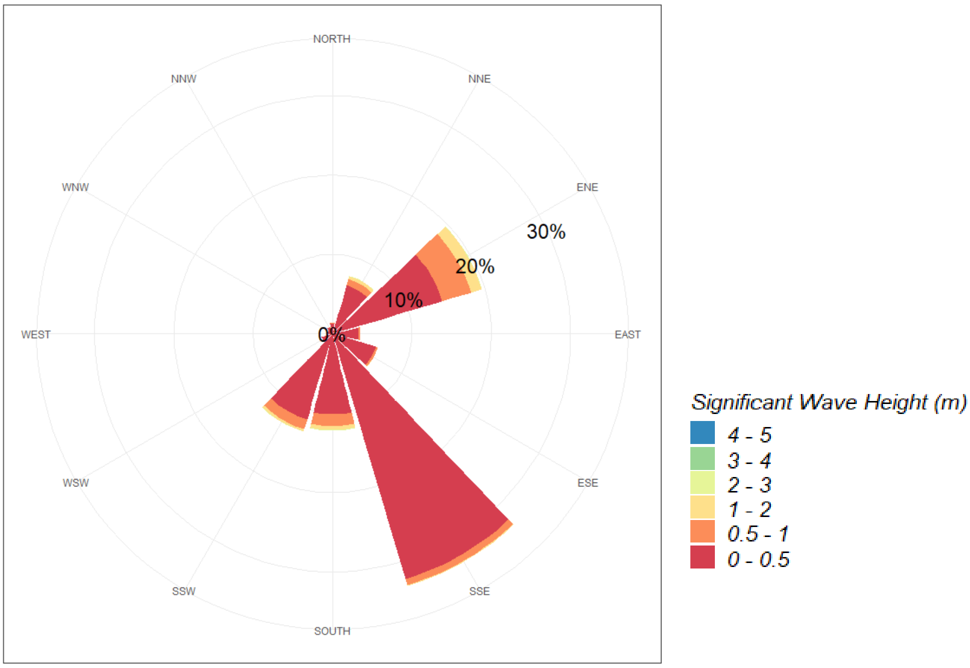

Figure 6.1: Point 1 - Annual rose diagram of Significant Wave Height (m).

Spring

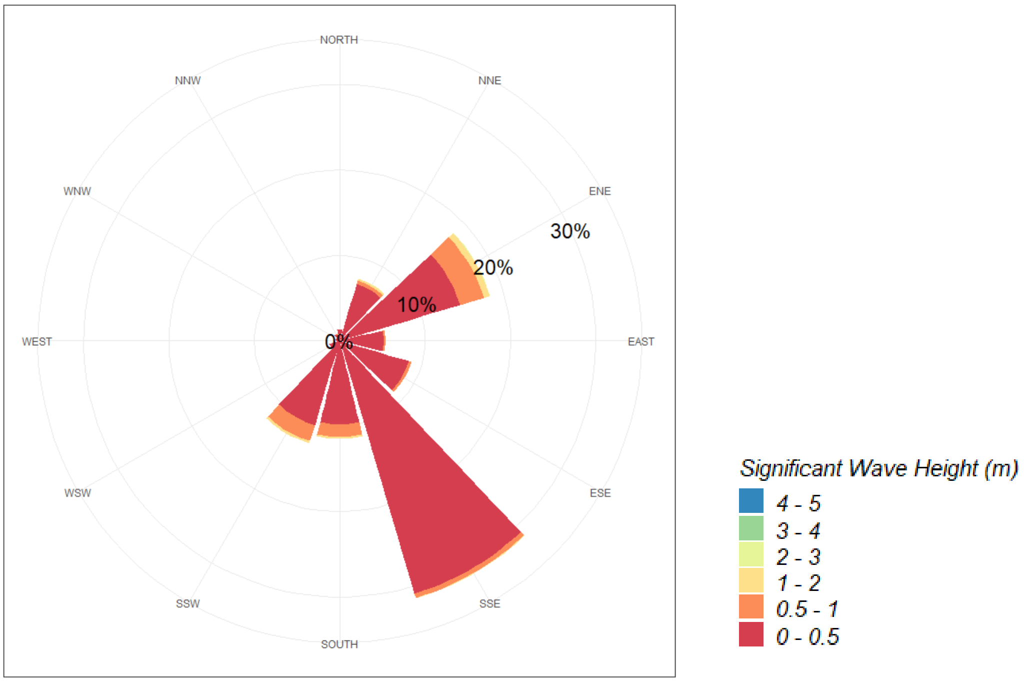

Figure 6.2:Point 1 - Rose diagram of Significant Wave Height (m) during spring.

Summer

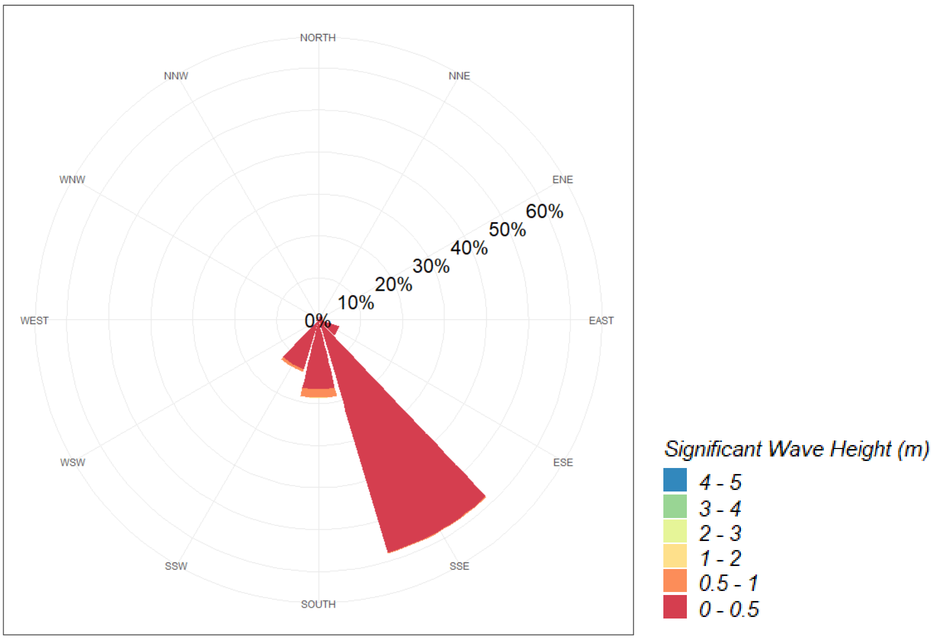

Figure 6.3:Point 1 - Rose diagram of Significant Wave Height (m) during summer

Autumn

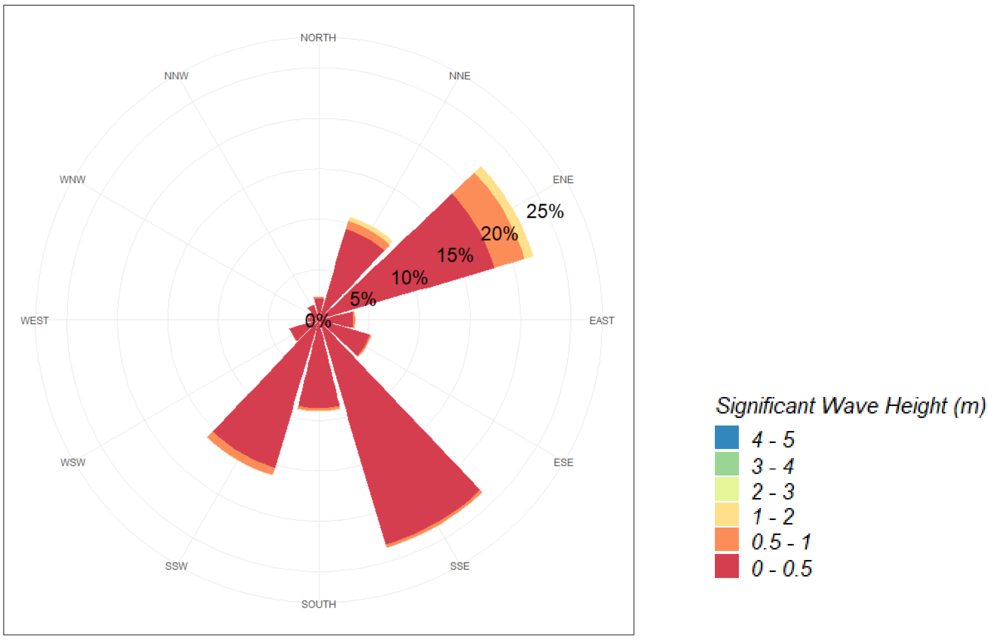

Figure 6.4:Point 1 - Rose diagram of Significant Wave Height (m) during autumn

Winter

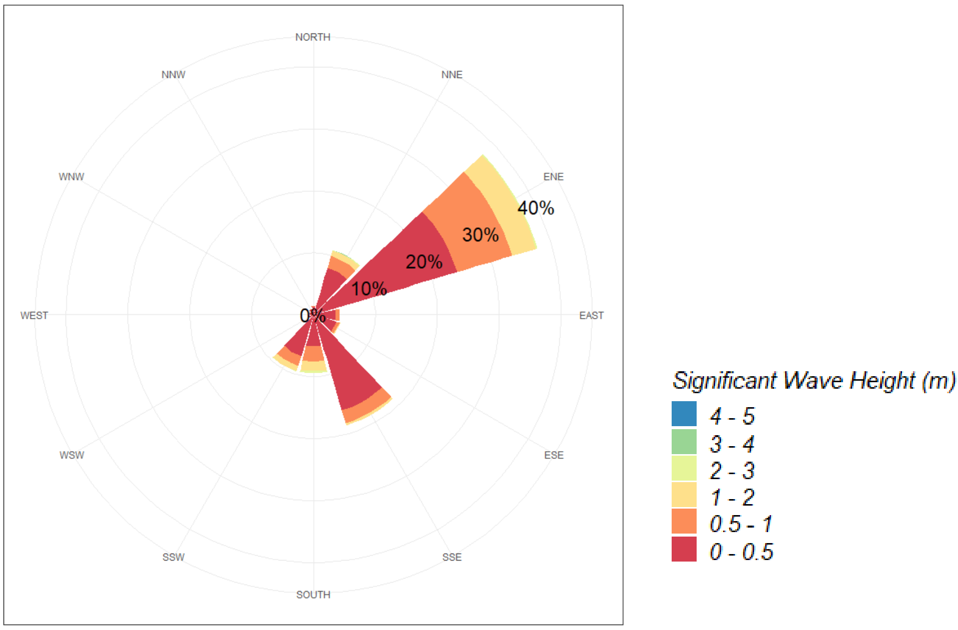

Figure 6.5: Point 1 - Rose diagram of Significant Wave Height (m) during winter

POINT2(34.9, 33.85)

Annual

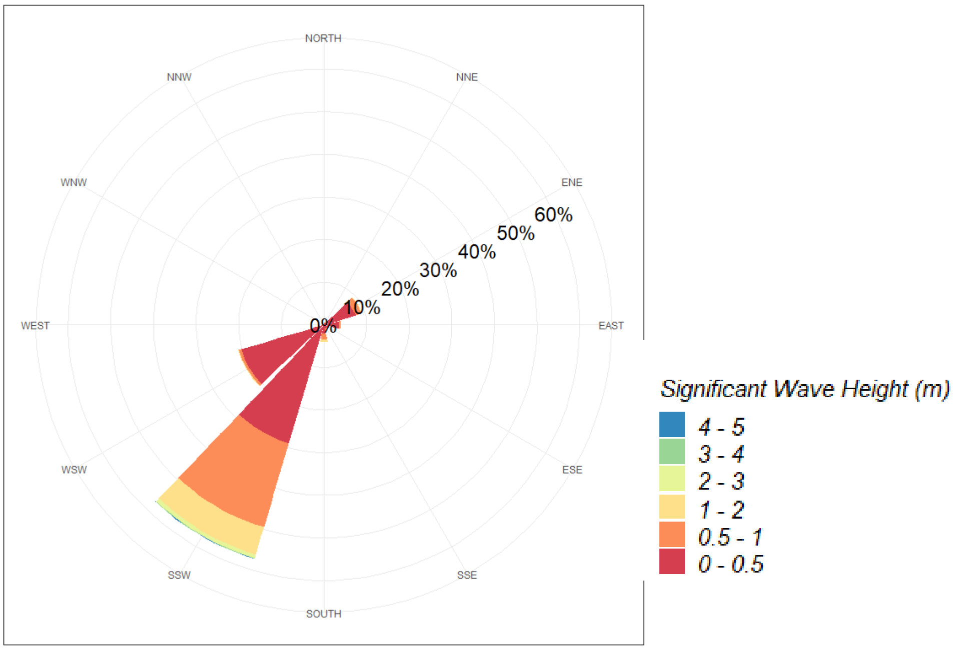

Figure 6.6: Annual Point 2 - Rose diagram of Significant Wave Height (m)

