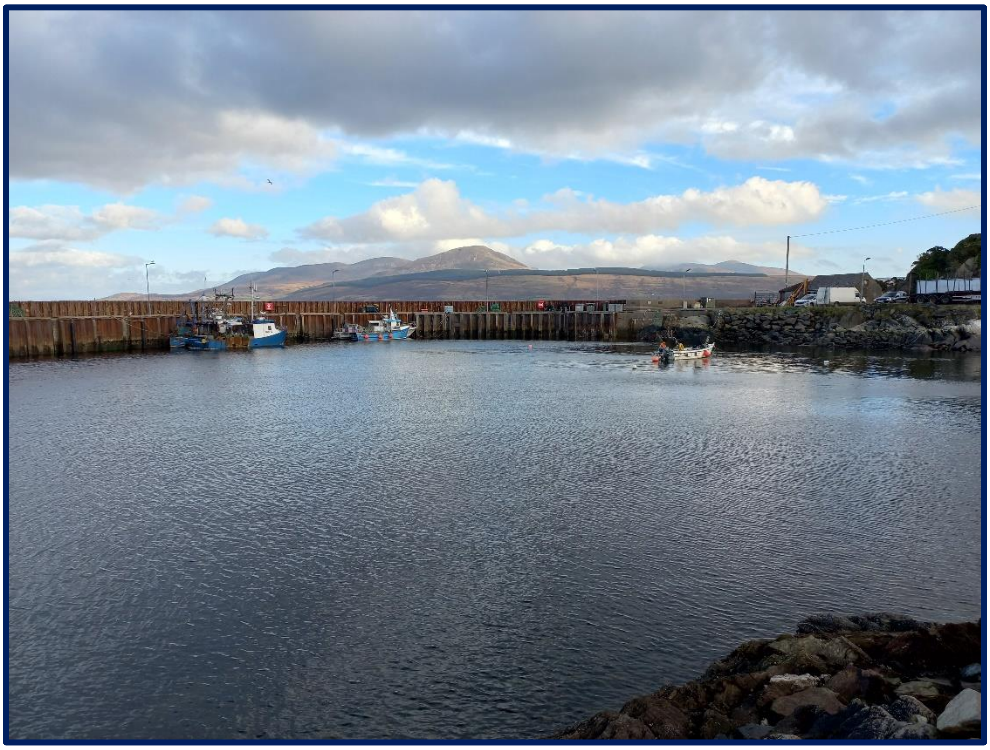
MOWI SCOTLAND LTD

CARRADALE HARBOUR PONTOON & DREDGE



MARINE LICENCE APPLICATION
SUPPORTING DOCUMENT

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CARRADALE HARBOUR PONTOON

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CARRADALE HARBOUR PONTOON

MARINE LICENCE APPLICATION
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1. INTRODUCTION

As part of the Carradale Harbour Pontoon project, two Marine Licence applications are required: 'Construction' and 'Dredging & Sea Disposal'. The applications will be submitted by Wallace Stone on behalf of MOWI Scotland Ltd.

In addition, a Best Practicable Environmental Option (BPEO) report has been produced to consider the most appropriate means of disposing of the dredge spoil. The BPEO is submitted in addition to this Supporting Document as part of the Dredge and Disposal Marine Licence Application.

The purpose of this Supporting Document is to provide supporting information to the marine licence application process. It includes details of the proposed project, including the works associated with installation of the proposed pontoon and dredging within the Harbour. In accordance with Marine Scotland's Marine Licence Application, it is important to consider the application with reference to Scotland's National Marine Plan (SNMP). This document outlines the SNMP policies and describes the potential interactions and alignment of the proposed works with the SNMP. The report considers potential environmental impacts and details mitigation measures to reduce potential negative environmental effects.

2. PROJECT DESCRIPTION

Carradale Harbour is located on the east side of the Kintyre peninsula which lies on Scotland's west coast (Grid Reference NR 81924 38664).

MOWI Scotland Ltd. plan to install a pontoon within Carradale Harbour for shared use by MOWI for commercial activities and private use by the local community. Argyll & Bute Council are the Statutory Harbour Authority (SHA) for Carradale Harbour and are therefore responsible for its management and maintenance.

The proposed works will include installation of 4No. 8mx2.5m prefabricated pontoon units which will be held in place by 2No. tubular steel guide piles. The pontoons will be accessed from the existing quayside via a 20m long access bridge. A critical part of the works will involve dredging of the seabed in an area around the proposed pontoons to provide suitable water depths and ensure the pontoons do not ground. The dredge material will be disposed of at the licenced disposal site in Campbeltown (MA060).

2.1 Methodology

The dredging operation within the harbour will most likely utilise a backhoe dredger on a stationary vessel. A split-hopper barge or equivalent bottom opening vessel will be utilised, so that dredge material can be released from the bottom of the vessel at the licenced disposal site. Dredging operations within the Harbour will require to be carefully planned and strictly controlled, to ensure no interference with the vessels using the Harbour. Exact details of the dredging methodology will be confirmed once a dredge Contractor has been appointed.

Marine piling plant will undertake the installation of steel tubular guide piles which will be driven into the seabed and socketed to rockhead. After installation of the piling, the prefabricated pontoon sections will be lifted into the water by crane sitting on the adjacent quayside. The pontoons will then be connected to the new guide piles. The pontoon access bridge will be lifted into position using a crane and connected to a frame on the existing quay structure.

2.2 Proposed programme

The works are expected to take 3 months to complete, with no night-time working anticipated. The works programme has not yet been confirmed, however, the start date is estimated to be the 11th November 2024.

3. MARINE PLAN ASSESSMENT

As the proposed works will be undertaken below Mean High Water Springs (MHWS) and within 12 nautical miles of the Scottish Coastline, the project falls within the remit of the Marine (Scotland) Act 2010. The 2015 Scottish National Marine Plan (SNMP) covering inshore waters is a requirement of the Act. The SNMP lays out the Scottish Minister's policies for the sustainable development of Scotland's seas and provides General Planning Principles (GENs). The proposed works have been reviewed against SNMP policies to determine how the works have considered SNMP (see Table 1).

Table 1 - Proposals reviewed against Scotland's National Marine Plan

General Planning Principles	Policy Text/Requirements	Carradale Harbour Pontoon & Dredge Considerations
GEN 2: Economic Benefits	Sustainable development and use which provides economic benefit to Scottish communities is encouraged when consistent with the objectives and policies of this Plan.	The proposed works form part of MOWI's plans to expand their operations in Carradale. MOWI plans to invest in Carradale Harbour which will help stimulate economic growth and improve local amenities. MOWI have been part of the Carradale community for the past 10 years, directly employing 12 people. The Harbour is a multi-user facility, which is utilised by both commercial and recreational vessels. MOWI will use the proposed pontoon for their own commercial activities, whilst also permitting the local community to use the berths recreationally which will provide safer means of access. The dredge works will improve safe navigational access within the harbour for other commercial and recreational vessels operating from the harbour.

GEN 3: Social Benefits	Sustainable development and use which provides social benefits is encouraged when consistent with the objectives and policies of this Plan.	As per GEN 2 [Investment + shared use + employment]
GEN 4: Co-Existence	Proposals which enable coexistence with other development sectors and activities within the Scottish marine area are encouraged in planning and decision making processes, when consistent with policies and objectives of this Plan.	As per GEN 2 [Shared use + improved navigation]
GEN 6: Historic Environment	Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance.	Fishing has been a main activity in Carradale since the 17th century, with the communities first pier being constructed in 1858. The current pier was constructed circa 2006, therefore although the harbour itself has significant history, the structure from which the proposed pontoon will be accessed is of modern construction and there will be no impact on the historic environment. The proposed pontoon will ensure the harbour and the community continues to benefit from the fishing industry as it has done since the 17th century.
GEN 7: Landscape / Seascape	Marine planners and decision makers should ensure that development and use of the marine environment take seascape, landscape and visual impacts into account.	Installation of the proposed works will have minimal visual impact on the existing landscape/seascape.
GEN 8: Coastal Process and Flooding	Developments and activities in the marine environment should be resilient to coastal change and flooding, and not have unacceptable adverse	The proposed works will not have a detrimental effect on flooding. A Wave Modelling Study was undertaken to assess the impact on coastal processes. The study concluded that as the proposed berthing pontoon is a floating structure it will

	impact on coastal processes or contribute to coastal flooding.	have no impact on the tidal levels or tidal circulation in the harbour. Additionally, the proposed dredging was found to not be significant in terms of impact on the tidal regime in the harbour. Thus, the proposed scheme will have no significant impact on the tidal regime, either in terms for heights or flows, at Carradale harbour.
GEN 9: Natural Heritage	Development and use of the marine environment must: (a) Comply with legal requirements for protected areas and protected species. (b) Not result in significant impact on the national status of Priority Marine Features. (c) Protect and, where appropriate, enhance the health of the marine area.	No ecological designations, protected areas or priority marine features are identified in the vicinity of the site.
GEN 10: Invasive Non-Native Species	Opportunities to reduce the introduction of invasive non-native species to a minimum or proactively improve the practice of existing activity should be taken when decisions are being made.	The potential for introduction of non–native species with equipment brought in to complete the dredge requires consideration, as discussed in Section 4: Potential Impacts.
GEN 12: Water Quality and Resource	Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, Marine Strategy Framework Directive or other related Directives apply.	Carradale Harbour is within Water Framework Directive waterbody 200025 Kilbrannan Sound. Preservation of water quality has been considered in Section 4: Potential Impacts.

GEN 13: Noise	Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects.	Piling works will generate sound with a frequency range of 500 to 2,000 hertz. Refer to Section 4 for mitigation measures.
GEN 14: Air Quality	Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits.	Carradale Harbour is located outwith any Air Quality Management Plan areas. No significant effects on air quality from the proposed works are predicted.
GEN 18: Engagement	Early and effective engagement should be undertaken with the general public and all interested stakeholders to facilitate planning and consenting processes.	MOWI Scotland Ltd. have engaged with the local community and the Statutory Harbour Authority (Argyll & Bute Council) regarding the proposed works and future development in and around the harbour.

4. ENVIRONMENTAL CONSIDERATIONS

Potential impacts arising from the proposed works at Carradale are described in Table 2, along with identified mitigation.

Table 2 - Potential Impacts by Activity/Topic and Proposed Mitigation

Activity	Potential Impact	Mitigation Measures
Dredging activity – removal of sediment from harbour bed	Possible reduction in water quality due to increased sediment loading in water column.	• Ground investigation found that ground is mostly sand with low silt content. • Works will be monitored to ensure silt plumes remain localised and dissipate quickly; • Should silt plumes be persistent and widespread, methods will be reviewed; • Additional mitigation may include specific dredge techniques which allow material to settle within the bucket of a backhoe dredge prior to removal from the water.
Disposal activity – dumping of dredged material at spoil site	Possible reduction in water quality due to increased sediment loading in water column.	• Existing licenced spoil site MA060 will be used. • A split-hopper or equivalent bottom-opening vessel will be used, a low energy process which encourages material to drop promptly to the seabed; • Works will be monitored to ensure silt plumes remain localised and dissipate quickly; and • Should silt plumes be persistent and widespread, methods will be reviewed.

Operations and movement of dredge disposal vessels	The introduction of Invasive Non-Native Marine Species (INNMS) from vessels / equipment has the potential to cause ecological impacts.	• Equipment mobilised to carry out the dredge will be inspected to ensure it is free from soilage; and • All vessels are expected to be compliant with the relevant requirements of the International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 and where appropriate follow Guidelines for the Control and Management of Ships Biofouling to Minimize the Transfer of Invasive Aquatic Species.
	Marine Navigation - Dredging vessels operating in the area may adversely affect the safety of other water users during the proposed works.	• All vessels operating in the area will be under direction of the Harbour Master; • A Notice to Mariners will be issued in advance of the works; and • Dredge/disposal vessels will adhere to a fixed route, speed and direction when carrying out operations. This will be done as far as practicably possible with regards to tidal and weather conditions.
	Containment – fuel/oils and hazardous substances - Accidental releases of hazardous materials from spills or leaks can impact upon land and/or water quality with knock on ecological implications if not dealt with promptly.	• Appropriate maintenance will be carried out on vessels, plant and machinery to minimise the risk of leaks; • Bunded fuel, oil and chemical storage will be provided, and will be locked when not in use; • Refuelling will be carried out by trained operatives following site refuelling procedures;

		• The dredge contractor will be required to align to the harbour's spill plans and spill kits will be in place with operatives trained in their use; and • All oils and chemicals will be subject to Control of Substances Hazardous Health (COSHH) assessments under the COSHH Regulations 2002.

	In-Air Noise - Plant and vessels used during the proposed dredging activity will generate noise. While this is not anticipated to differ significantly from routine vessel operations within the harbour, including previous dredge works, it will be audible to people in the Harbour area.	• Dredging activity will take place during daytime hours only, as far as practically possible;
		• Noise control measures will be implemented as best practice, following guidance from 'BS5228:2009 Noise and vibration control on construction and open sites':
		  ○ Plant will be shut down between work periods or throttled down to a minimum; and
		  ○ Regular maintenance of all equipment used on site will be conducted, including maintenance related to noise emissions.

	Waste/Litter - Waste from general site activities that is not managed appropriately may be released into the terrestrial or marine environment where it can cause harm.	• Good housekeeping on all floating plant will be employed during the works; • Plant operatives will be made aware that littering will not be tolerated; and • The use of single use plastics will be discouraged.

Piling Works	Underwater noise – Piling works causing noise and vibration with the possibility of disturbing marine species.	Odex piling will be used to install the guide piles for the pontoons. Although the chances of acoustic disturbance causing effects at a level to impact upon an individual's ability to survive, breed, reproduce or raise young have been assessed as unlikely, mitigation measures will still be implemented. The mitigation measures are aligned to the Joint Nature Conservation Committee’s (JNCC) Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling. The odex piling marine mammal mitigation will provide the following measures: 1. A 500m mitigation zone will be established around the piling rig. 2. Trained MMOs will conduct a 20min pre-watch prior to the commencement of piling operations. a. If the 500m mitigation zone remains clear of marine mammals during the watch, permission will be given to commence piling; b. If a marine mammal is sighted within the mitigation zone during the 20min watch, piling will be delayed until the zone has been clear of marine mammals for at least 10min.

		3. Once piling has commenced there will be no requirement to stop works if a marine mammal enters the mitigation zone, as long as piling has been continuous, with no breaks exceeding 10min; 4. If a break in piling operations exceeds 10min, but remains less than 30min, then a normal 20min MMO watch shall be deployed. 5. If a break in piling operations has been planned to last for a period of <30min, but exceeds 30min, irrespective of whether the noise generator has been running or not, a 20min pre-watch will be required before piling can recommence as detailed above. 6. All MMO operations will be recorded using the JNCC marine mammal reporting forms template and submitted to Marine Scotland once the works are complete.