Spring

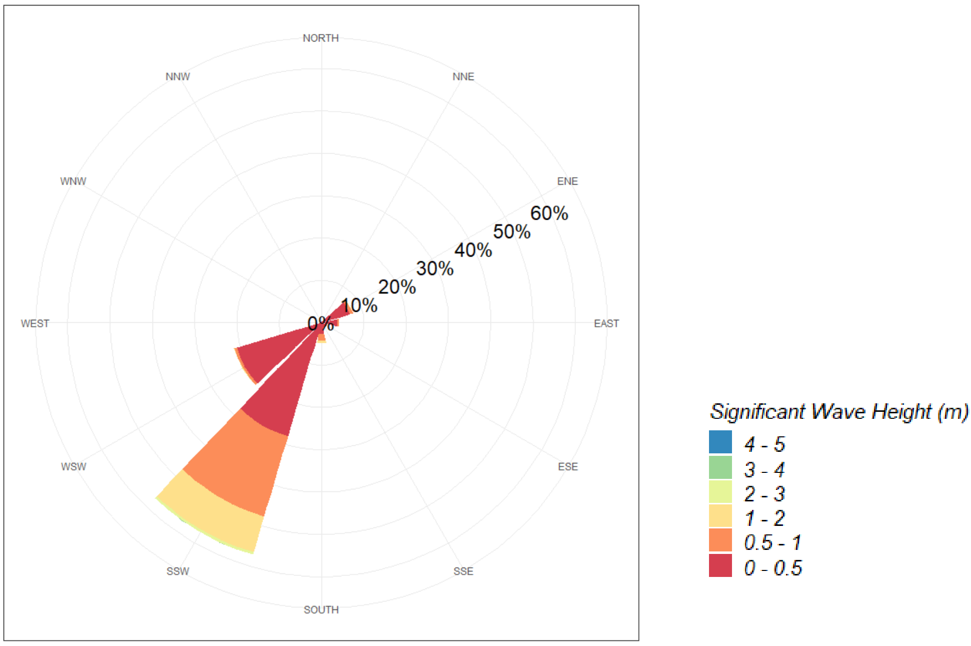

Figure 6.7:Point 2 - Rose diagram of Significant Wave Height (m) during spring

Summer

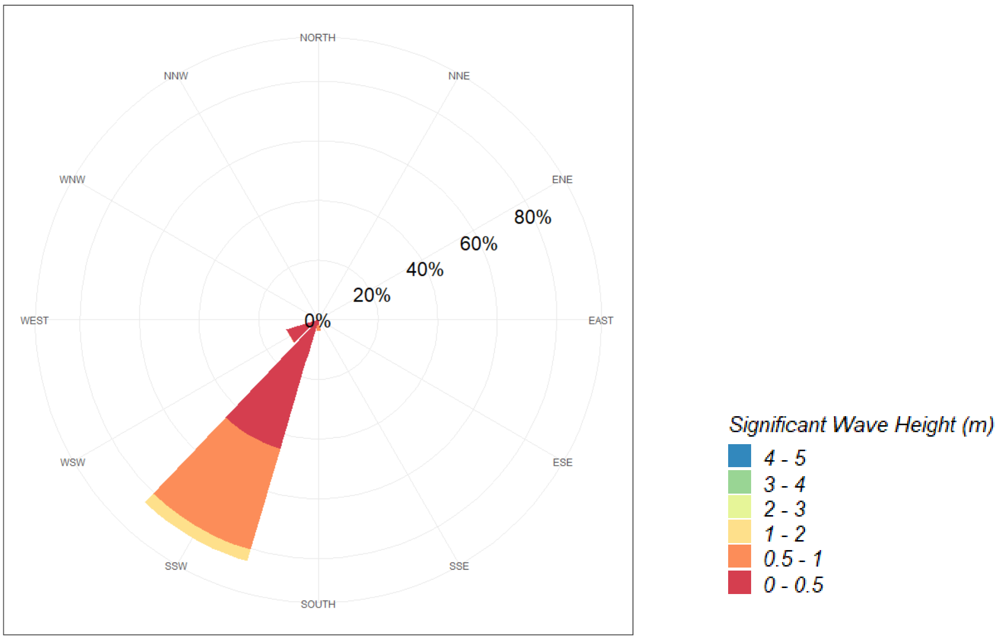

Figure 6.8:Point 2 - Rose diagram of Significant Wave Height (m) during summer

Autumn

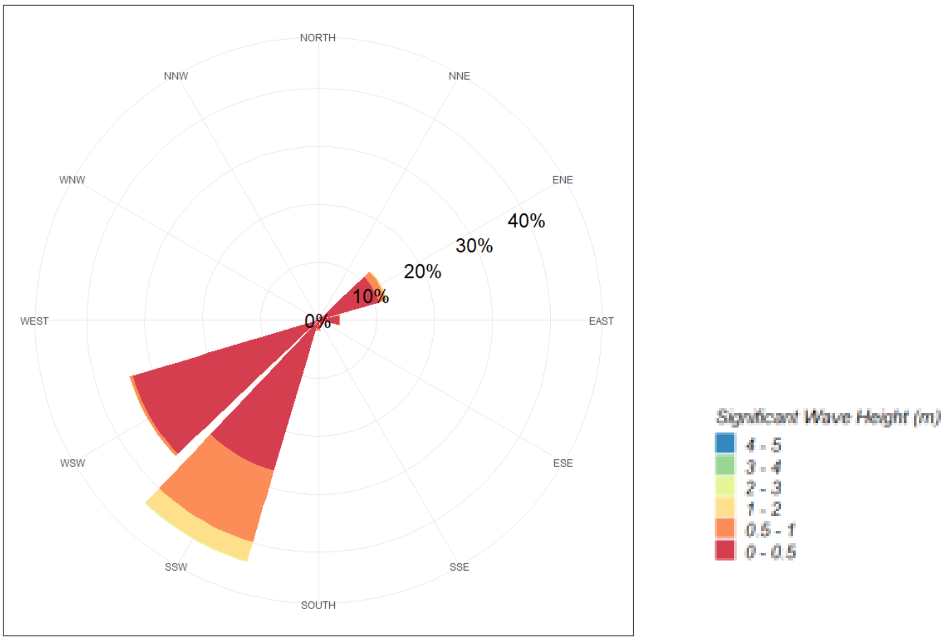

Figure 6.9:Point 2 - Rose diagram of Significant Wave Height (m) during autumn

Winter

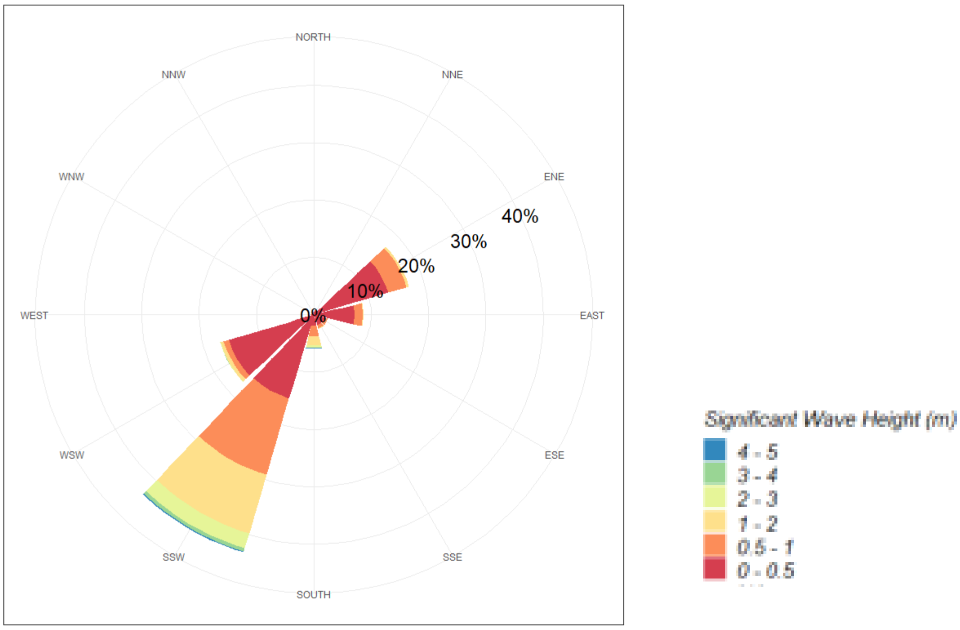

Figure 6.10: Point 2 - Rose diagram of Significant Wave Height (m) during winter

POINT3 (34.85, 36.65)

Annual

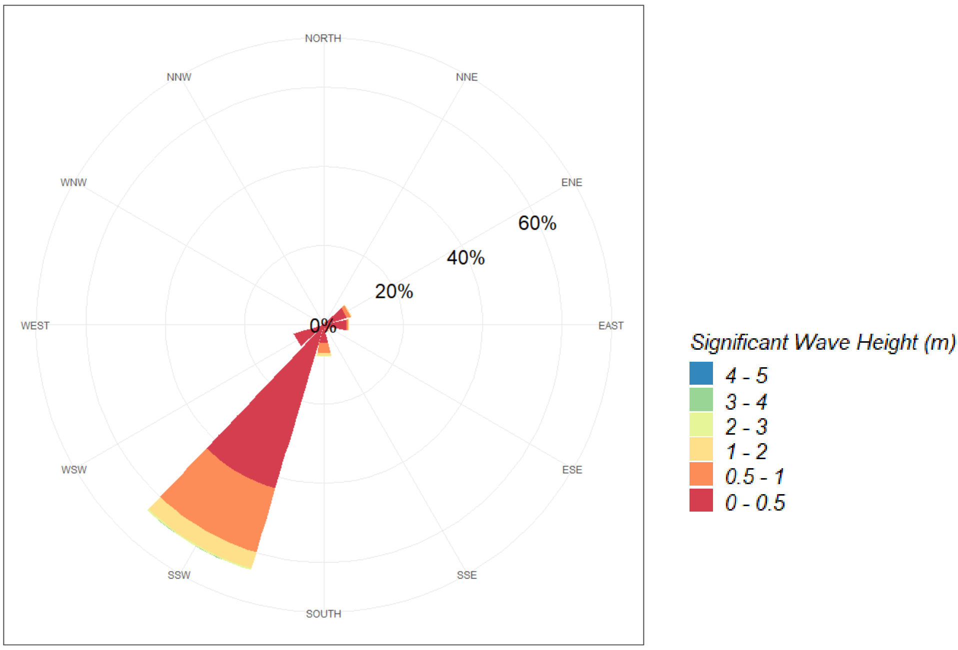

Figure 6.11:Annual Point 3 - Rose diagram of Significant Wave Height (m)