5. CONCLUSION

This document has been produced to provide supporting information and assist Marine Scotland in assessing the Marine Licence Applications for the proposed works to install a new pontoon and undertake dredging within Carradale Harbour on behalf of MOWI Scotland Ltd. The document has provided details of the project and sets out how the Marine Licence Applications for the Construction and Dredge & Disposal activities have considered Scotland’s National Marine Plan (SNMP) by outlining the SNMP policies and describing the potential interactions of the proposed works with the SNMP. Potential environmental impacts have also been considered with and mitigation measures identified.

It has been concluded that the proposed works associated with the marine licence application for the installation of a new pontoon and dredging within Carradale Harbour are generally in line with the policies outlined in the SNMP. It is anticipated that the works are unlikely to adversely affect the aims of the plan.

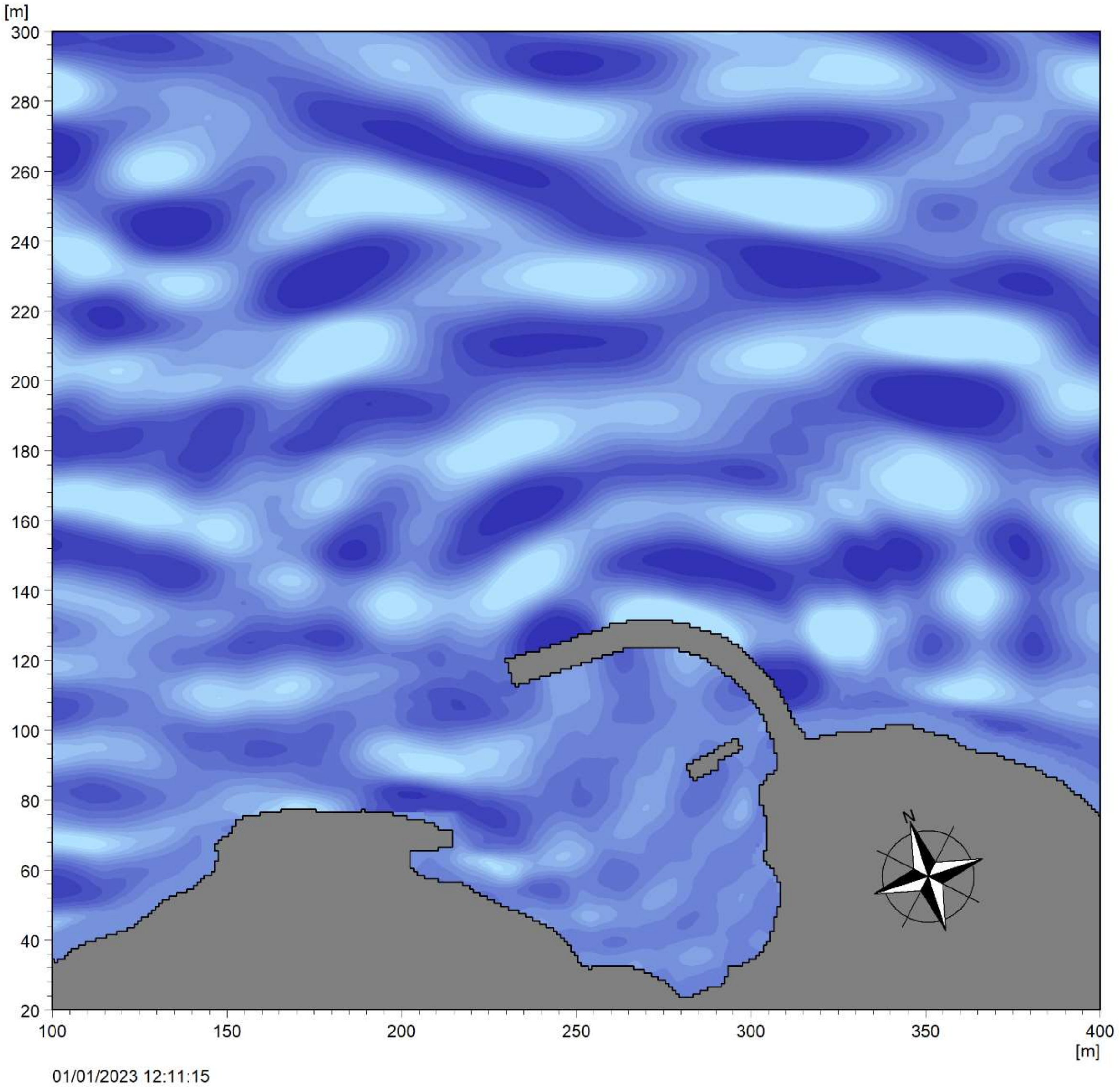
In addition to this document, a Best Practicable Environmental Option (BPEO) report has been produced to consider the most appropriate means of disposing of the dredge spoil. The BPEO will also be submitted as part of the Dredge and Disposal Marine Licence Application.

Appendix A – RPS – Wave Modelling Study

MOWI

CARRADALE HARBOUR

WAVE MODELLING STUDY



Wave modelling study
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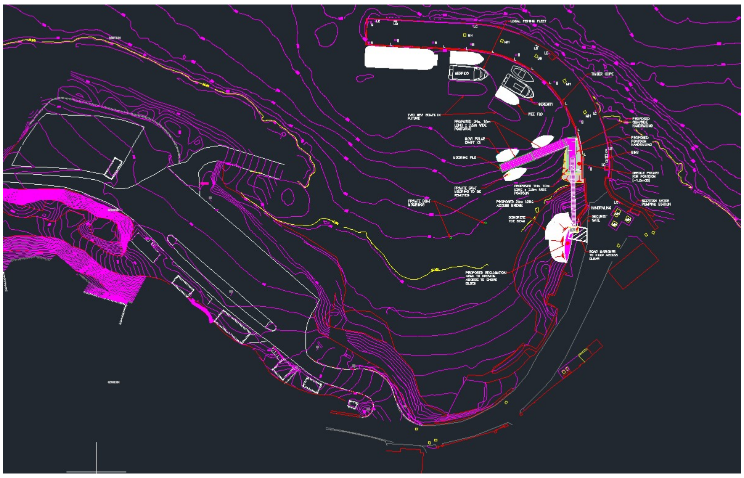
1 INTRODUCTION

MOWI had previously proposed to install a pontoon berthing facility in Carradale harbour which failed to receive planning permission. Wallace Stone LLP has prepared plans for two possible revised schemes and MOWI have commissioned RPS to undertake wave studies for Carradale harbour to assist Wallace Stone LLP with the selection and design of the preferred Option.

The wave study incudes the simulation of the incoming storm waves and harbour disturbance studies for both of the alternative schemes. In addition the modelling work included the assessment of the impact of the preferred scheme on the hydrodynamics of the existing berths in Carradale harbour.

The two alternative schemes for an additional pontoon facility in Carradale Harbour prepared by Wallace Stone LLP are shown in Figure 1-1.



Scheme 1

Scheme 2

Figure 1-1 Wallace Stone LLP alternative pontoon berth schemes for Carradale Harbour

2 SITE LOCATION AND EXPOSURE

The red circle in Figure 2.1 shows the location of Carradale Harbour on the eastern shore of the Mull of Kintyre. The harbour is located on the northern side of Carradale Point and is most exposed to waves which propagate down Kilbrannan Sound from the northerly sector.

Figure 2-1 Location of Carradale on the eastern shore of the Mull of Kintyre, Scotland

The greatest direct fetch for wave generation is some 18 kilometres from a direction of 15° N. Waves from a southerly sector can propagate into the area but due to the orientation of the harbour, waves from the south to southeast sector do not significantly affect the wave climate in the harbour.

Figure 2-2 Existing Carradale Harbour layout

3 WIND AND WATER LEVEL DATA

Wind data

Wind data prepared by the UK Met Office for BS EN 1991-1-4:2005, extreme wind speeds throughout the British Isles, has been used for this study. This data is overland wind speeds, thus, to allow for lower wind friction over water compared to overland, the wind speeds for wave generation were increased by 17% in accordance with Figure NA.3 of the 2010 Annex to BS EN 1991.

For restricted fetch directions, the length of fetch over which the waves are generated determines the time period for which winds must blow to fully develop the waves. Wind duration times of about 1 hour were found to be required for maximum wave generation from the east-northeast to east sector over the short fetches across from Arran. For the fetches along Kilbrannan Sound, a time scale of about 2.5 hours is required to fully develop the waves from the north to north-northeast sector.

The over water wind speeds used for the 1 in 0.5, 1 in 1 and 1 in 10 year return period storm wave generation across the fetches are shown in Table 3.1 and for the 1 in 50 and 1 in 100 year return period storms in Table 3.2.

Table 3-1 Over water wind speeds for wind wave generation over local fetches

Storm Direction	Wind Speed m/s 1 in 0.5 year return period	Wind Speed m/s 1 in 1 year return period	Wind Speed m/s 1 in 10 year return period
330	17.77	18.96	22.66
345	17.68	18.87	22.54
0	16.99	18.14	21.75
15	16.43	17.55	21.04
30	16.40	17.52	21.01
45	16.39	17.50	20.98
60	15.95	17.04	20.42
75	15.74	16.81	20.15
90	15.53	16.58	19.88
105	15.95	17.03	20.42
120	16.31	17.42	20.88

Table 3-2 Over water wind speeds for wind wave generation over local fetches

Storm Direction	Wind Speed m/s 1 in 50 year return period	Wind Speed m/s 1 in 100 year return period
330	25.21	26.48
345	25.07	26.33
0	24.23	25.47
15	23.44	24.65
30	23.40	24.60
45	23.37	24.57
60	22.70	23.84
75	22.42	23.54
90	22.14	23.27
105	22.74	23.91
120	23.26	24.45

Water level data

The standard Admiralty tidal levels in metres to CD at Carradale are:

HAT	3.5
MHWS	3.1
MHWN	2.6
MSL	1.85
MLWN	1.1
MLWS	0.4
LAT	0.0

The extreme water levels at Carradale have been taken from the data derived by EA/SEPA for the Coastal Flood Boundary Mainland data set. The point in this data set which is close to Carradale is the UK Mainland_1920 point and gives the extreme water levels to CD shown in Table 3-3.

Table 3-3 Extreme predicted water levels to CD at Carradale Harbour

return period	level to CD
1	4.24
2	4.36
5	4.53
10	4.65
20	4.77
50	4.94
100	5.07
200	5.19

Carradale harbour is exposed to storm directions from about 330^o to 45^o N which are the opposite directions to those where storm waves and storm surges combine. Thus all simulations were undertaken at MHWS.

4 MODELLING THE WAVE CLIMATE

4.1 Bathymetry

The wave transformation simulations required the bathymetry around the Kilbrannan Sound, Inchmarnock Water and parts of the Sound of Bute, as well as the Carradale Harbour area, to be included in the model. This was undertaken using a flexible mesh model grid system with the depth value at each nodal point entered into the computer model. The depth data for the model was derived from surveys of Kilbrannan Sound, including parts of the Sound of Bute undertaken for the UK Hydrographic Office. This data was supplemented by the Aspect Surveys Ltd.'s multibeam survey of Carradale harbour and its approaches. The extent of the overall data set used to build the spectral wave model is shown in Figure 4-1.

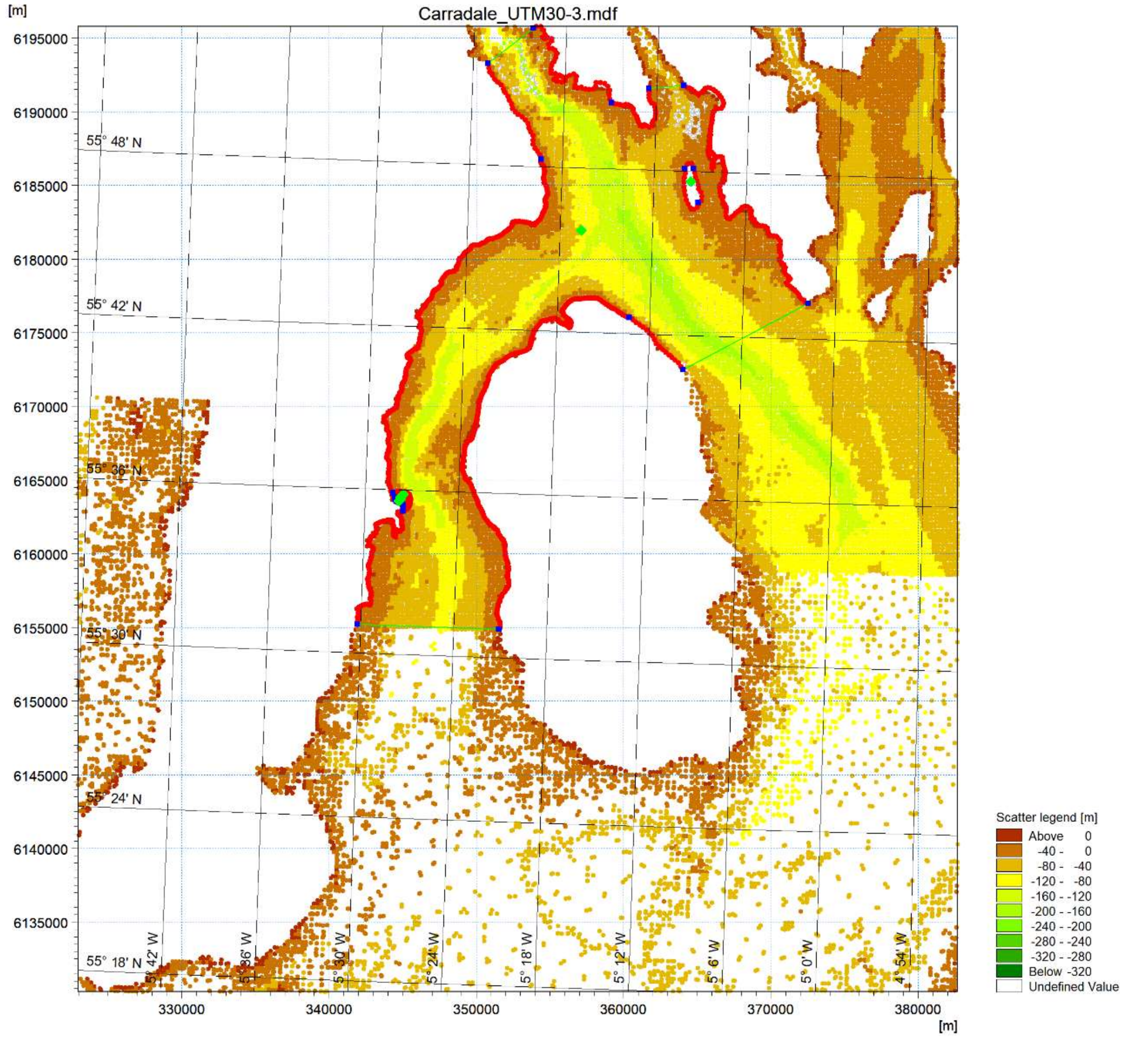


Figure 4-1 Bathymetry datasets used to build the Spectral Wave Model.

The bathymetry of the wave transformation model is shown in the left hand diagram in Figure 4-2 and the model mesh in the right hand diagram in Figure 4-2. The cell sizes of the model ranged from the equivalent of 300 metres in the outer parts of the model down to 3m gird size around Carradale Harbour.

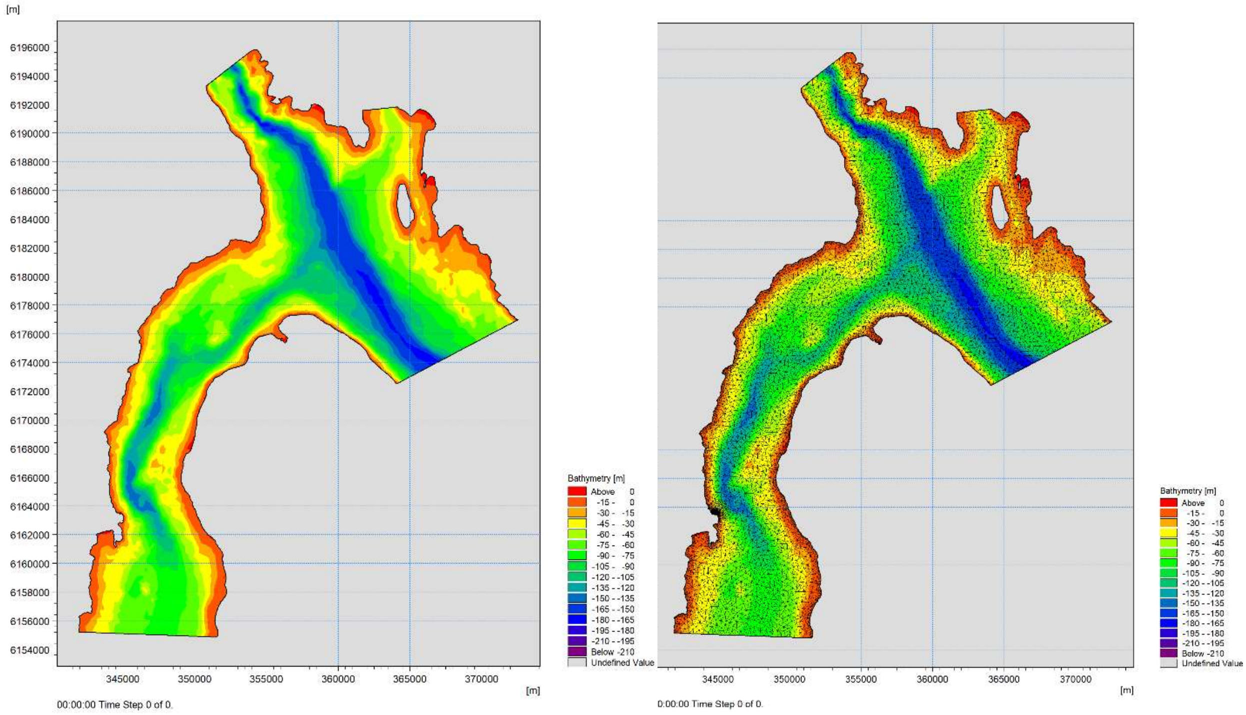


Figure 4-2 Flexible mesh wave transformation model bathymetry for Kilbrannan Sound

The bathymetry data for the Boussinesq wave disturbance model was also taken from Aspect Surveys Ltd.'s multibeam survey and other data shown in Figure 4-3. The model bathymetry to MHWS used to build the Boussinesq model is shown in Figure 4-4. The Boussinesq model had a very fine 1 metre grid resolution.

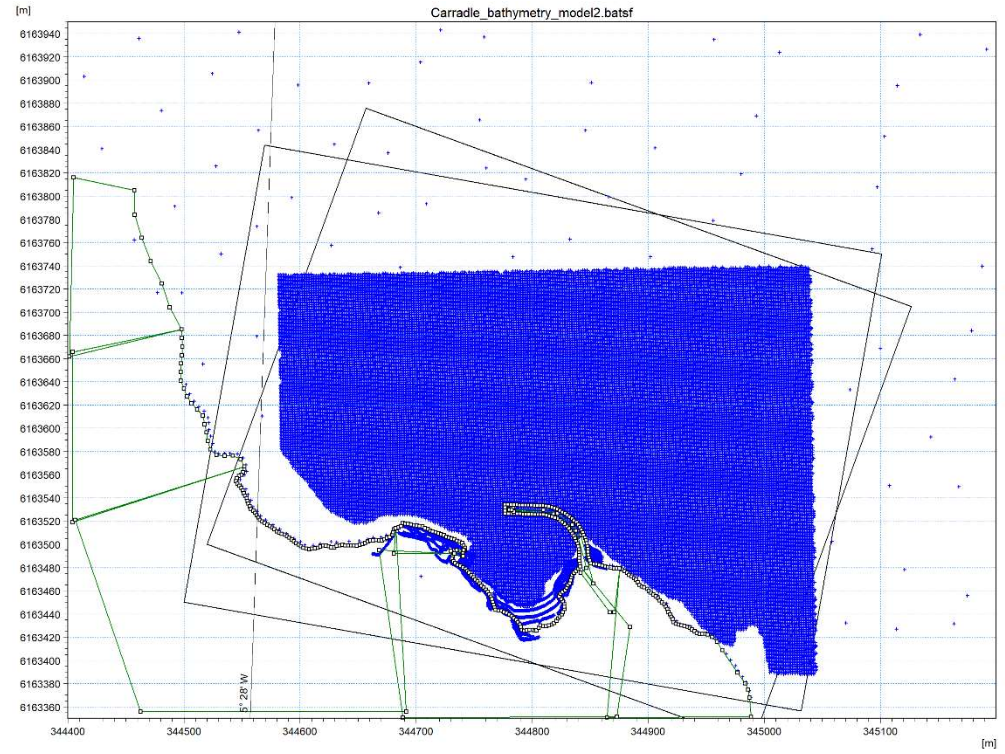


Figure 4-3 Bathymetry datasets used to build the Boussinesq Wave Model

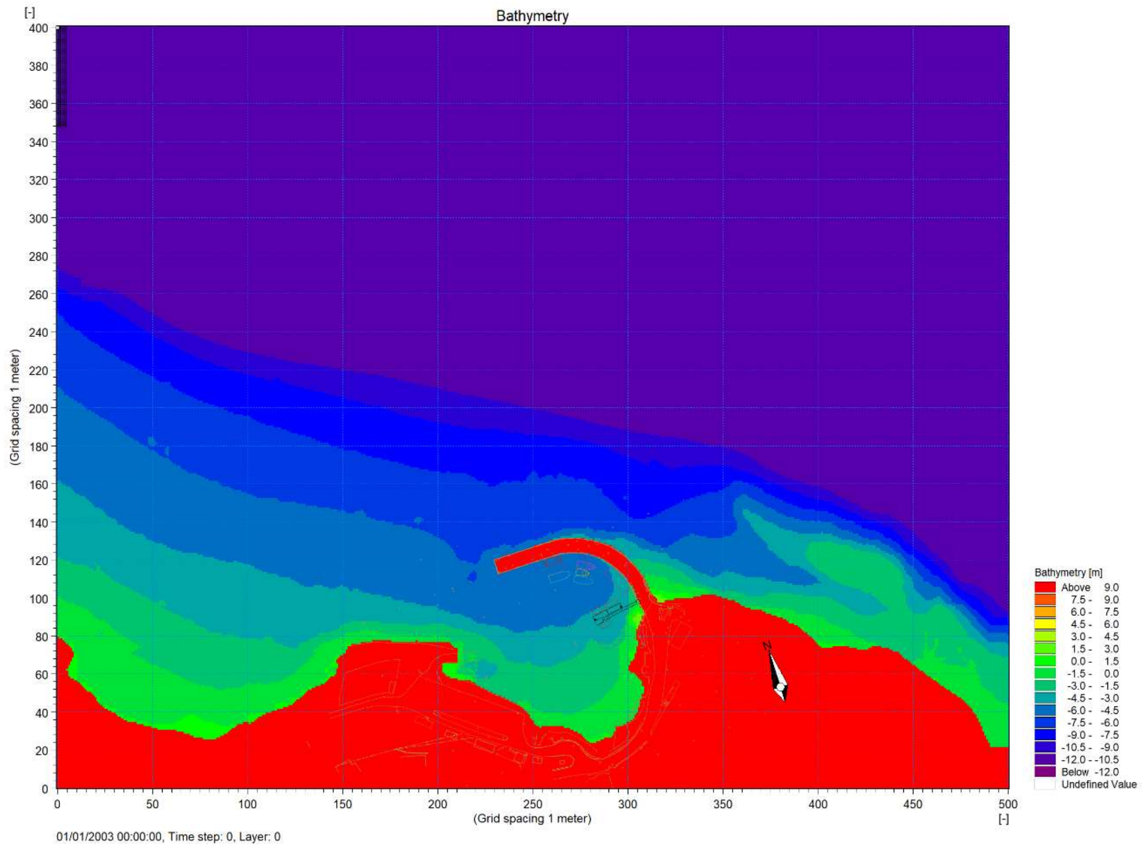


Figure 4-4 Boussinesq Wave Model Bathymetry around Carradale Harbour at MHWS

4.2 Wave Model Software

4.2.1 Wave transformation model

The wave transformation modelling was undertaken using the MIKE21 Spectral Wave model (SW). The MIKE 21 SW model is a third generation spectral wind-wave model based on unstructured meshes. The model simulates the growth, decay and transformation of wind-generated waves and swells in offshore and coastal areas.

MIKE 21 SW includes the following physical phenomena:

- Wave growth by action of wind
- Non-linear wave-wave interaction
- Dissipation due to white-capping
- Dissipation due to bottom friction
- Dissipation due to depth-induced wave breaking
- Refraction and shoaling due to depth variations
- Diffraction
- Wave-current interaction
- Effect of time-varying water depth and flooding and drying

The discretization of the governing equation in geographical and spectral space is performed using a cell-centred finite volume method. In the geographical domain, an unstructured mesh technique is used. The time integration is performed using a fractional step approach where a multi-sequence explicit method is applied for the propagation of wave action.

MIKE 21 SW includes two different formulations:

- Directional decoupled parametric formulation
- Fully spectral formulation

The fully spectral formulation was used in the simulations. The spectral formulation is based on the wave action conservation equation, as described in e.g. Komen et al. (1994) and Young (1999), where the directional-frequency wave action spectrum is the dependent variable.

4.2.2 Wave disturbance model

The simulation of the wave disturbance in Carradale Harbour was undertaken using the advanced Boussinesq wave model, MIKE21 BW. This model is the state-of-the-art numerical model for the calculation and analysis of short and long period waves in ports, harbours and coastal areas.

MIKE 21 BW is capable of reproducing the combined effects of all the important wave phenomena of interest in port, harbour and coastal engineering. These include:

- Shoaling
- Refraction
- Diffraction
- Wave breaking
- Bottom friction
- Moving shoreline
- Partial reflection and transmission
- Non-linear wave-wave interaction
- Frequency spreading
- Directional spreading

Phenomena, such as wave grouping, surf beats, generation of bound sub-harmonics and super-harmonics and near-resonant triad interactions, can also be modelled using MIKE 21 BW. The 2DH module (two horizontal space co-ordinates) solves the enhanced Boussinesq equations by an implicit finite difference technique with variables defined on a space-staggered rectangular grid.

Of particular importance for the simulations at Carradale is the ability of the model to simulate wave reflections and then to simulate in the impact of the interaction of the incoming and reflected waves around the harbour area.

4.3 Modelling Procedure

4.3.1 Wave generation and transformation modelling

The modelling was undertaken using a two stage computational model simulation procedure. In the first stage wave transformation simulations were undertaken for each 15^o storm direction from 330^o to 120^o for each of the 1 in 0.5, 1 in 1, 1 in 10. 1 in 50 and 100 year return period events with the water levels set at MHWS.

The results of these simulations showed that the 30^o storm direction gave the largest waves which would approach Carradale Harbour from a direction of about 24^{o}N. Although the waves which approach Carradale during a storm from 345^o are smaller than those during an equivalent storm from 30^o, the 345^o storm waves approached Carradale from a 15^o direction thus may more easily penetrate into the harbour, Figure 4-5. Consequently storms from both 345^o and 30^o were simulated in the second stage wave modelling using the Boussinesq wave model. As well as giving information about the incoming wave climate at the harbour, the results of the wave transformation modelling were used to derive the boundary data for the wave disturbance model of both the 30^o and 345^o storms.

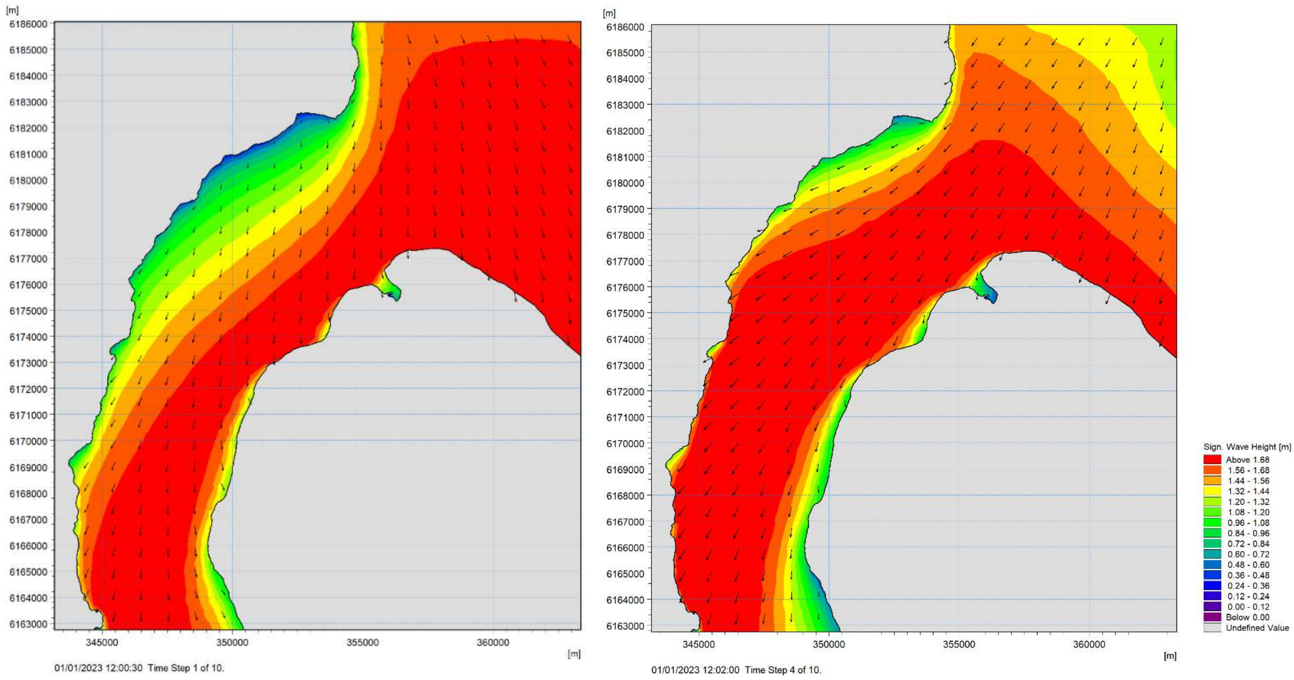


Figure 4-5 Significant wave height and mean wave direction – 1 in 10 year return period storm from 345^o (left)and 30^o (right)

4.3.2 Wave disturbance modelling

As can be seen from Figure 4-4, the Boussinesq wave disturbance model was aligned to a direction facing 20°N with the boundary of the model some 180 metres north of the harbour entrance. The boundary wave climate for the various simulations was taken from the results of the wave transformation modelling. Some 25 minutes of the storm climate for each of the storm return period events from both the 345° and 30° directions was generated for use in the wave disturbance modelling.