Spring

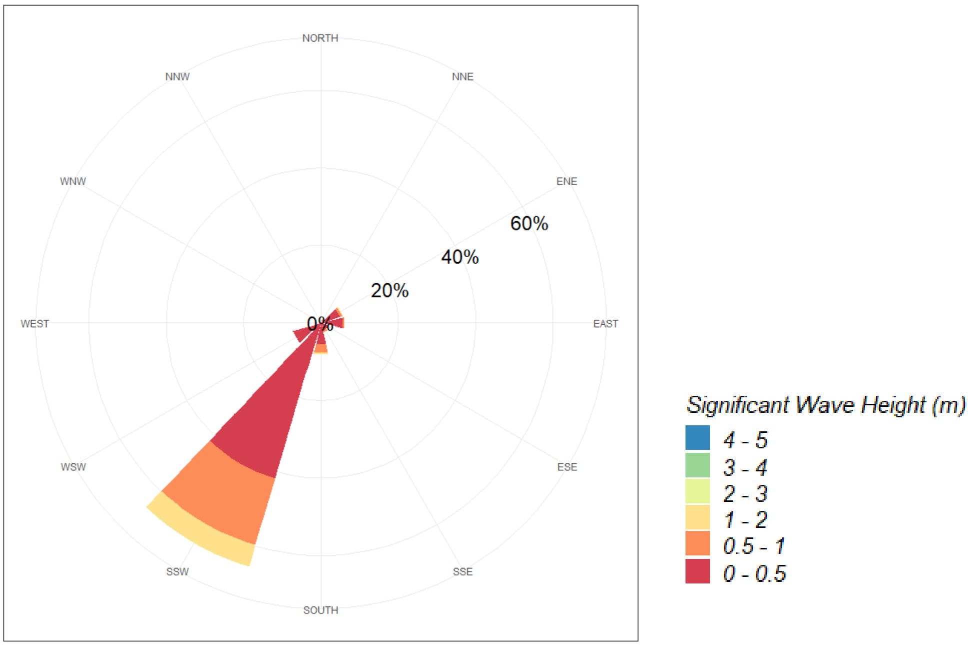

Figure 6.12:Point 3 - Rose diagram of Significant Wave Height (m) during spring

Summer

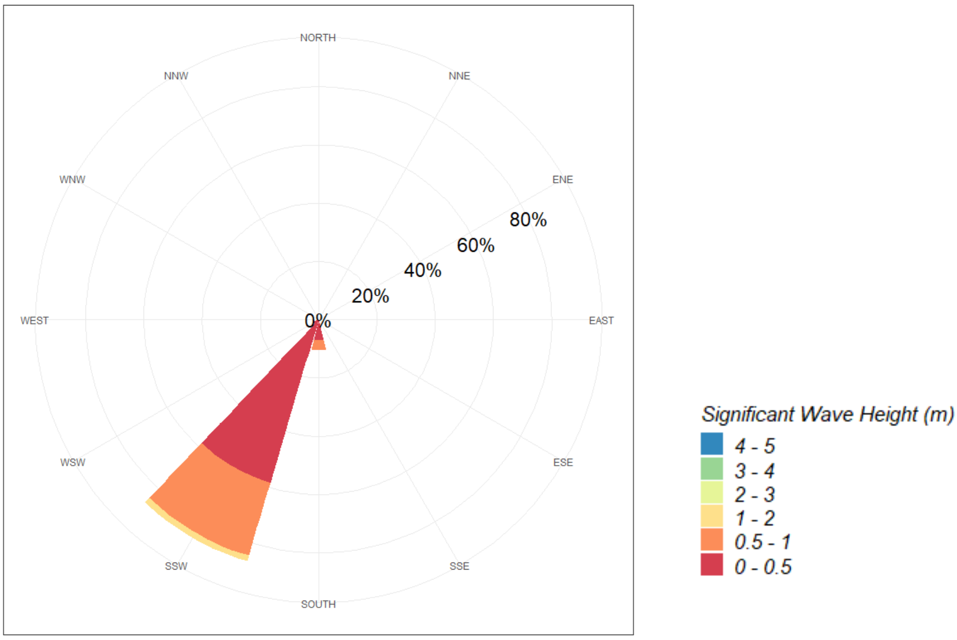

Figure 6.13:Point 3 - Rose diagram of Significant Wave Height (m) during summer

Autumn

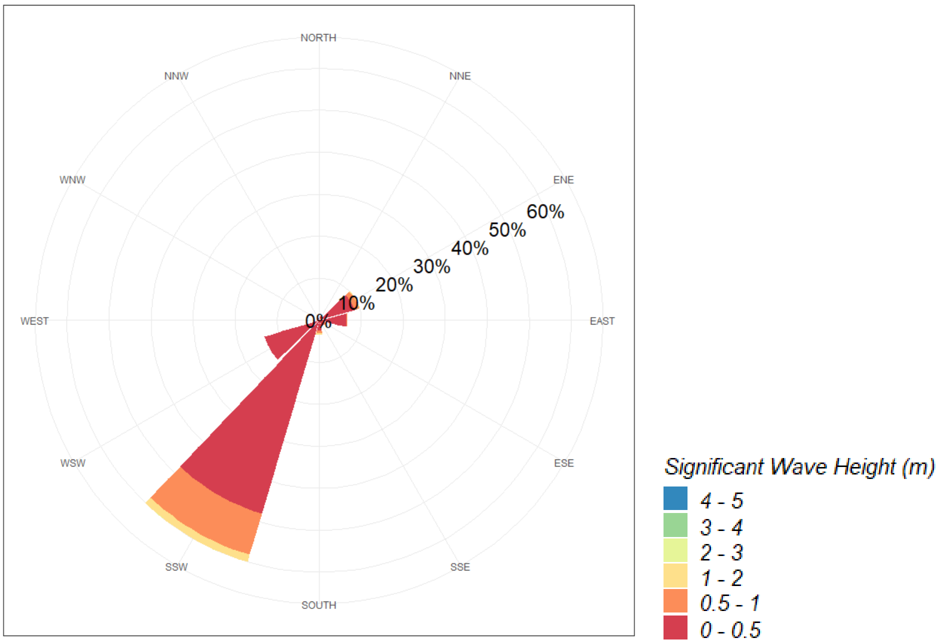

Figure 6.14:Point 3 - Rose diagram of Significant Wave Height (m) during autumn

Winter

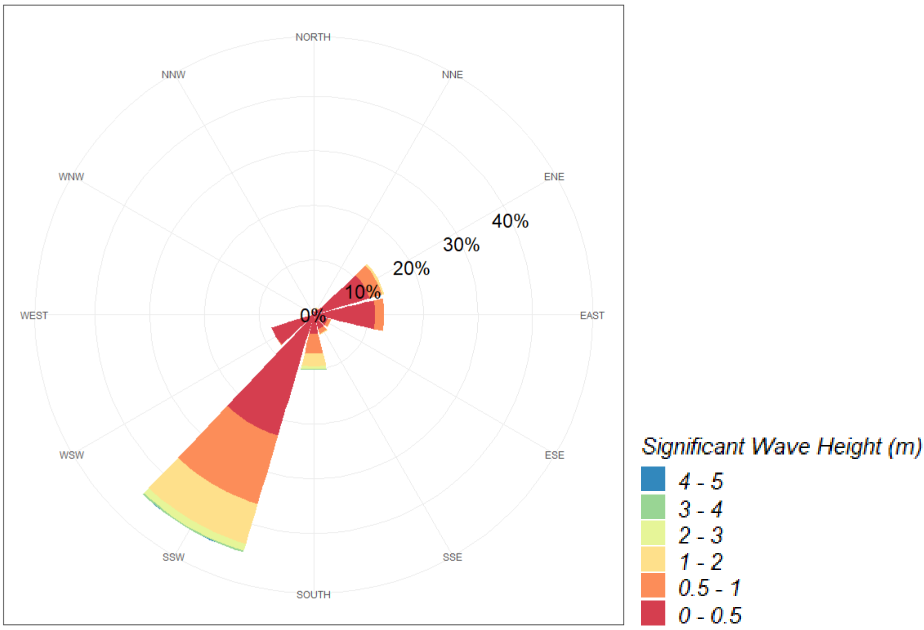

Figure 6.15: Point 3 - Rose diagram of Significant Wave Height (m) during winter

POINT4 (34.45, 33.6)

Annual

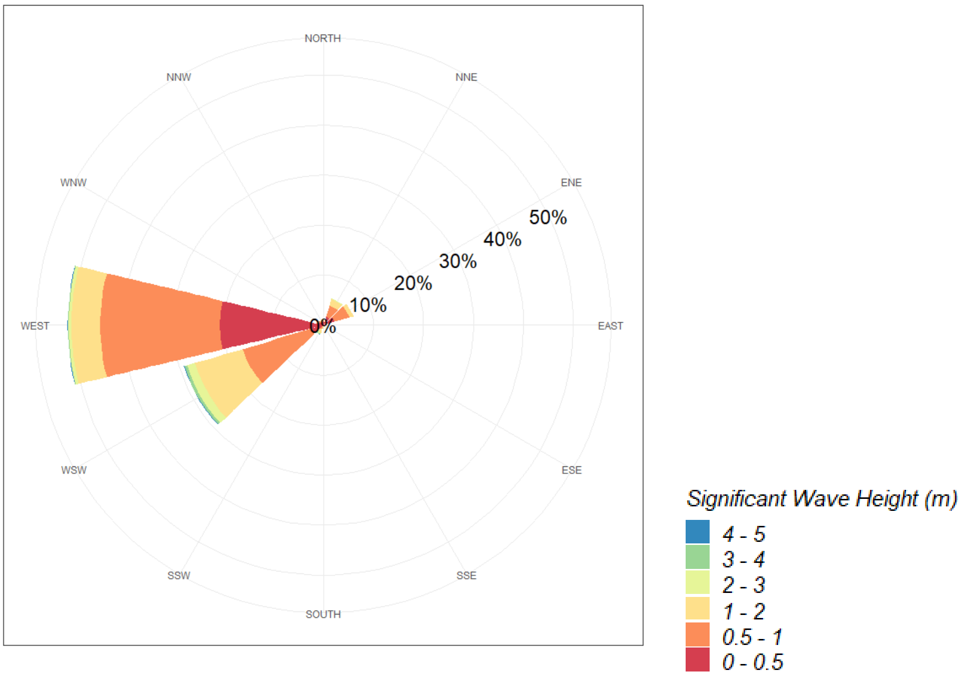

Figure 6.16:Annual Point 4 - Rose diagram of Significant Wave Height (m)