The Boussinesq wave model simulations were run with the water level set at MHWS for all storm events as wave penetration into the harbour will be greatest at time of high tides. The simulations were undertaken for 1 in 0.5, 1, 10, 50 and 100 year return period events from both 030° and 345° directions.

The model simulations were undertaken for the existing harbour and for the harbour with the proposed Options 1 and 2 in place so that the impact of the propose scheme could be fully evaluated. The simulations were run for a period of 25 minutes so that there would be a period in excess of 20 minutes for statistical analysis of the wave climate at the site. A snapshot of a typical wave disturbance patterns during a 1 in 0.5 and 1 in 10 year return period storm simulation is shown in Figure 4-6.

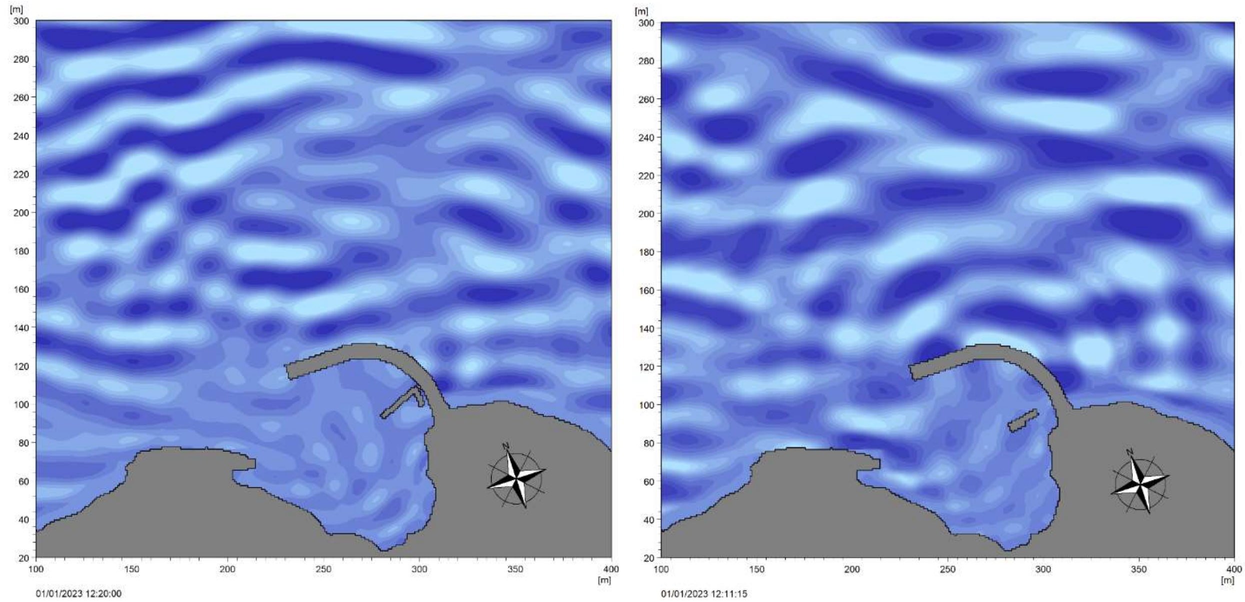


Figure 4-6 Typical storm wave patterns, Option 1 - 1 in 0.5 return period storm from 345° (left) and Option 2 - 1 in 10 return period storm from 30° (right)

5 WAVE CLIMATE AT PROPOSED PONTOON

5.1 Wave climate with Option 1 scheme

The predicted significant wave heights around the harbour with the proposed Option 1 pontoon jetty in place for each of the return period storms from both 345° and 30° directions are shown in Figures 5-1 to 5-5.

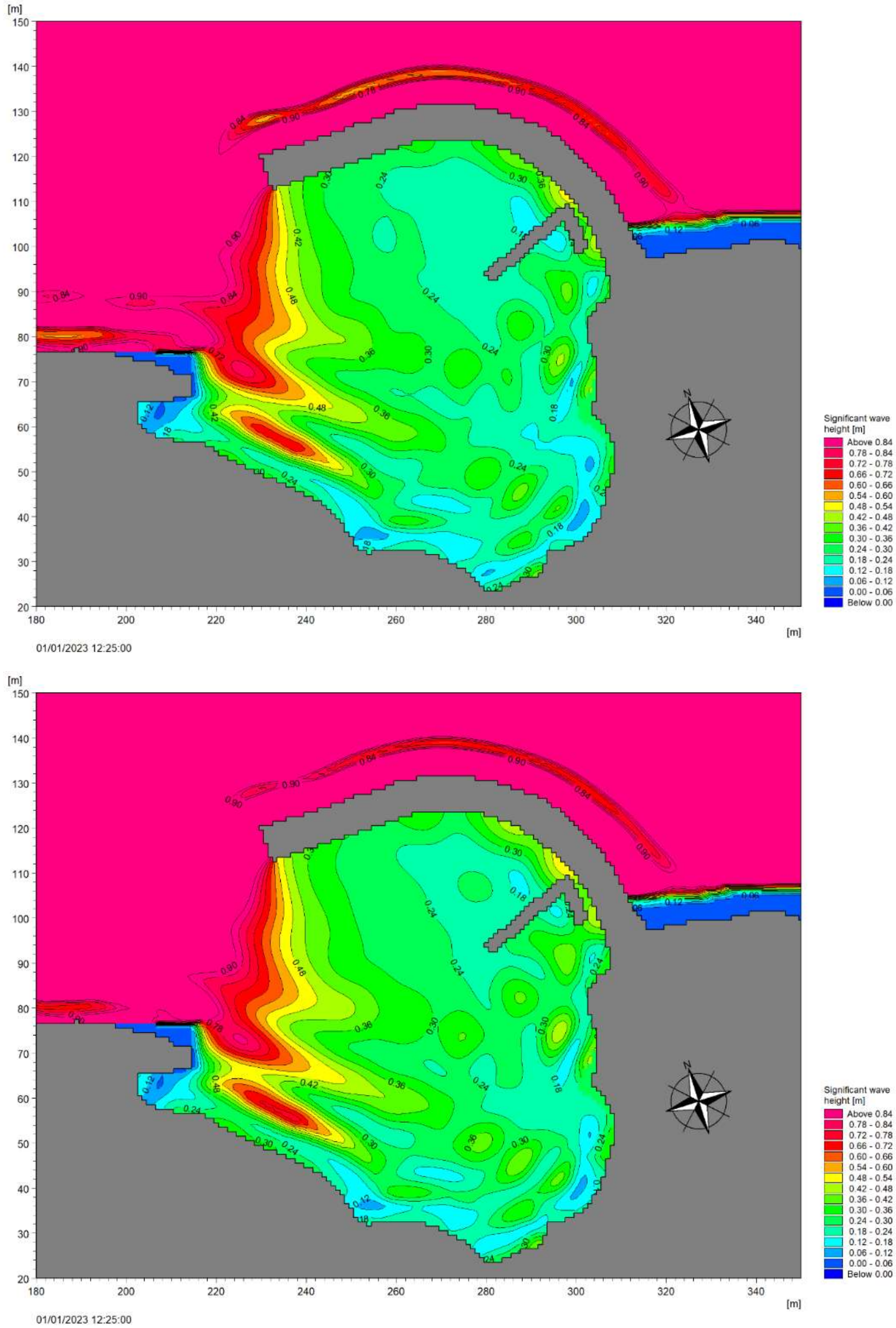


Figure 5-1 Option 1 - Significant wave heights – 1 in 0.5 year return period storm from 345° (top) and from 30° (bottom) at MHWS

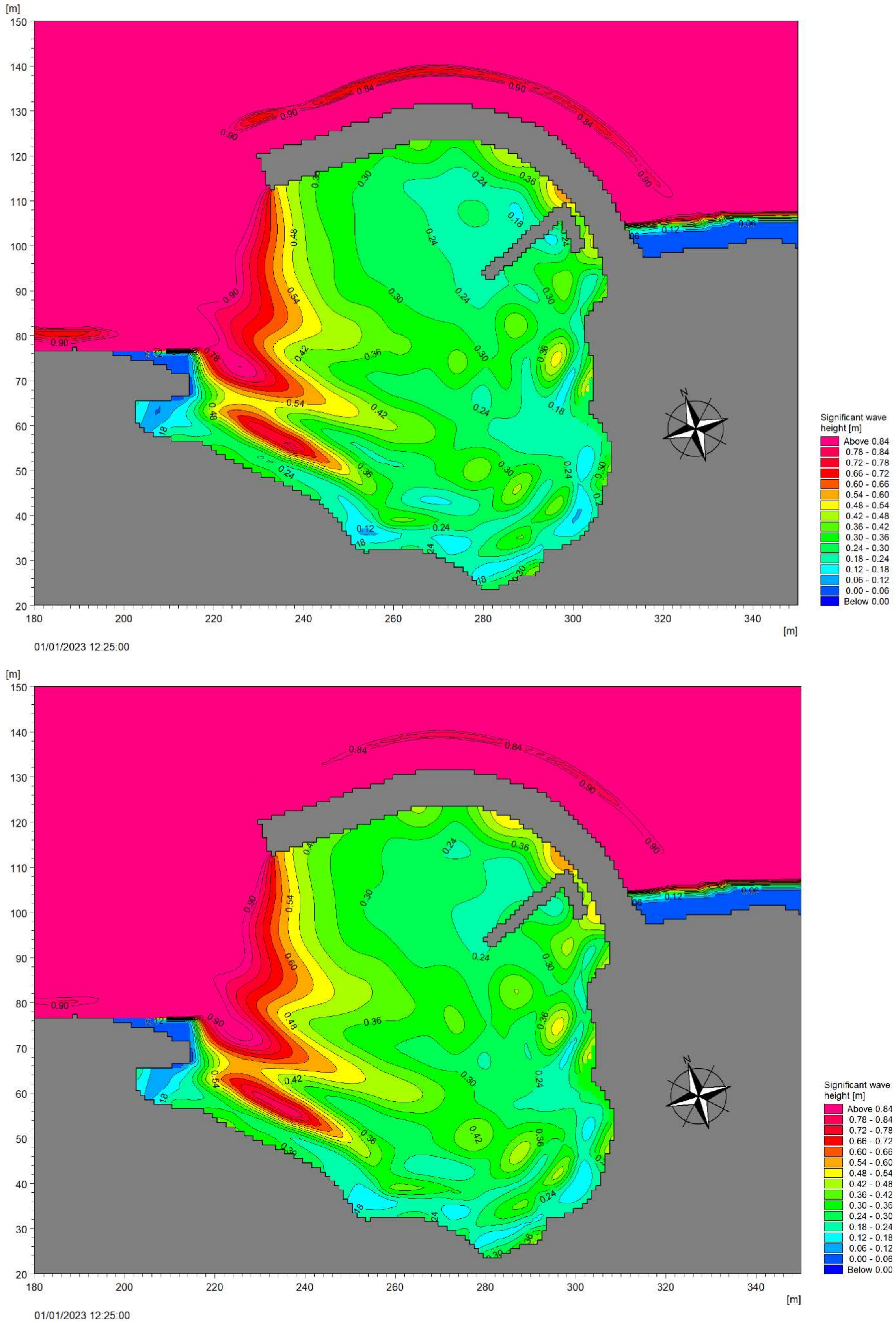


Figure 5-2 Option 1 - Significant wave heights – 1 in 1 year return period storm from 345° (top) and from 30° (bottom) at MHWS

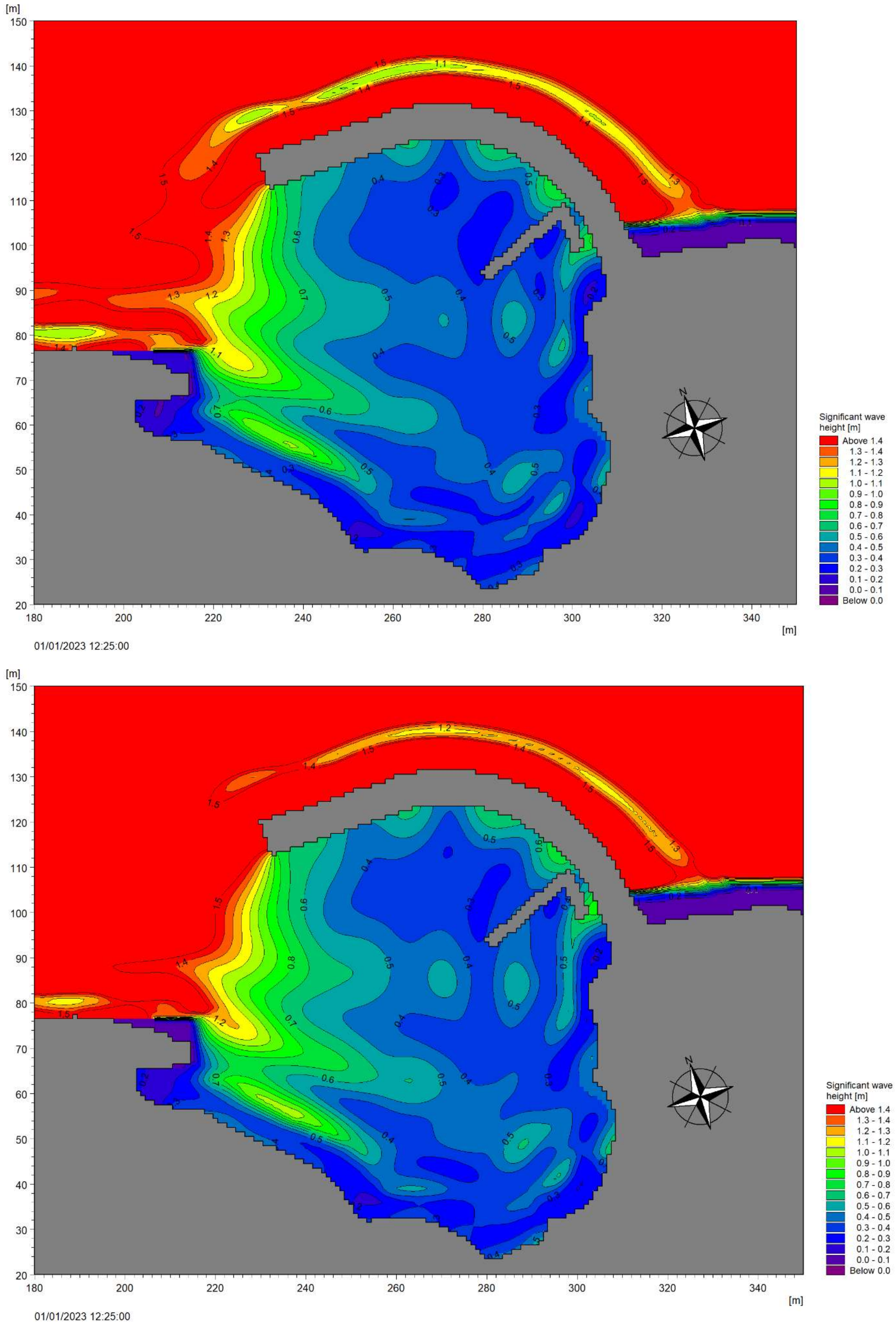


Figure 5-3 Option 1 - Significant wave heights – 1 in 10 year return period storm from 345° (top) and from 30° (bottom) at MHWS