Spring

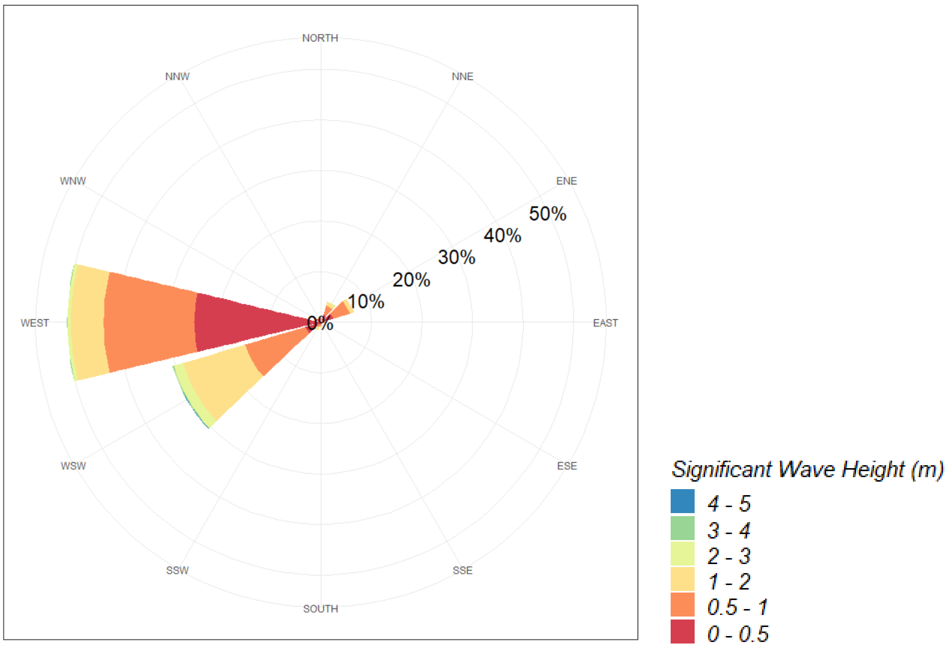

Figure 6.17:Point 4 - Rose diagram of Significant Wave Height (m) during spring

Summer

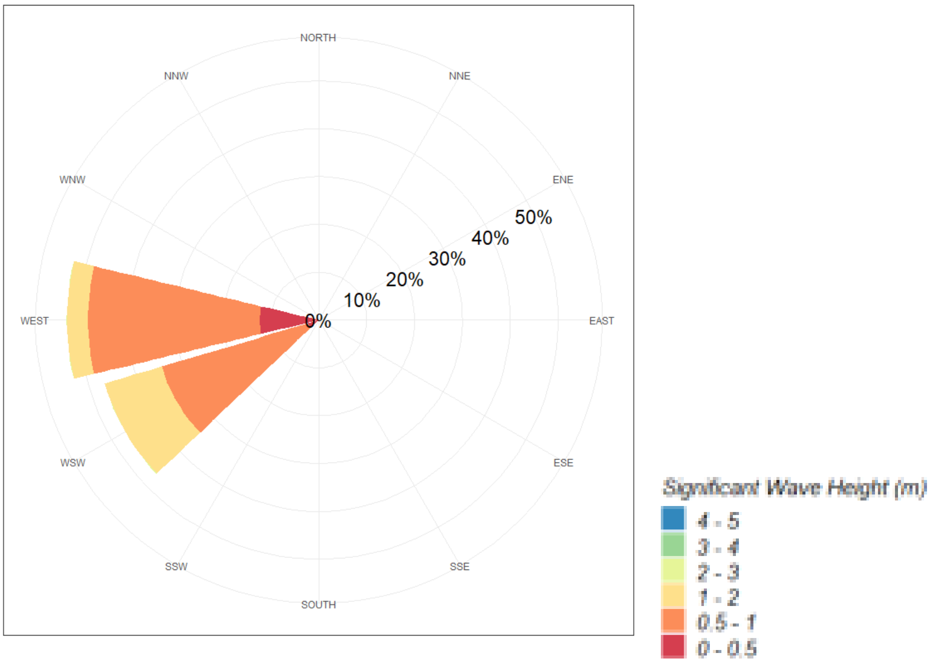

Figure 6.18:Point 4 - Rose diagram of Significant Wave Height (m) during summer

Autumn

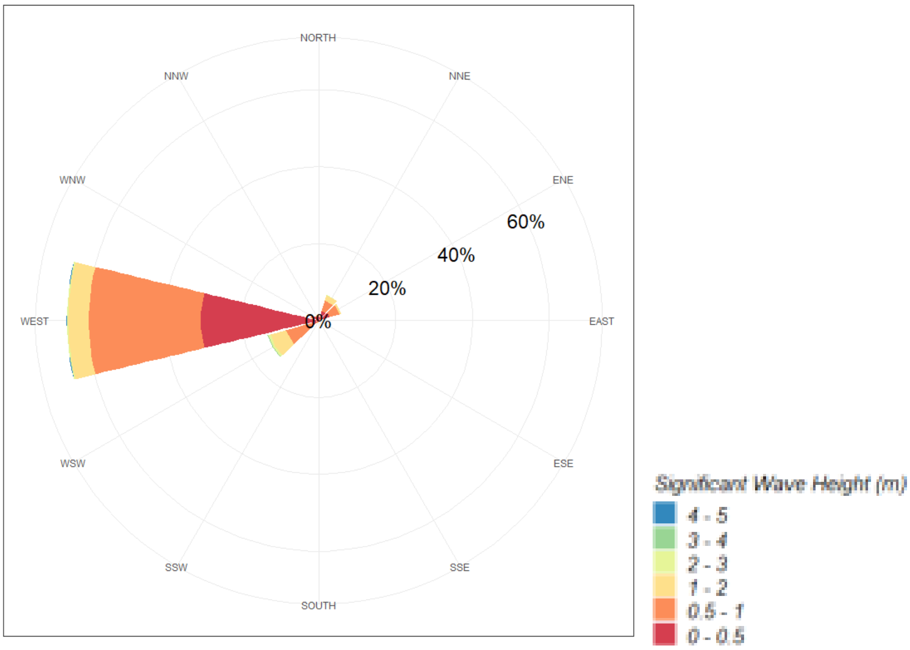

Figure 6.19:Point 4 - Rose diagram of Significant Wave Height (m) during autumn

Winter

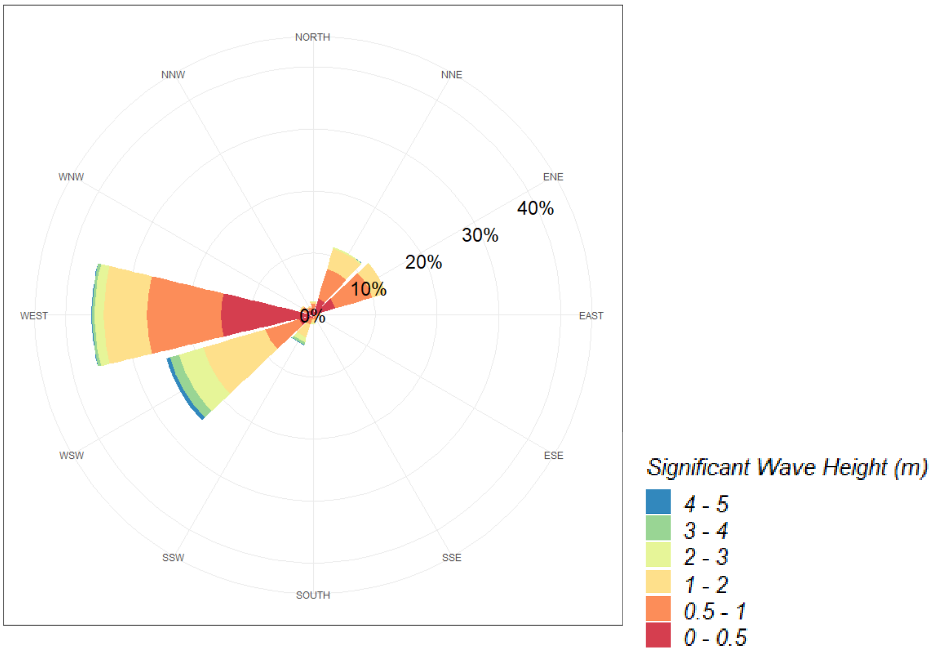

Figure 6.20: Point 4 - Rose diagram of Significant Wave Height (m) during winter

POINT5 (34.65, 33.55)

Annual

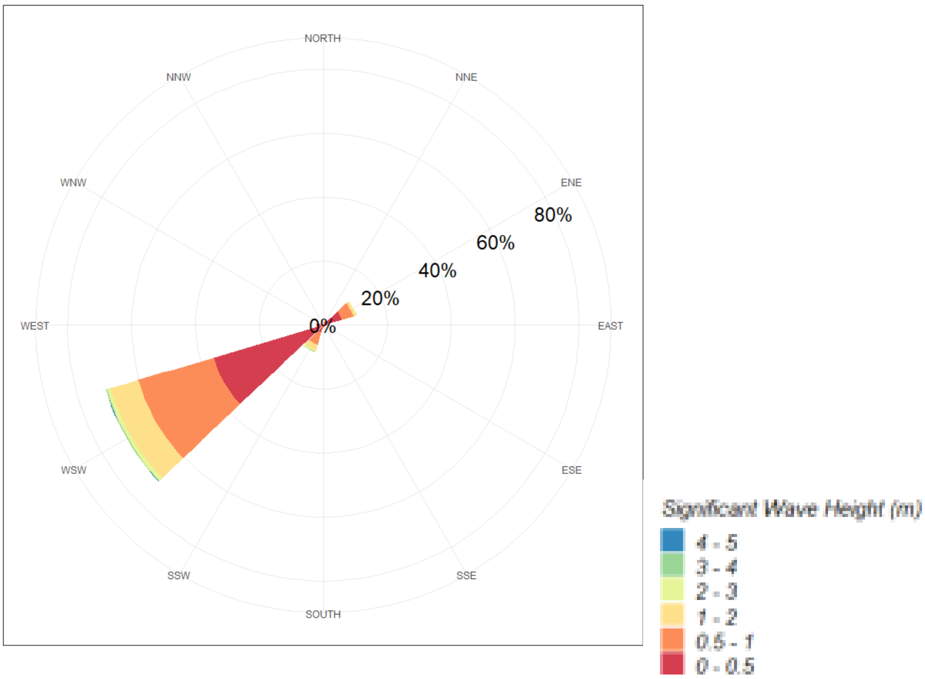

Figure 6.21:Annual Point 5 - Rose diagram of Significant Wave Height (m)

Spring

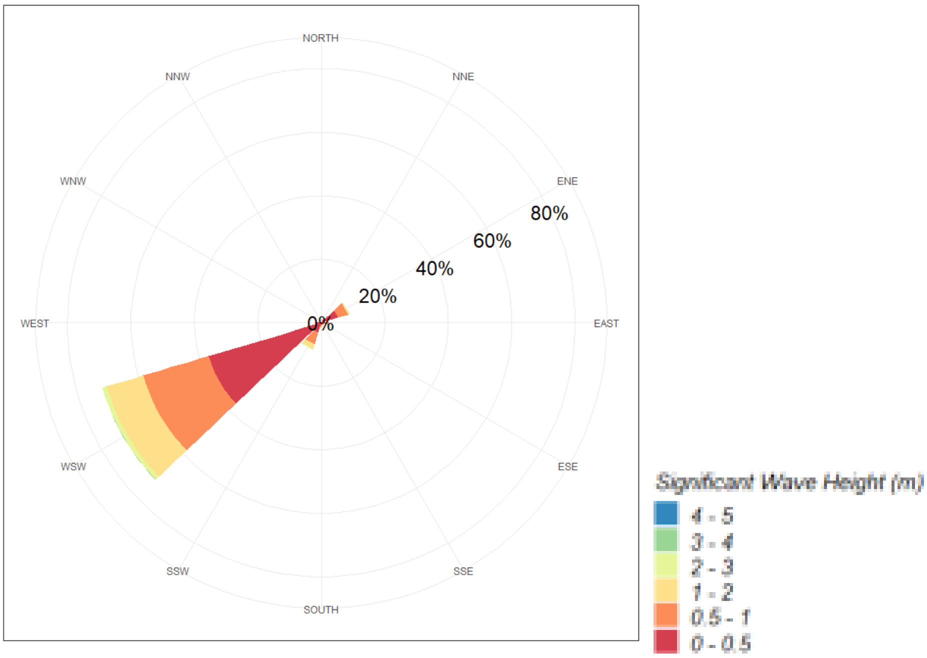

Figure 6.22:Point 5 - Rose diagram of Significant Wave Height (m) during spring

Summer

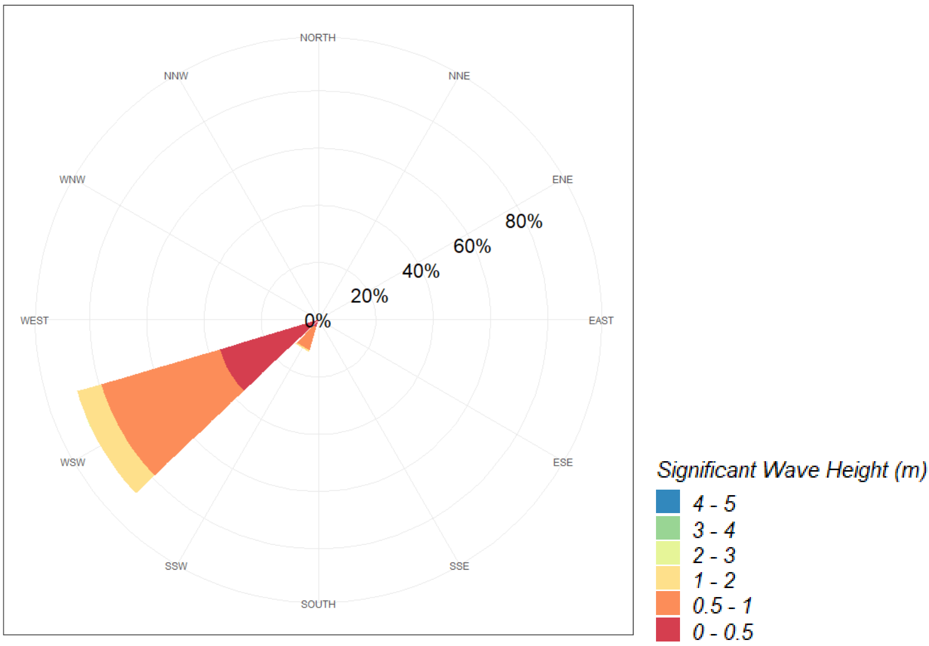

Figure 6.23:Point 5 - Rose diagram of Significant Wave Height (m) during summer

Autumn

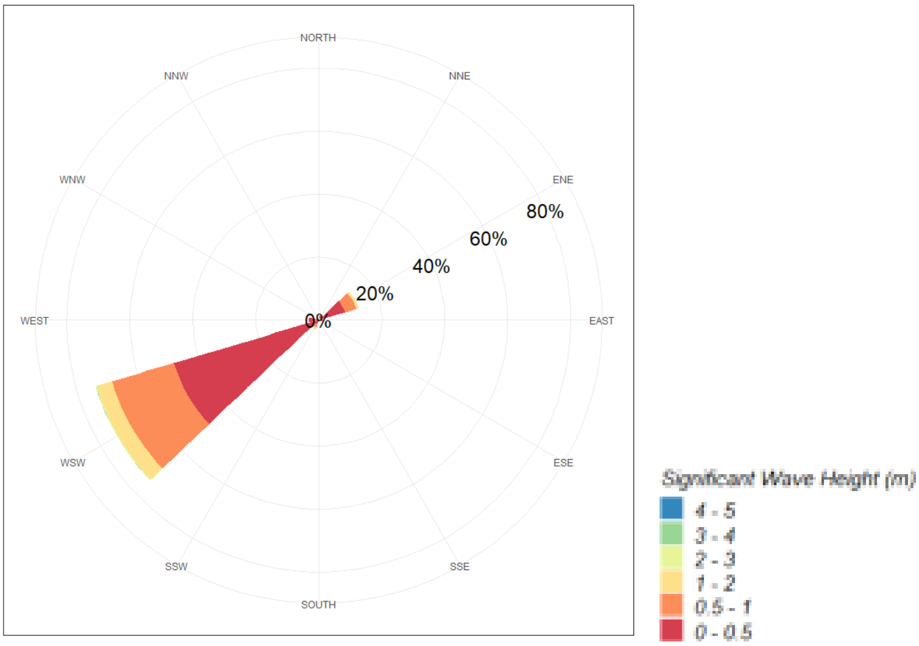

Figure 6.24:Point 5 - Rose diagram of Significant Wave Height (m) during autumn

Winter

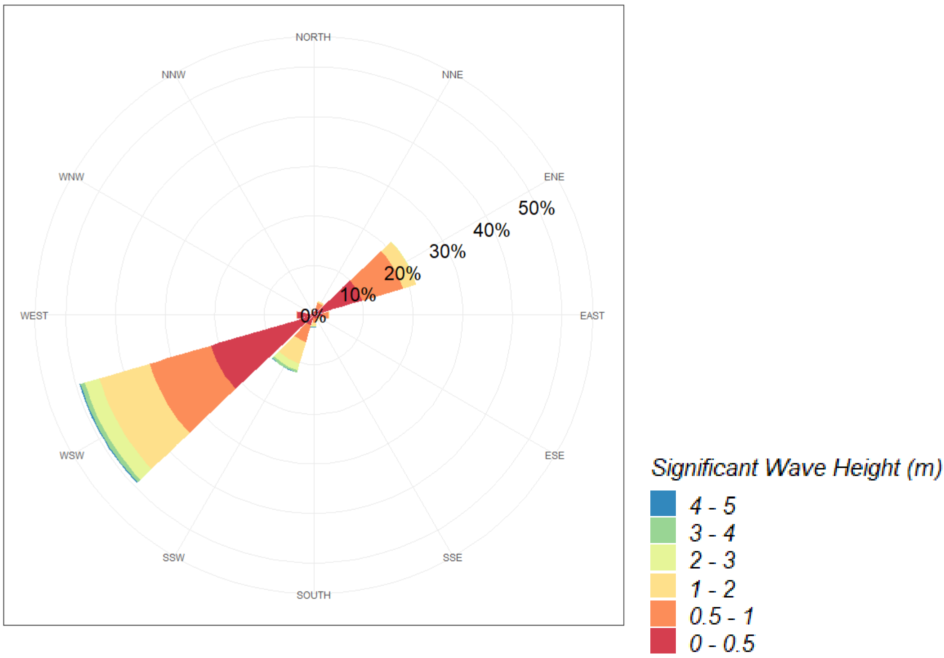

Figure 6.25: Point 5 - Rose diagram of Significant Wave Height (m) during winter

POINT6 (34.65, 33.25)

Annual

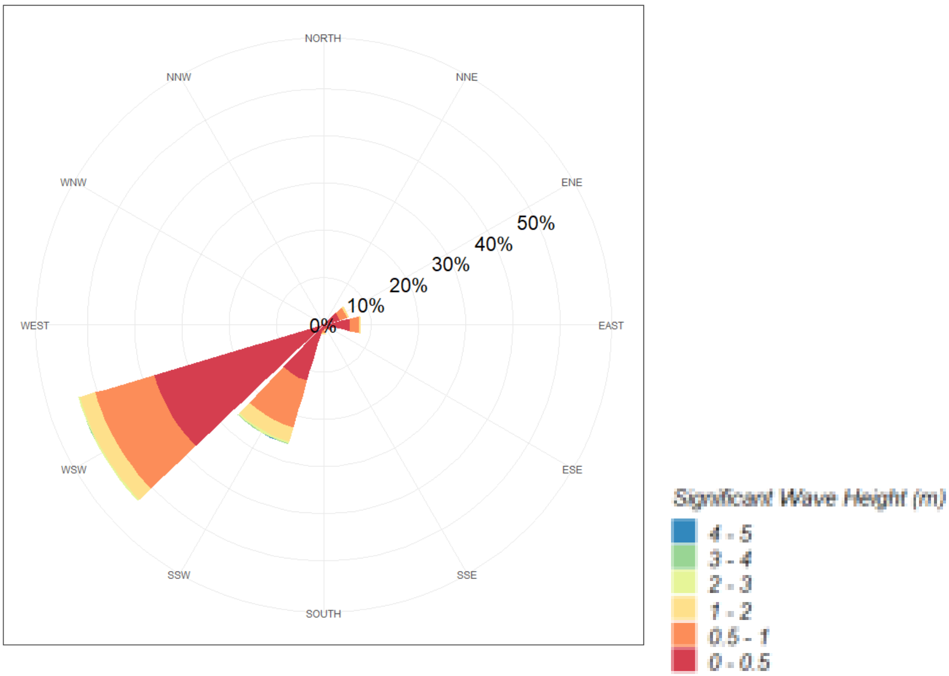

Figure 6.26:Annual Point 6 - Rose diagram of Significant Wave Height (m)