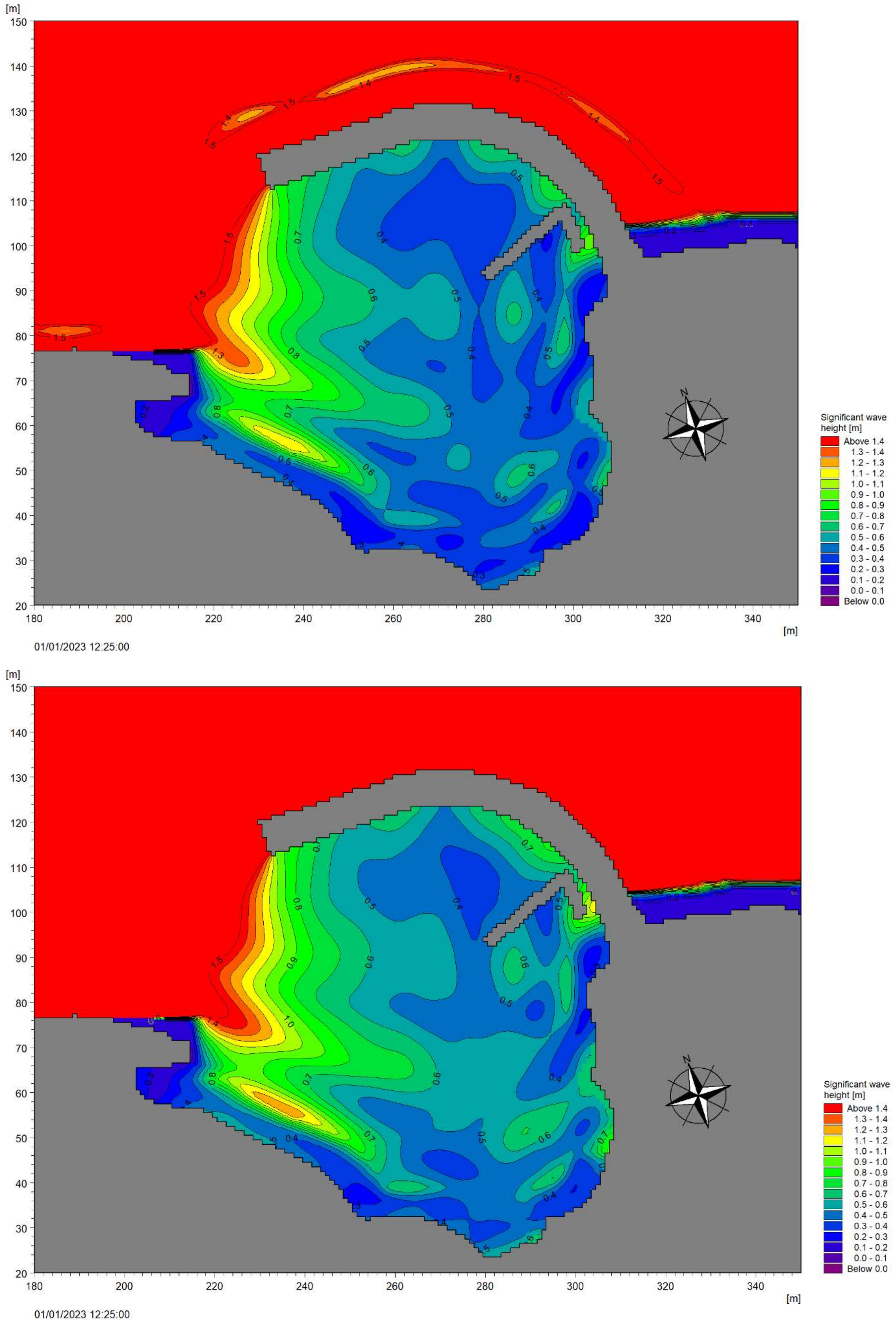


Figure 5-4 Option 1 - Significant wave heights – 1 in 50 year return period storm from 345° (top) and from 30° (bottom) at MHWS

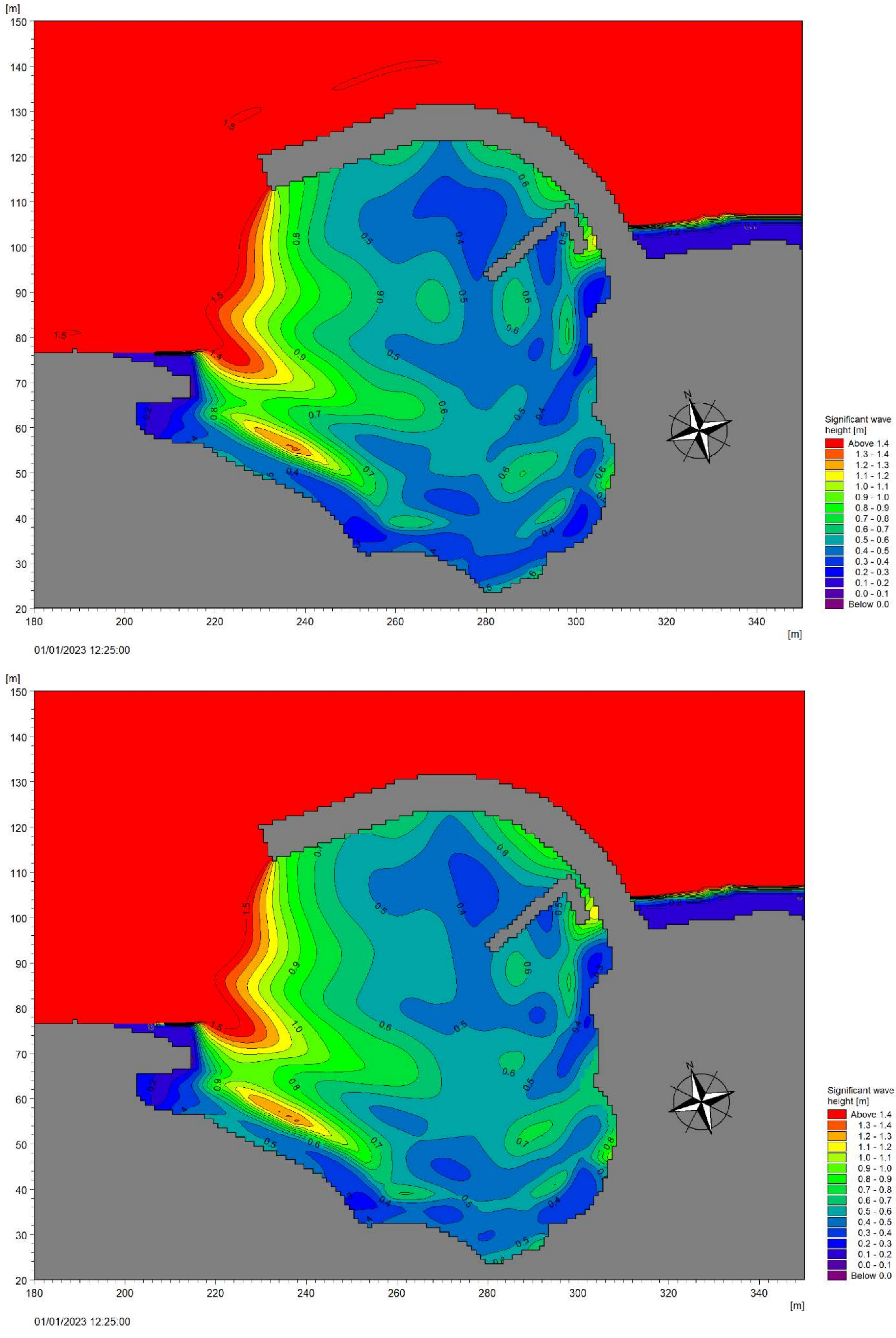


Figure 5-5 Option 1 - Significant wave heights – 1 in 100 year return period storm from 345º (top) and from 30º (bottom) at MHWS

5.2 Wave climate with Option 2 scheme

The predicted significant wave heights around the harbour with the proposed Option 2 pontoon jetty in place for each of the return period storms from both 345° and 30° directions are shown in Figures 5-6 to 5-10.

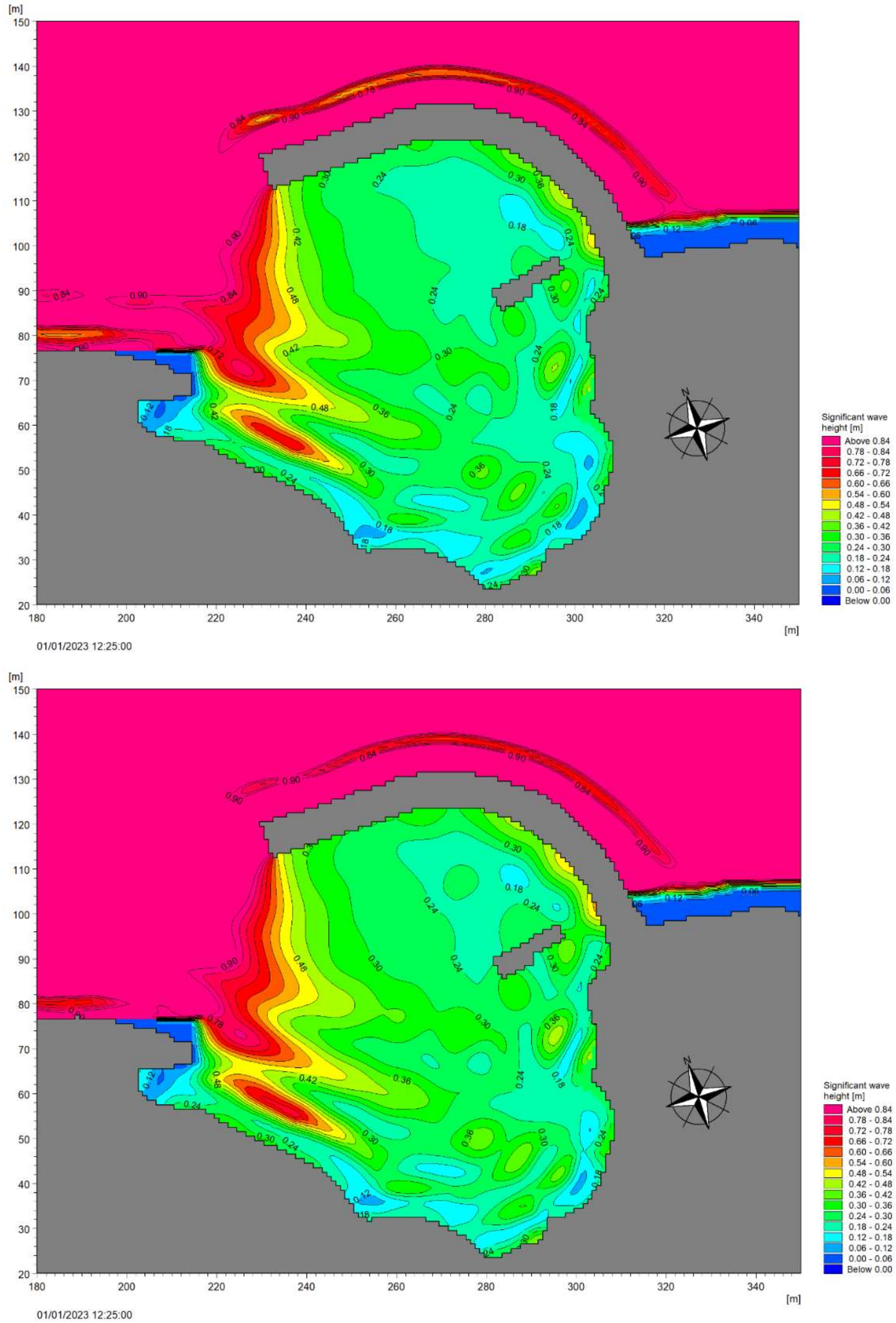


Figure 5-6 Option 2 - Significant wave heights – 1 in 0.5 year return period storm from 345° (top) and from 30° (bottom) at MHWS

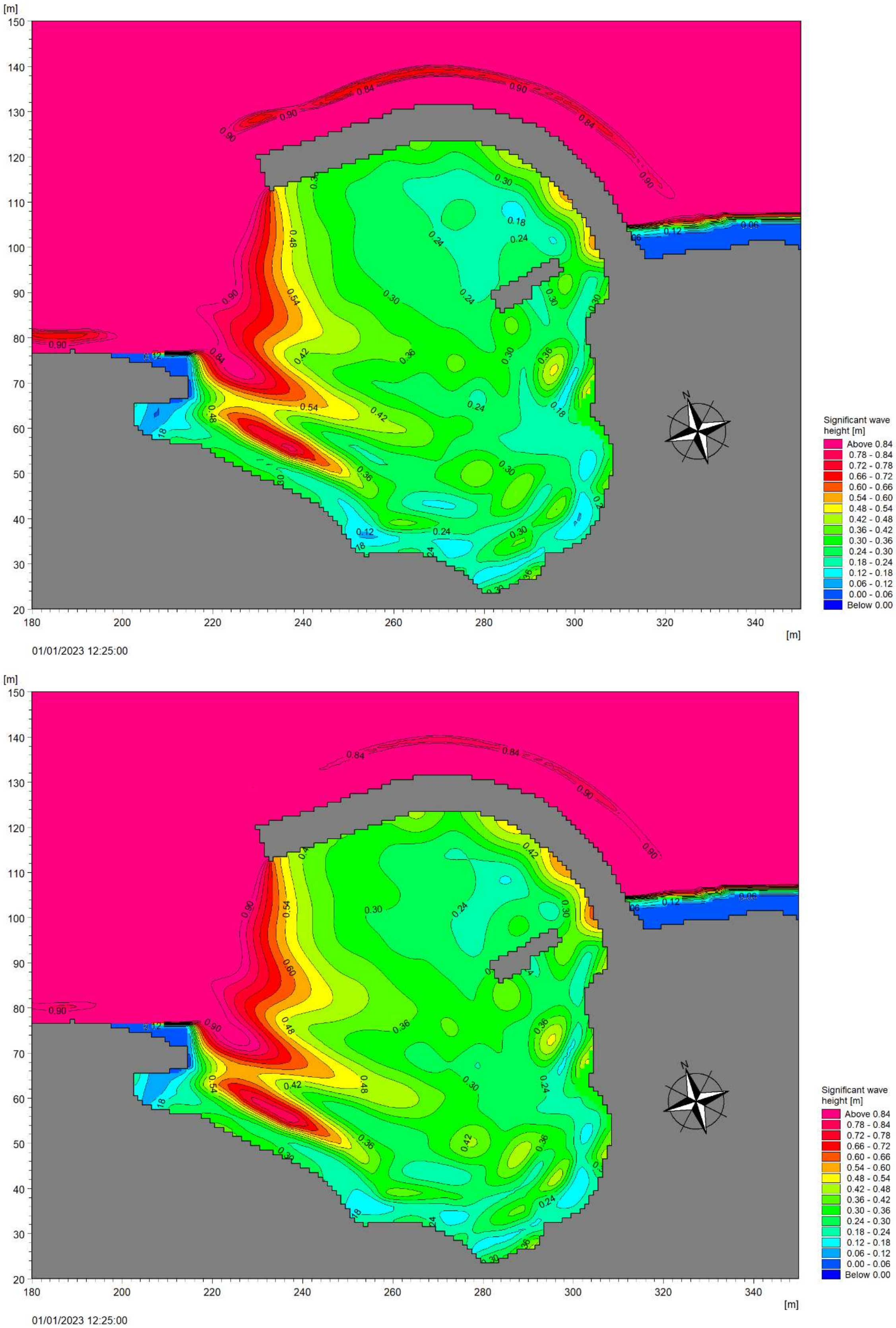


Figure 5-7 Option 2 - Significant wave heights – 1 in 1 year return period storm from 345° (top) and from 30° (bottom) at MHWS