Spring

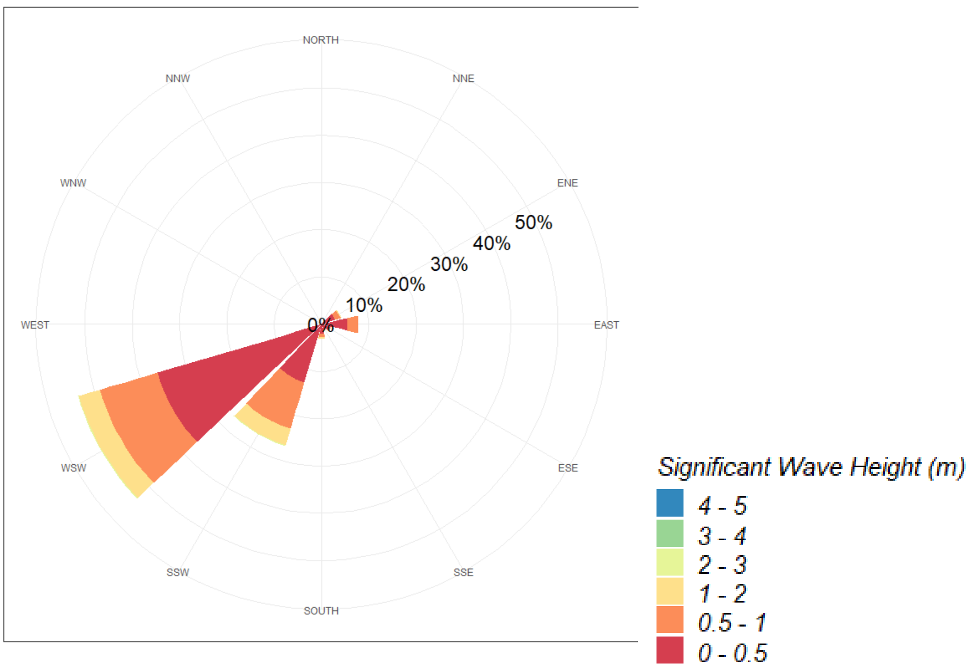

Figure 6.27:Point 6 - Rose diagram of Significant Wave Height (m) during spring

Summer

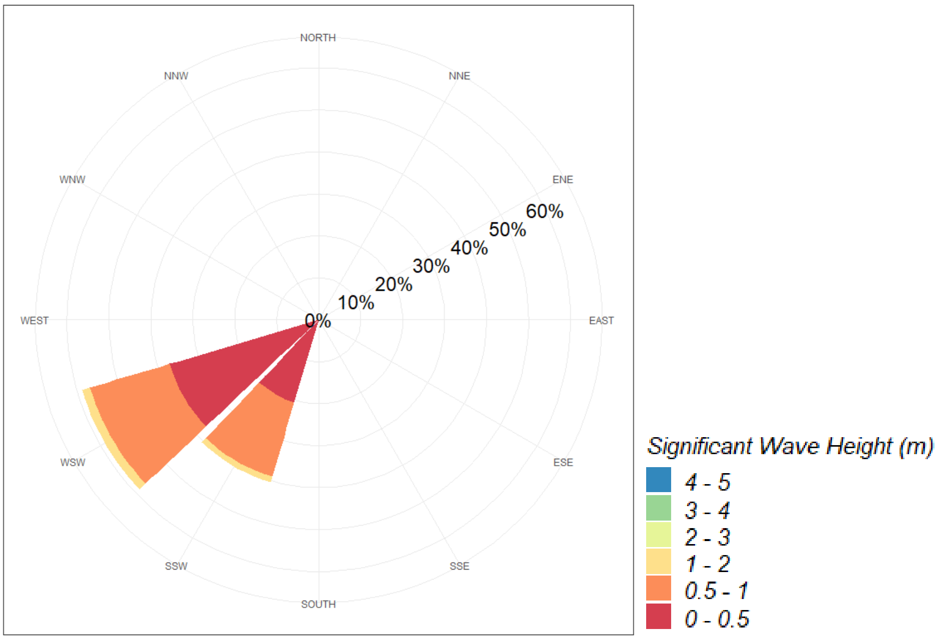

Figure 6.28:Point 6 - Rose diagram of Significant Wave Height (m) during summer

Autumn

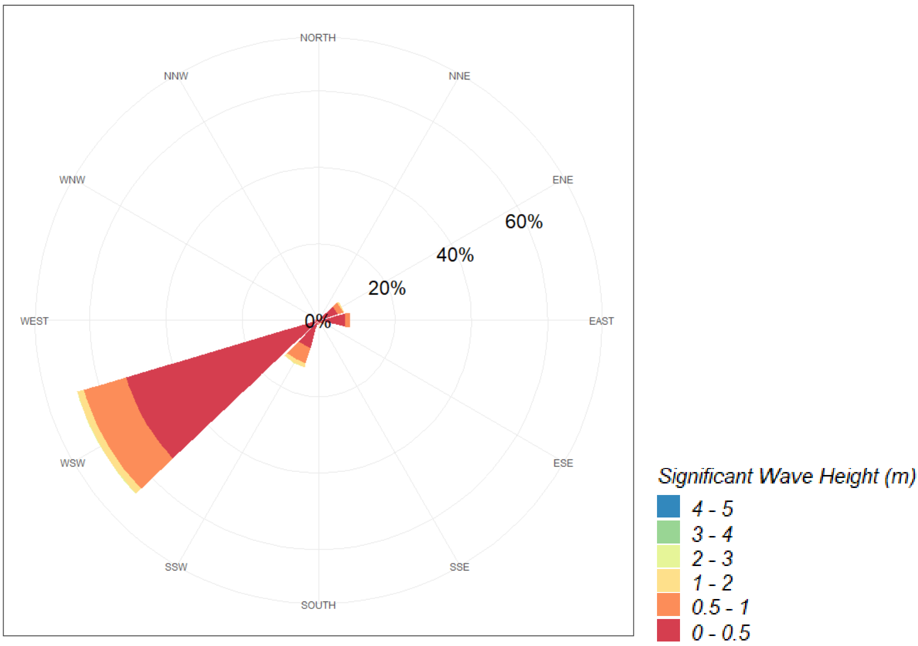

Figure 6.29:Point 6 - Rose diagram of Significant Wave Height (m) during autumn

Winter

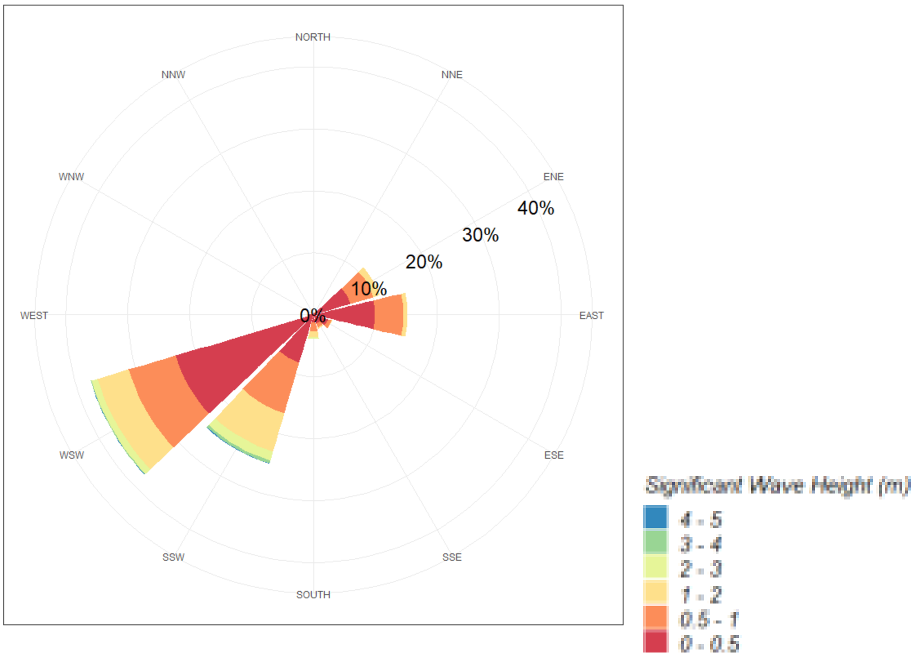

Figure 6.30: Point 6 - Rose diagram of Significant Wave Height (m) during winter

POINT7 (34.6, 32.65)

Annual

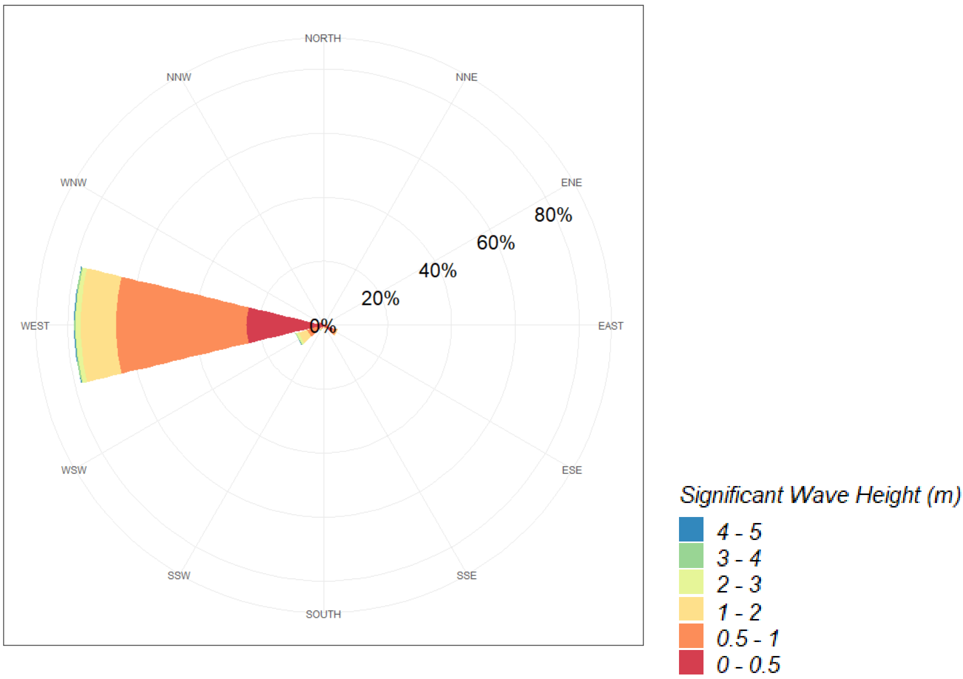

Figure 6.31:Annual Point 7 - Rose diagram of Significant Wave Height (m)

Spring

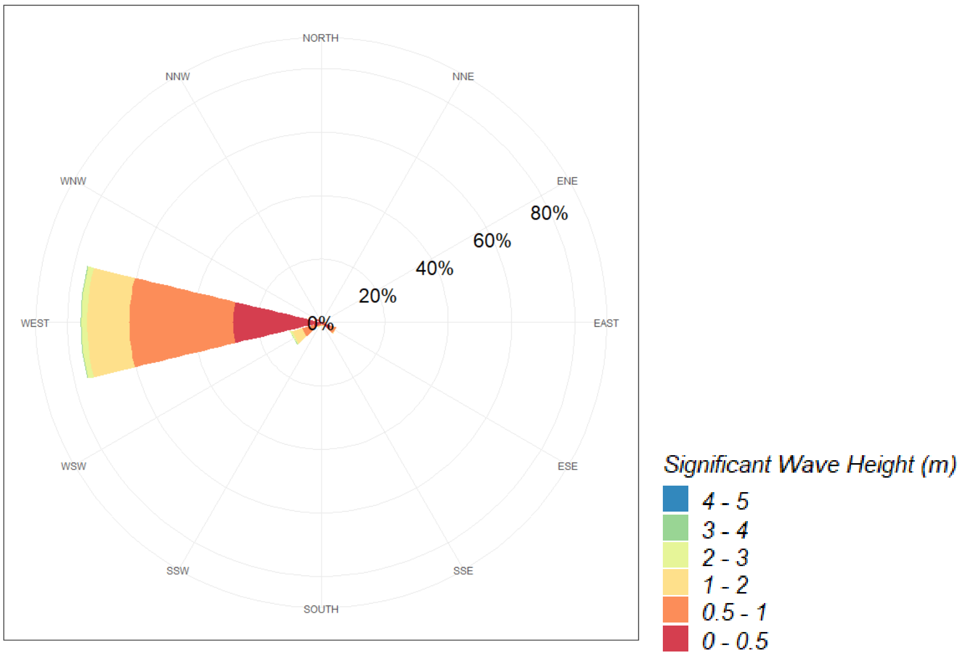

Figure 6.32:Point 7 - Rose diagram of Significant Wave Height (m) during spring

Summer

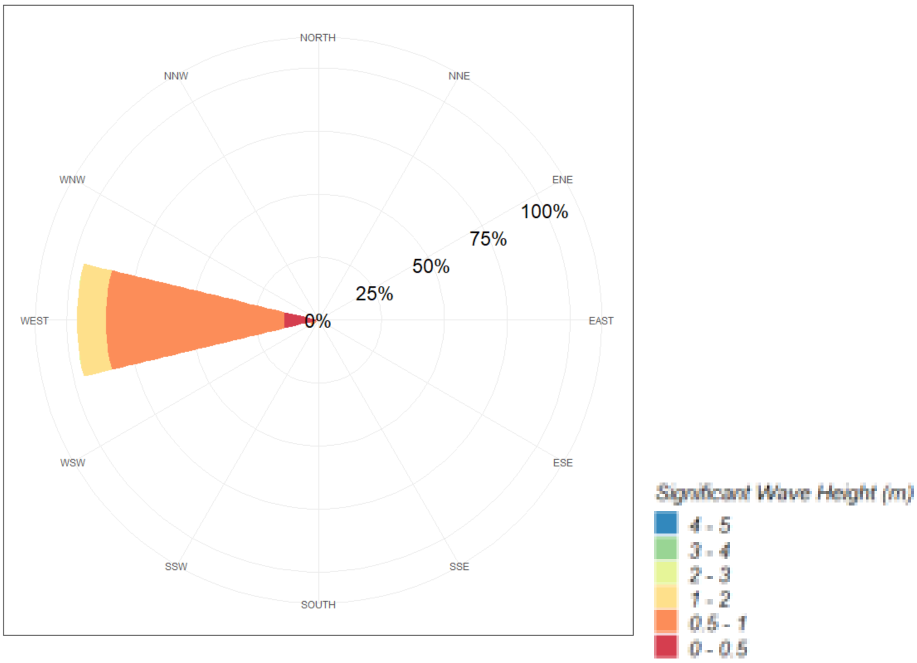

Figure 6.33:Point 7 - Rose diagram of Significant Wave Height (m) during summer

Autumn

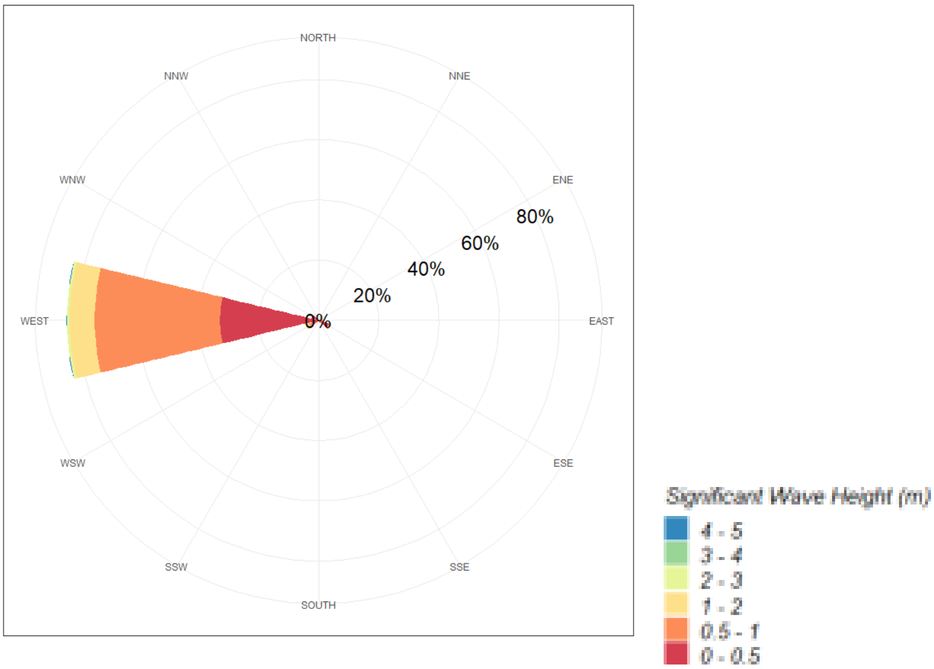

Figure 6.34:Point 7 - Rose diagram of Significant Wave Height (m) during autumn

Winter

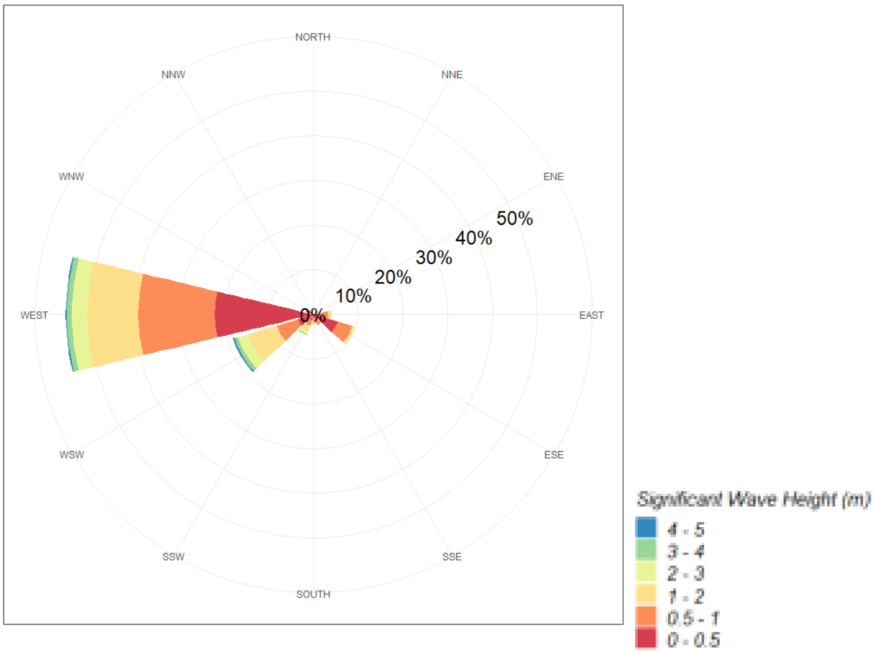

Figure 6.35: Point 7 - Rose diagram of Significant Wave Height (m) during winter

POINT8 (34.8, 32.35)

Annual

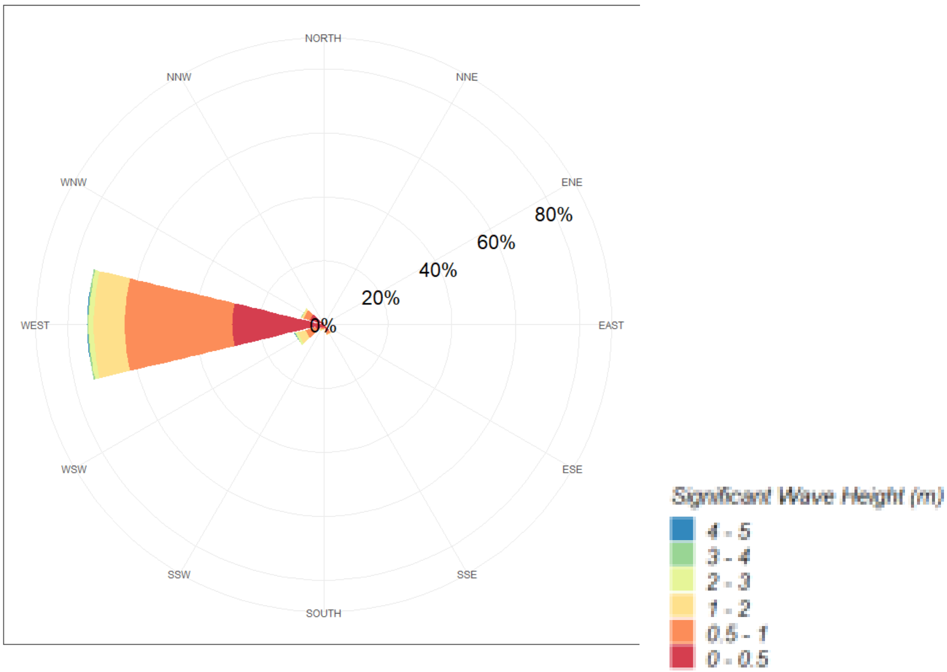

Figure 6.36:Annual Point 8 - Rose diagram of Significant Wave Height (m)

Spring

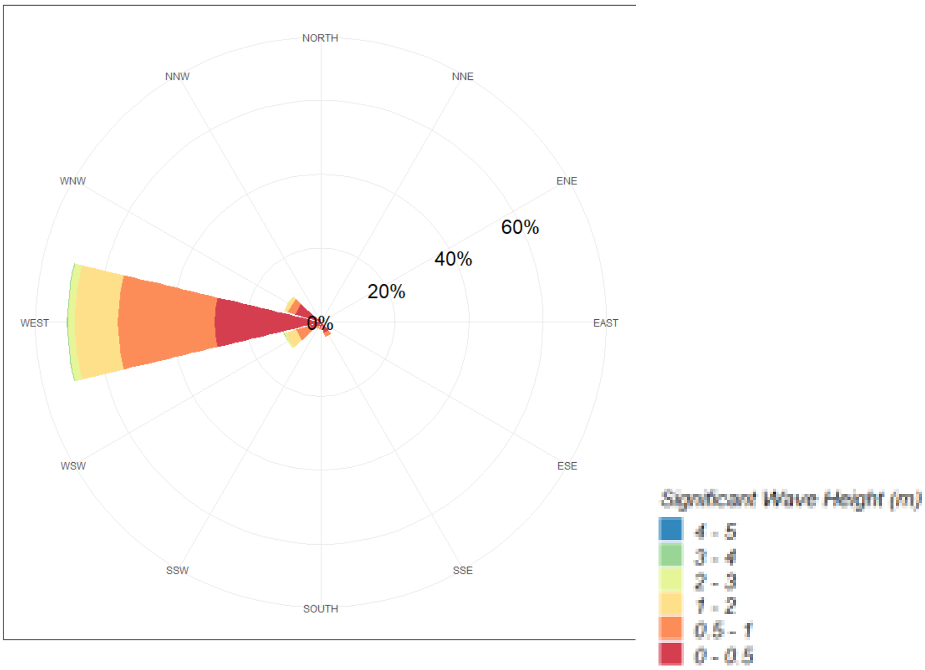

Figure 6.37:Point 8 - Rose diagram of Significant Wave Height (m) during spring

Summer

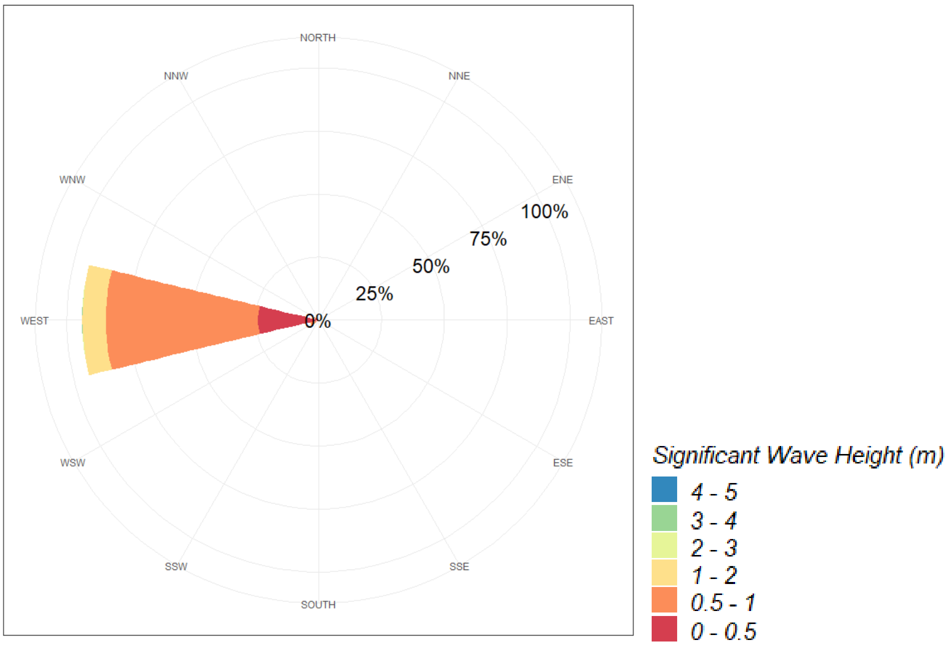

Figure 6.38:Point 8 - Rose diagram of Significant Wave Height (m) during summer

Autumn

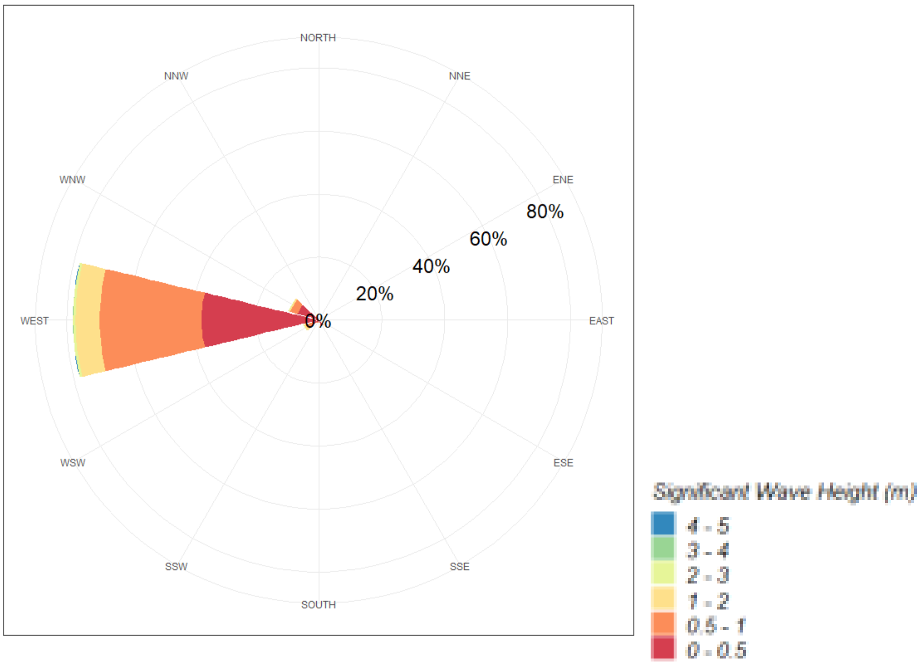

Figure 6.39:Point 8 - Rose diagram of Significant Wave Height (m) during autumn

Winter

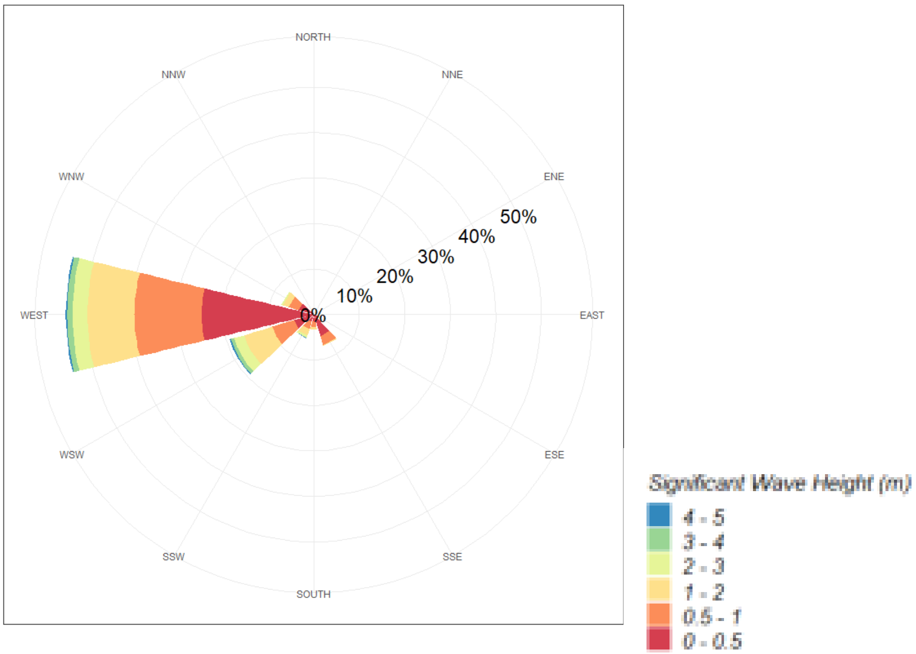

Figure 6.40: Point 8 - Rose diagram of Significant Wave Height (m) during winter

POINT9 (35.1, 32.4)