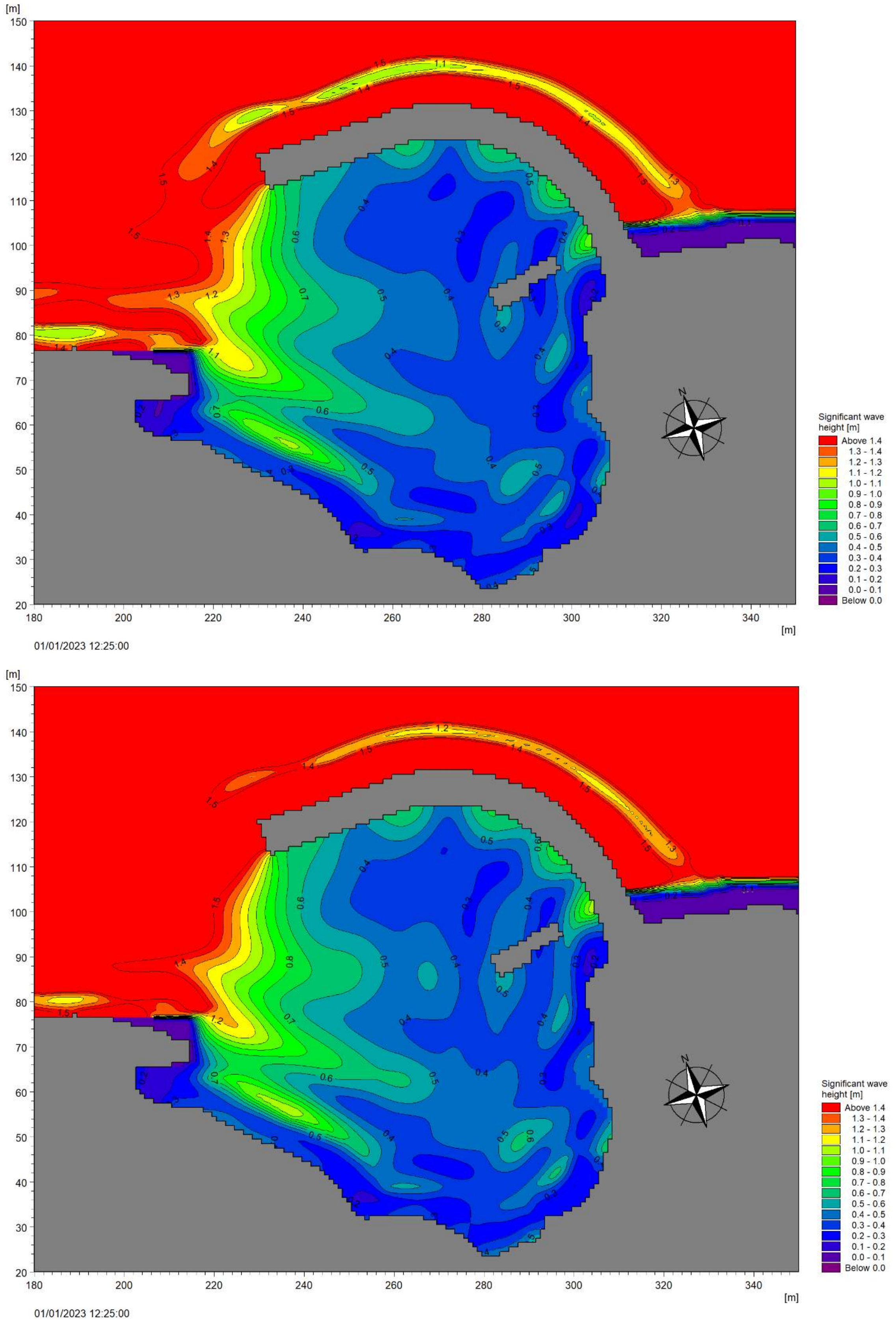


Figure 5-8 Option 2 - Significant wave heights – 1 in 10 year return period storm from 345° (top) and from 30° (bottom) at MHWS

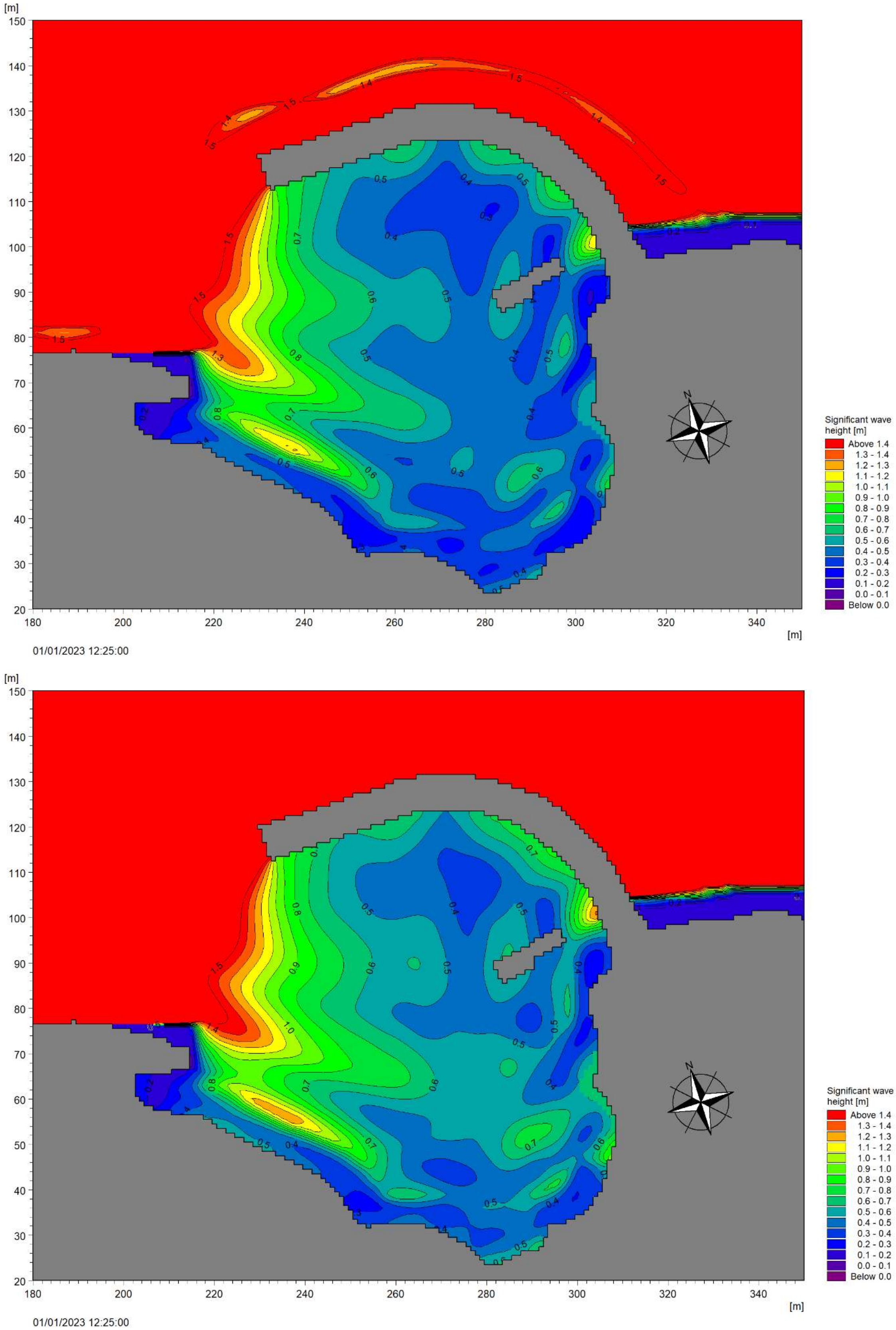


Figure 5-9 Option 2 - Significant wave heights – 1 in 50 year return period storm from 345° (top) and from 30° (bottom) at MHWS

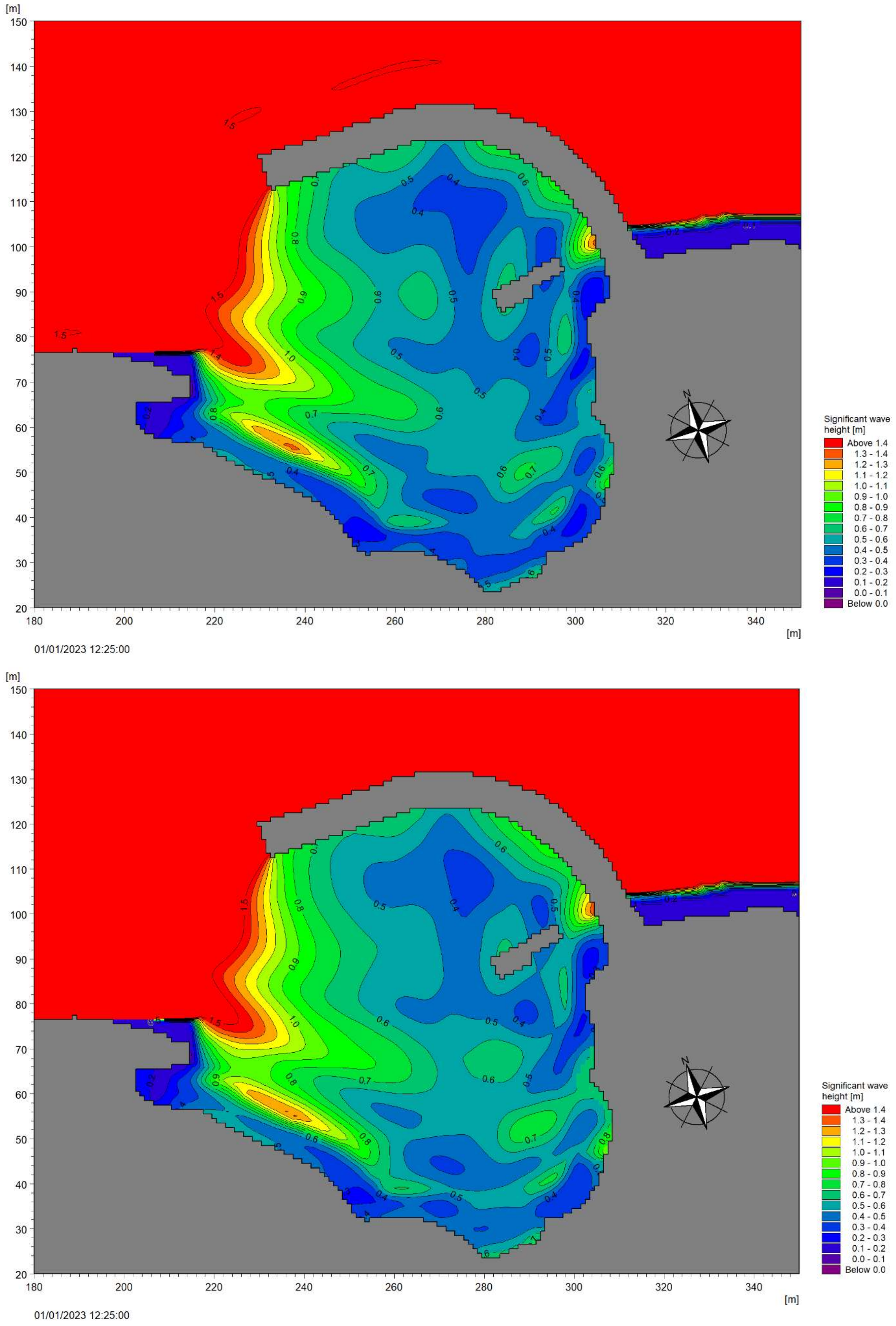


Figure 5-10 Option 2 - Significant wave heights – 1 in 100 year return period storm from 345º (top) and from 30º (bottom) at MHWS

5.3 Comparison of the results of simulation of Options

The significant wave heights around Carradale Harbour for each of the two development Options for the various return period storms are shown in Figure 5-1 to Figure 5-10. It should be noted that two wave height palettes have been used in the figures, one for the 1 in 0.5 and 1 year return period events and a second palette for the 1 in 10, 50 and 100 year return period events.

It will be seen from the results of the simulations that the wave heights at the berthing pontoon in Option1 are not excessive. However, the access pontoon at the toe of the access bridge is subjected to significant wave reflections and, as can be seen from Figure 5-11, the wave heights at this pontoon are quite severe even during a relatively low return period event.

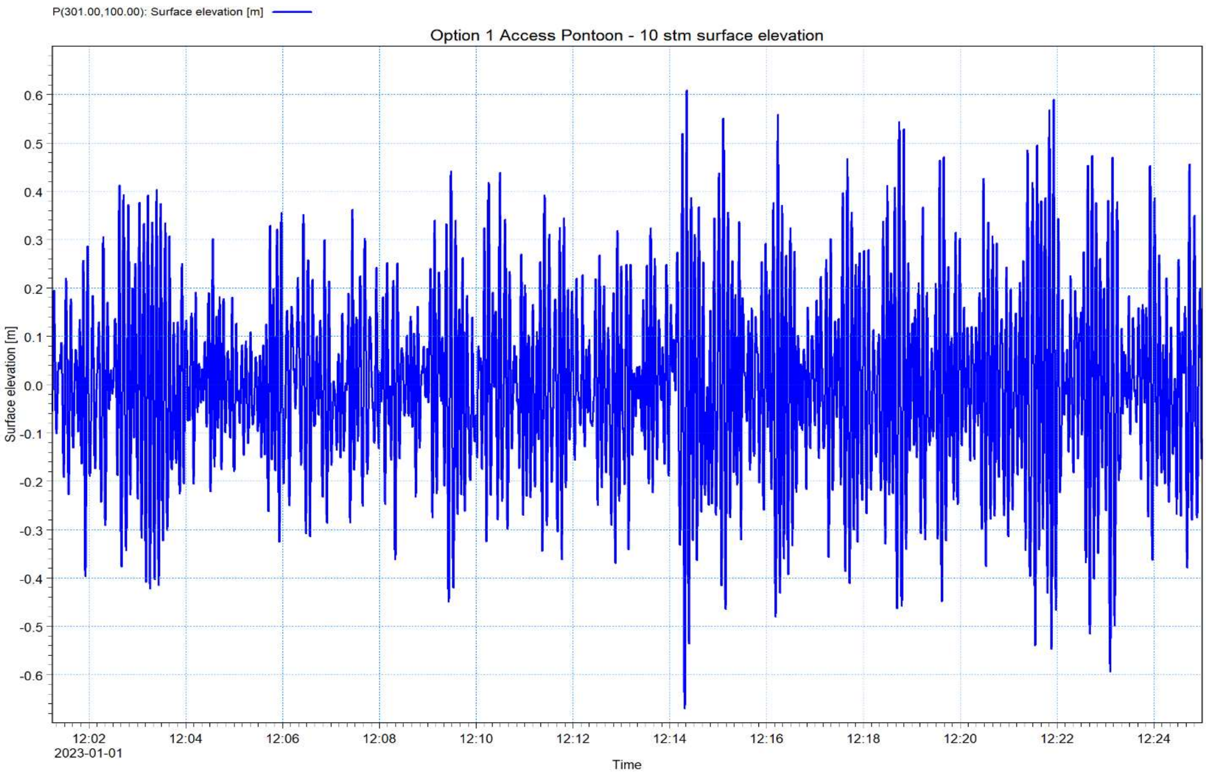


Figure 5-11 Option 1 access pontoon - 1 in 10 return period storm - Time series of surface elevation

In view of the excessive movement of the access pontoon in Option 1 during relatively low return period storm events this Option 1 is not recommended for the proposed facility in Carradale harbour.

The wave heights at the outer end of the Option 2 berthing pontoon during a 1 in 1 year return period event have significant wave heights of up to about 0.36m and up to 0.5m during a 1 in 10 year return period storm. These values are considered to be acceptable. However during a 1 in 50 year return period event the wave climate is expected to have significant wave heights of about 0.6 metre and maximum wave heights of about 1m. Thus boats may have difficulty remaining on this berth during 1 in 50 year return period events.

6 IMPACT ON COASTAL PROCESSES

6.1 Impact on tidal regime

The proposed berthing pontoon is a floating structure so it will have no impact on the tidal levels or tidal circulation in the harbour. Although there is a minor amount of dredging in the area around the Option 2 berth, this is not significant in terms of impact on the tidal regime in the harbour. Thus the proposed scheme will have no significant impact on the tidal regime, either in terms for heights or flows, at Carradale harbour.

6.2 Impact on the wave climate around the harbour

The impact of the proposed Option 2 development on the wave climate around the harbour has been assessed by comparing the wave in the harbour for the existing harbour and the harbour with the proposed scheme in place. The analysis has been undertaken for 1 in 0.5, 1 in 1 and 1 in 10 year return period storm events as the higher return periods occur so rarely that they have little influence on the overall coastal processes of the area.

Diagrams of the wave heights around the harbour are given below for the two most arduous wave directions Figure 6-1 to Figure 6-6. The wave climate diagrams for the existing harbour and the harbour with the proposed scheme are produced side by side for each of the wave conditions so that the differences, if any, can be seen.

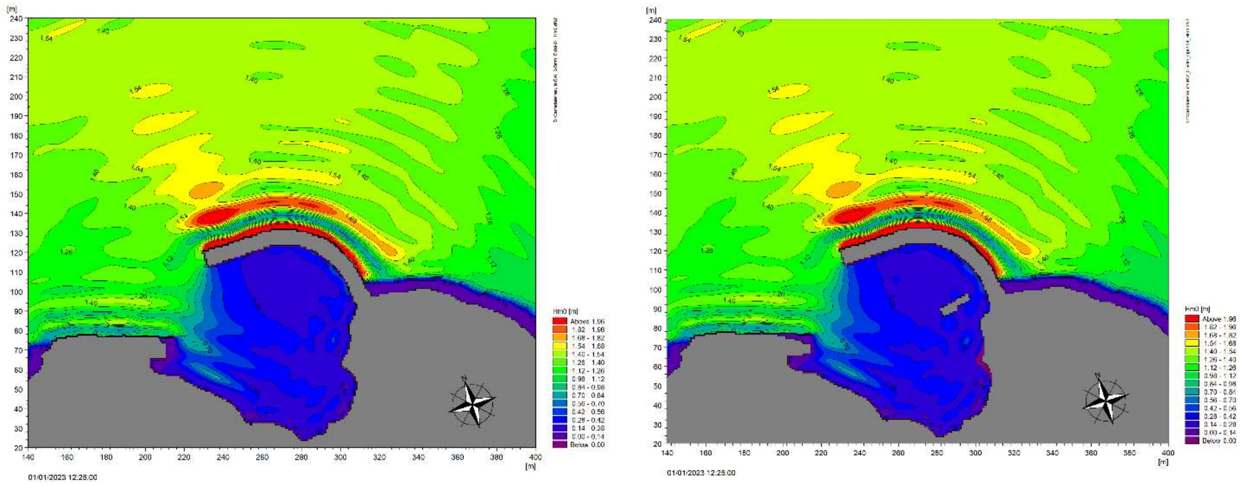


Figure 6-1 1 in 0.5 return period storm from 30° – Significant wave heights around the existing harbour (left) and around the harbour including the Option 2 scheme (right)

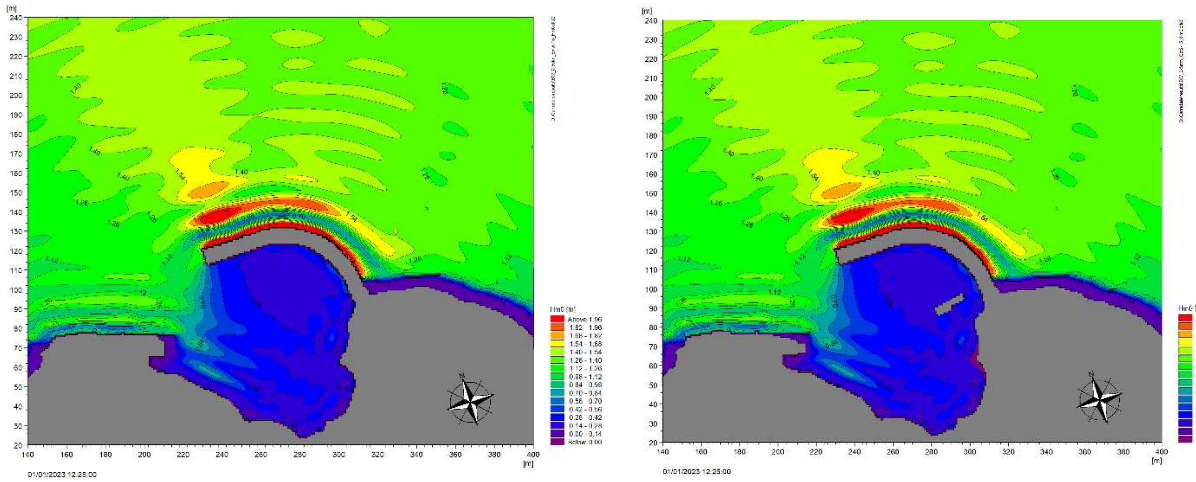


Figure 6-2 1 in 0.5 return period storm from 345º – Significant wave heights around the existing harbour (left) and around the harbour including the Option 2 scheme (right)

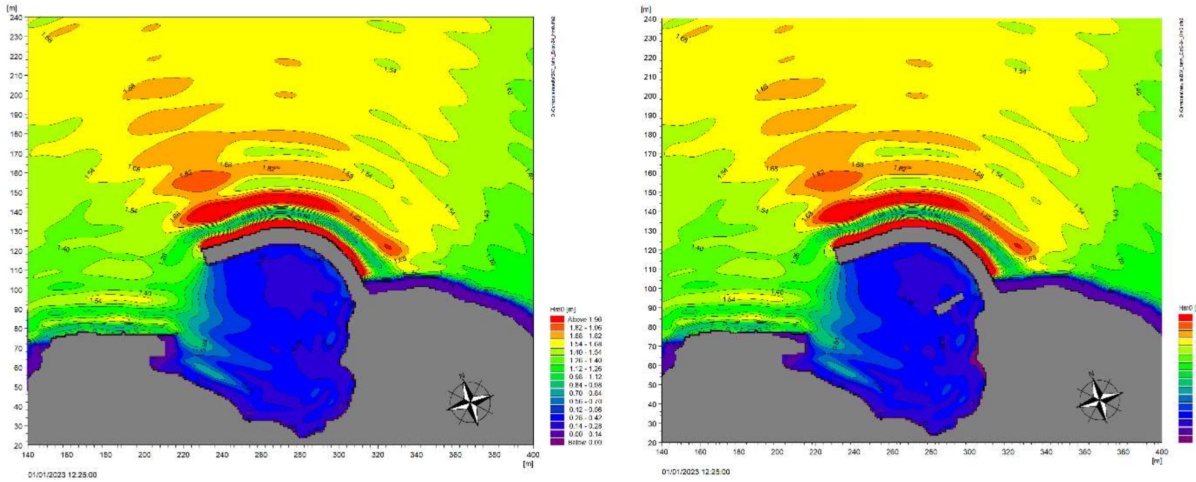


Figure 6-3 1 in 1 return period storm from 30º – Significant wave heights around the existing harbour (left) and around the harbour including the Option 2 scheme (right)

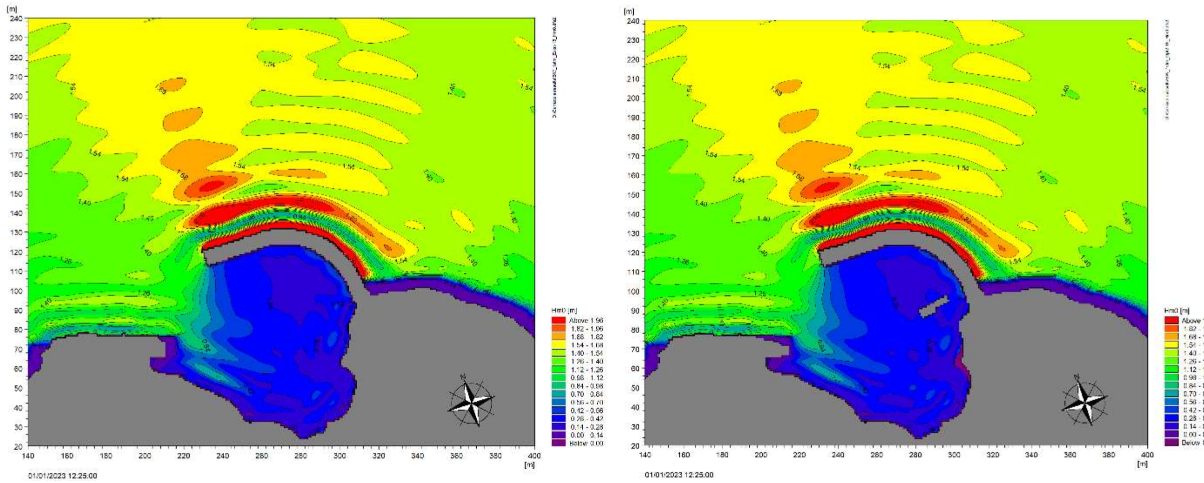


Figure 6-4 1 in 1 return period storm from 345º – Significant wave heights around the existing harbour (left) and around the harbour including the Option 2 scheme (right)

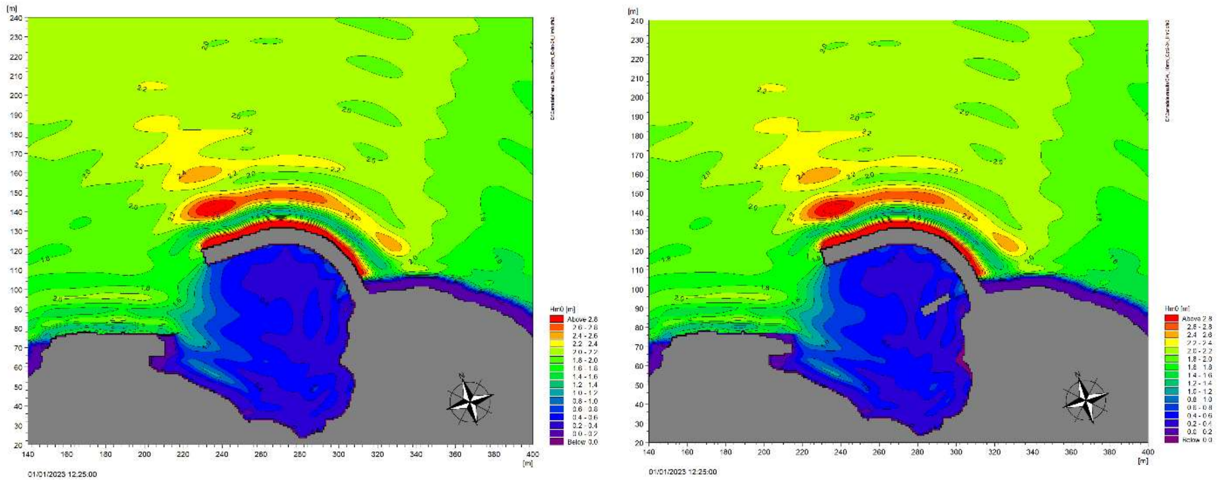


Figure 6-5 1 in 10 return period storm from 30º – Significant wave heights around the existing harbour (left) and around the harbour including the Option 2 scheme (right)

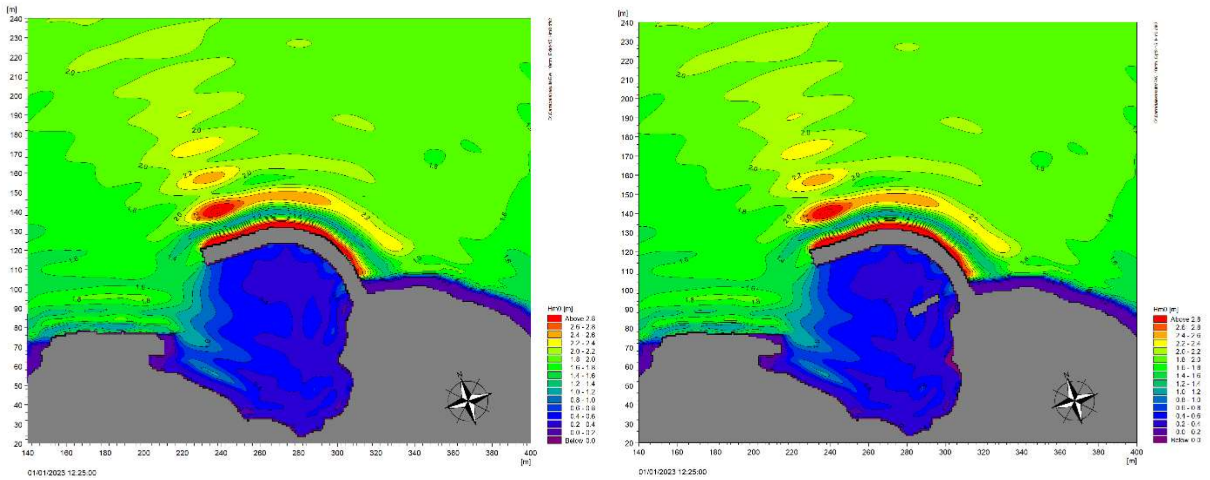


Figure 6-6 1 in 10 return period storm from 345º – Significant wave heights around the existing harbour (left) and around the harbour including the Option 2 scheme (right)

It will be seen from Figures 6-1 to 6-6 that there is only a small change in the wave conditions in the harbour resulting from the installation of the proposed Option 2 berthing pontoon. In order to evaluate the magnitude of these changes wave height difference plots (proposed scheme minus existing) have been shown for each of the return period events and storm wave directions in the following Figures 6-7 to 6-12.