Annual

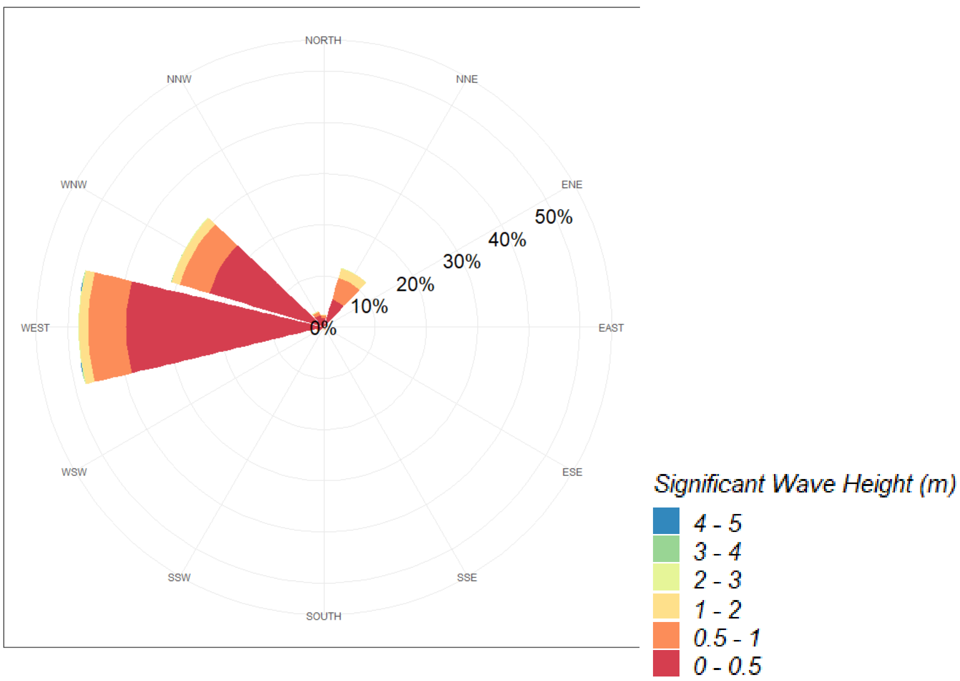

Figure 6.41:Annual Point 9 - Rose diagram of Significant Wave Height (m)

Spring

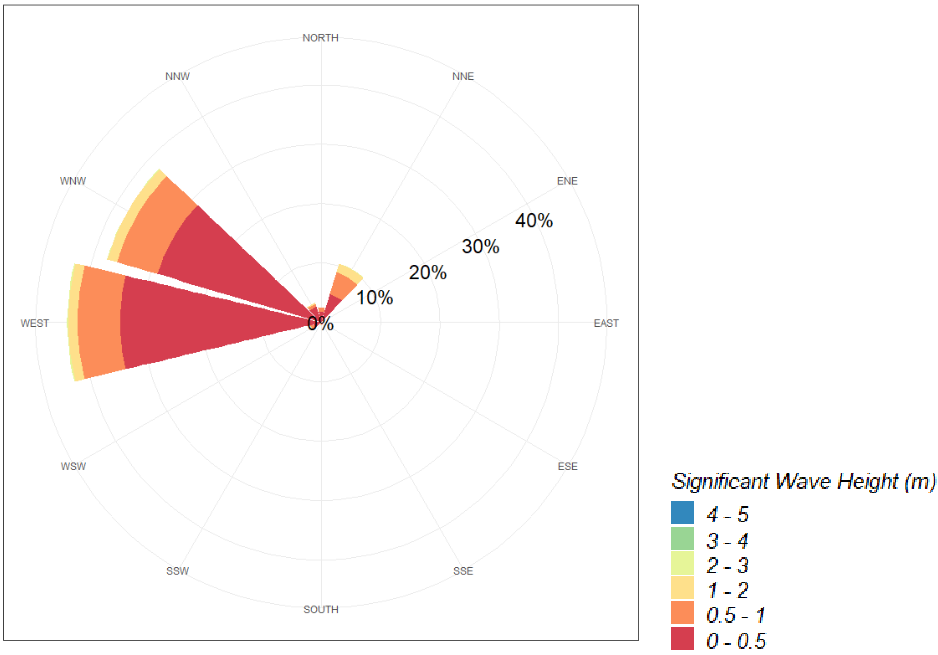

Figure 6.42:Point 9 - Rose diagram of Significant Wave Height (m) during spring

Summer

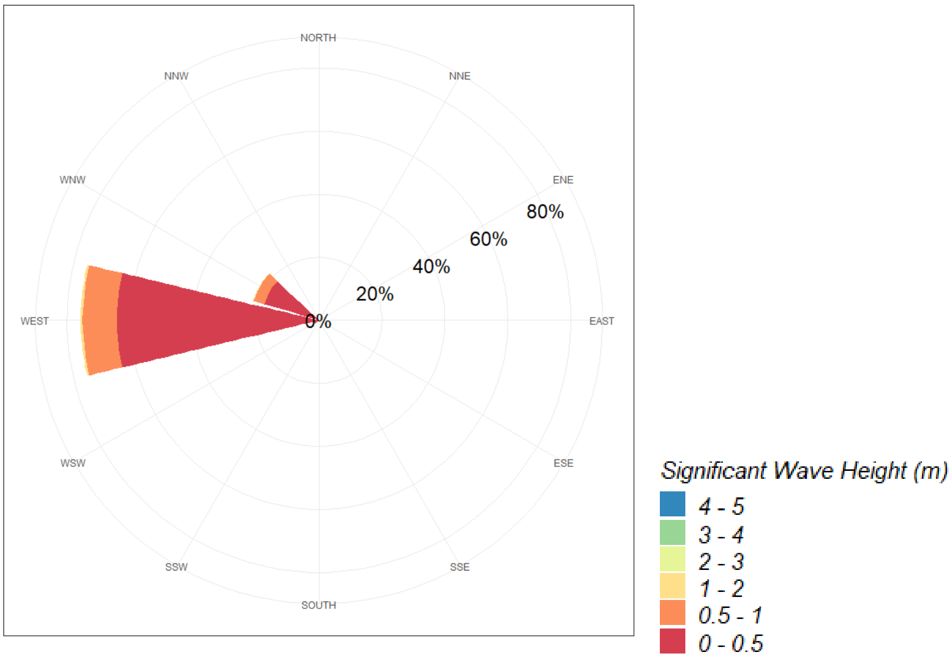

Figure 6.43:Point 9 - Rose diagram of Significant Wave Height (m) during summer

Autumn

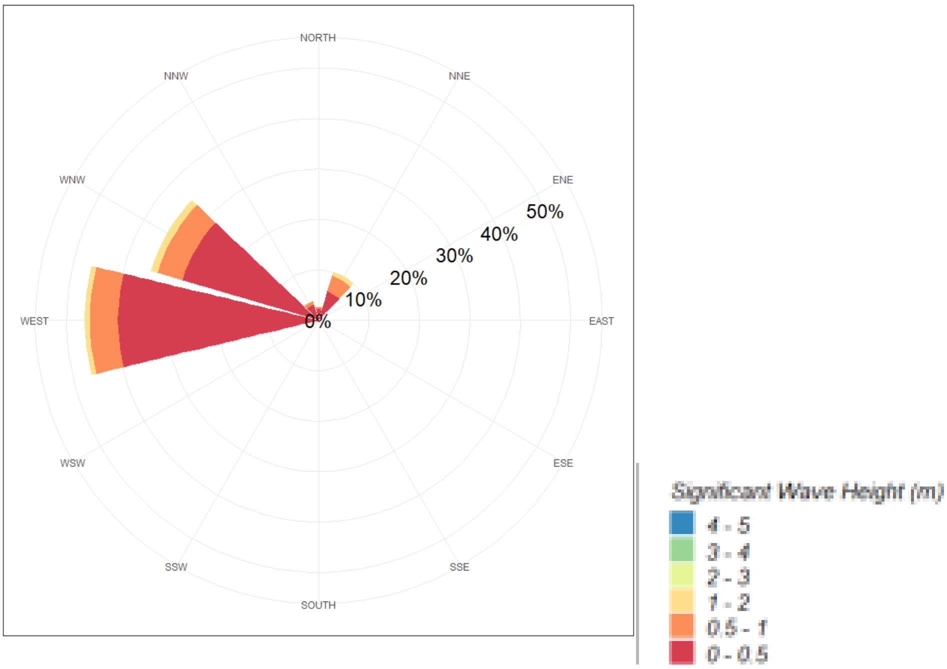

Figure 6.44:Point 9 - Rose diagram of Significant Wave Height (m) during autumn

Winter

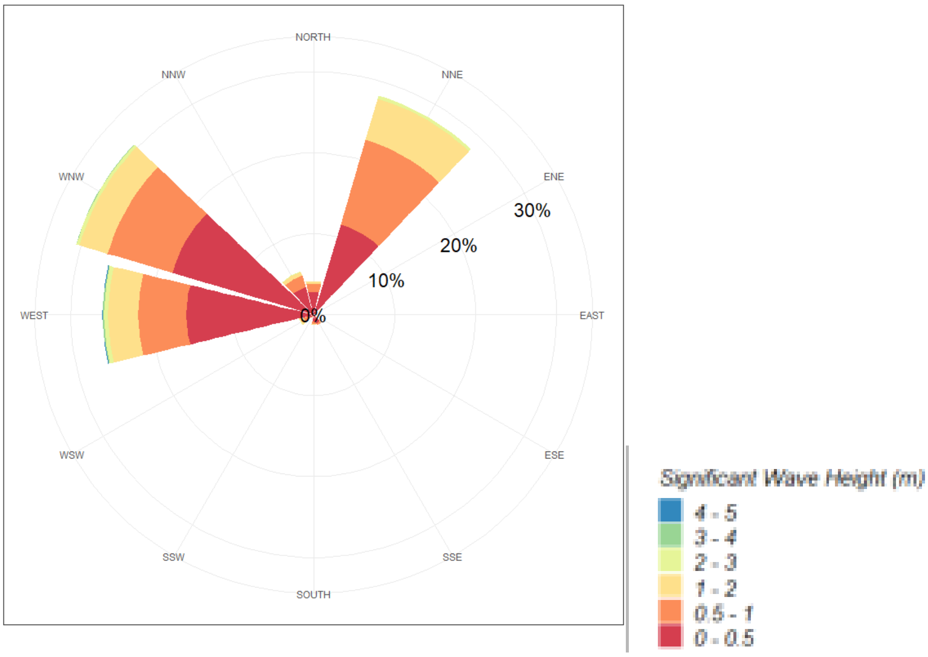

Figure 6.45: Point 9 - Rose diagram of Significant Wave Height (m) during winter

SWH return period

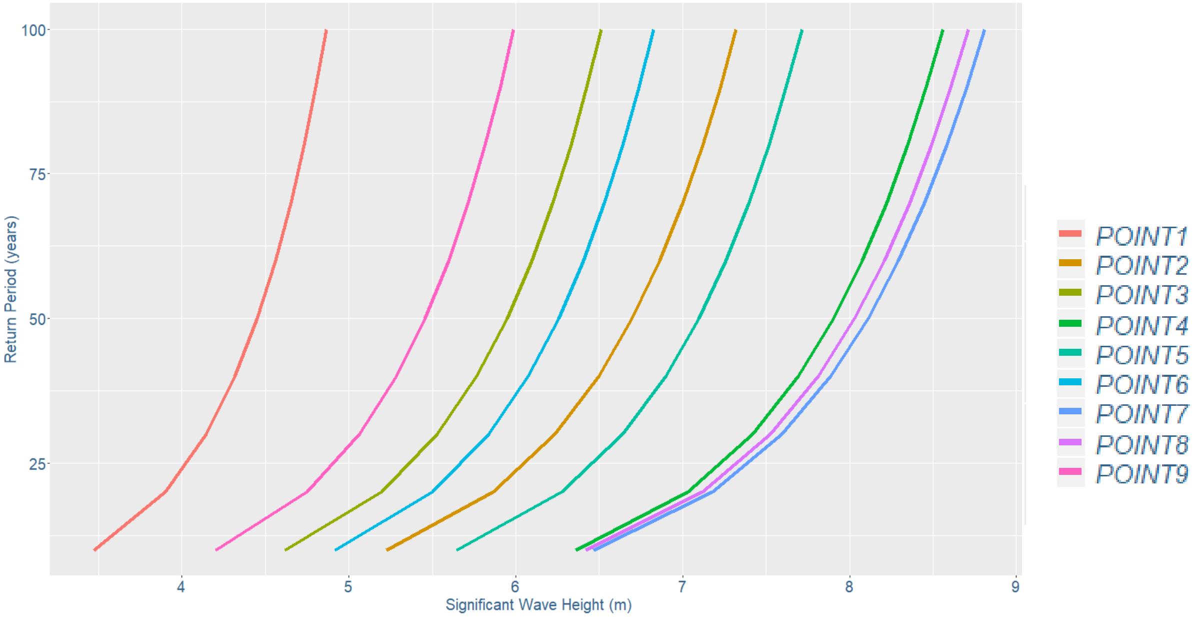

Figure 6.46: Significant wave height return period