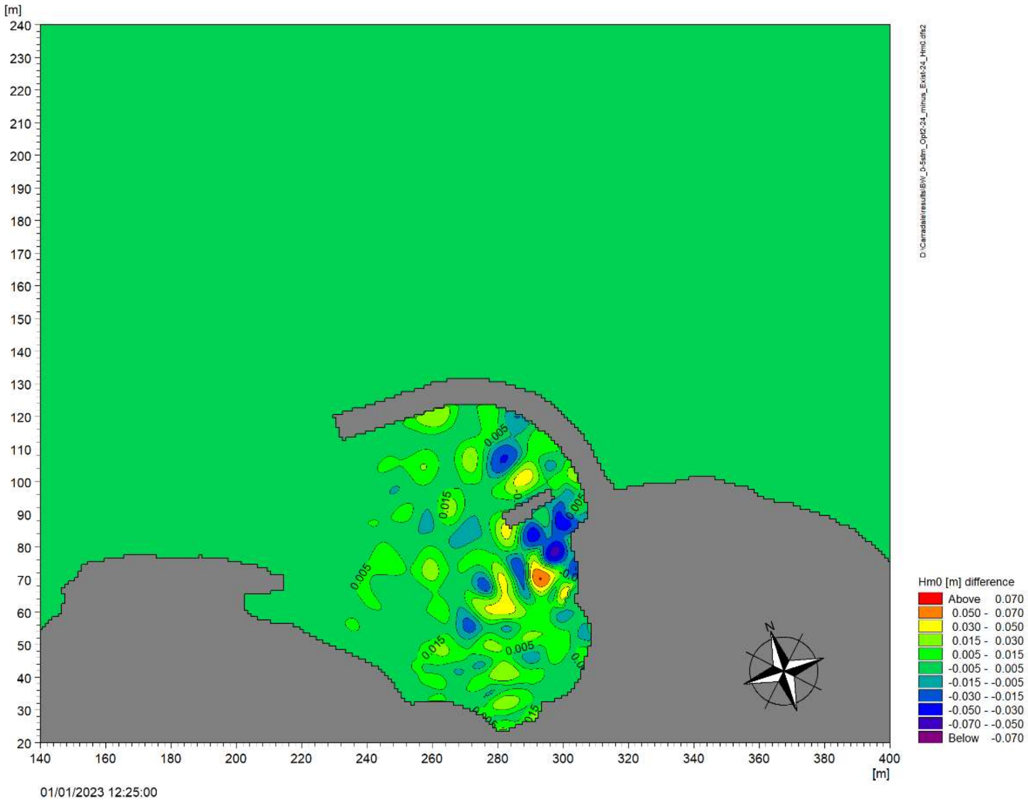


Figure 6-7 Significant wave height difference – 1 in 0.5 return period storm from 30°

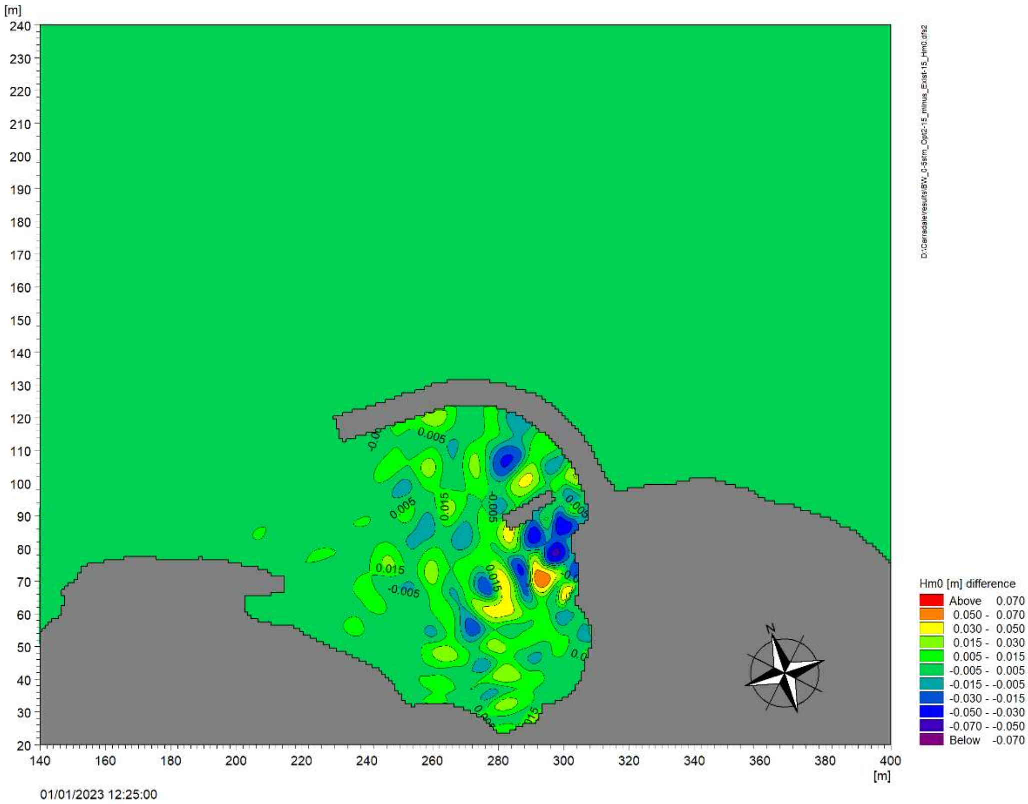


Figure 6-8 Significant wave height difference – 1 in 0.5 return period storm from 345°

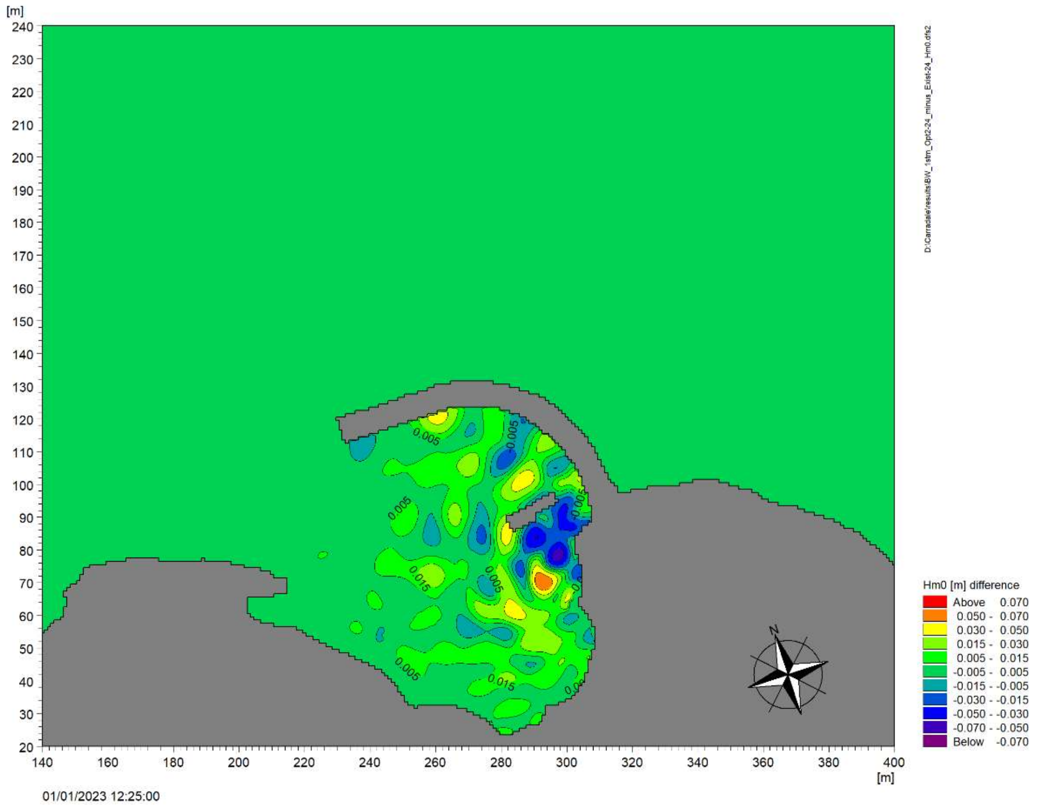


Figure 6-9 Significant wave height difference – 1 in 1 return period storm from 30º

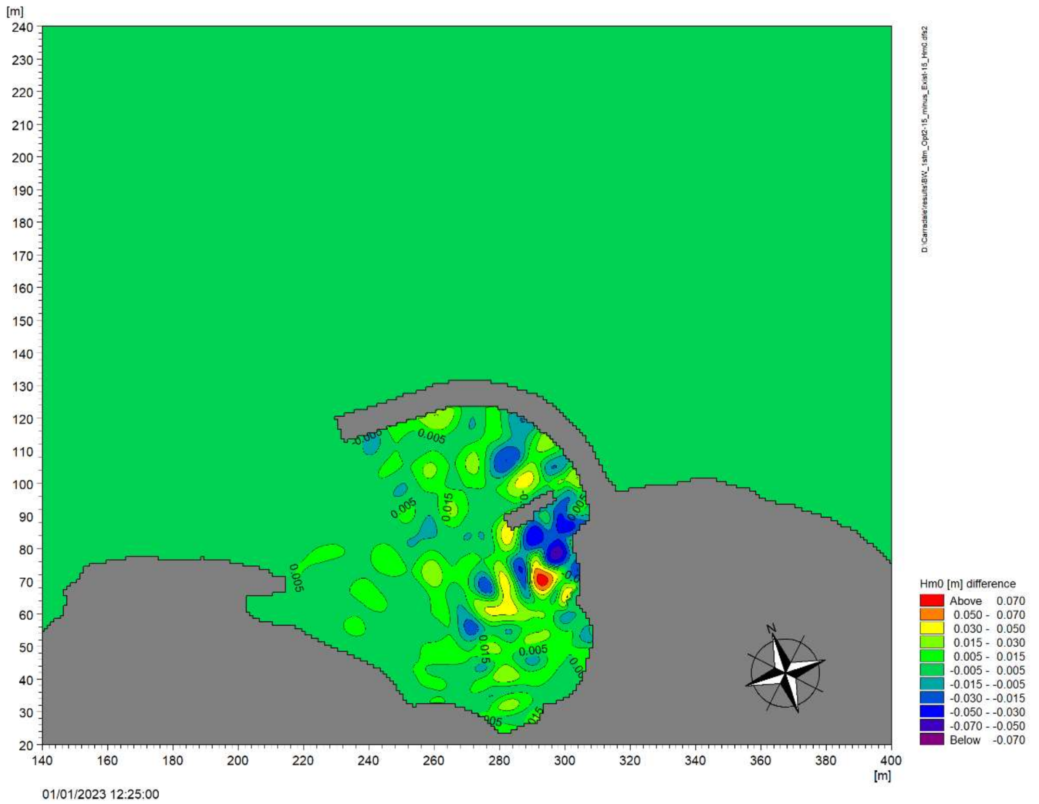


Figure 6-10 Significant wave height difference – 1 in 1 return period storm from 345º

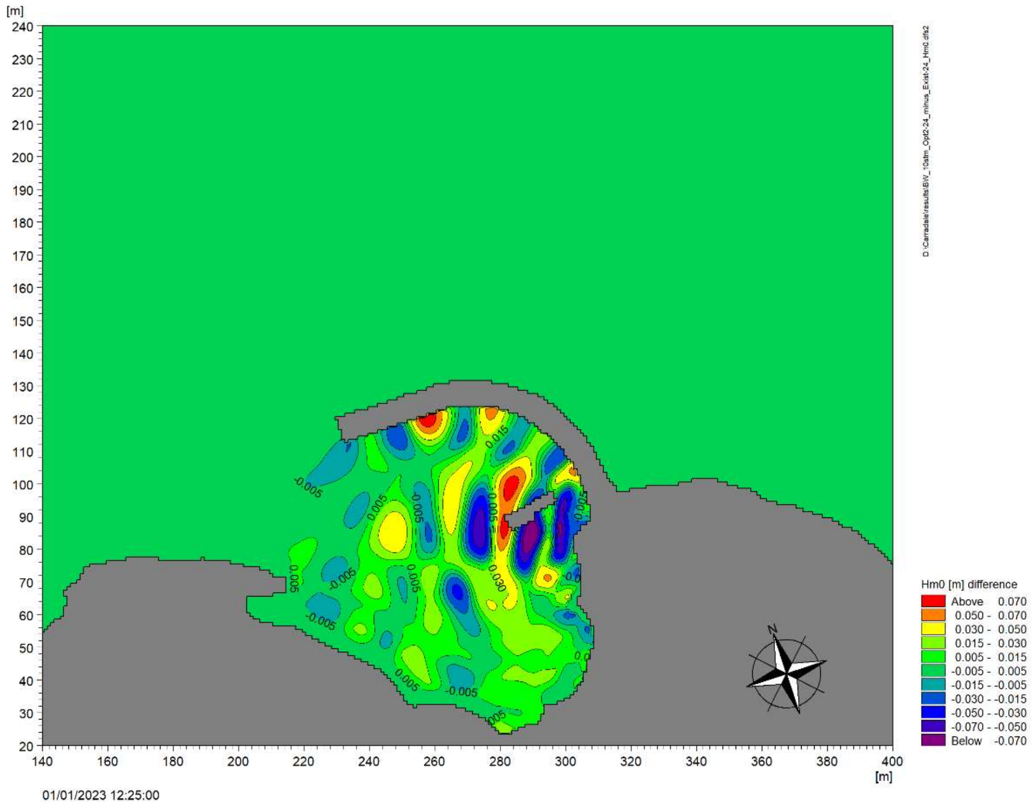


Figure 6-11 Significant wave height difference – 1 in 10 return period storm from 30°

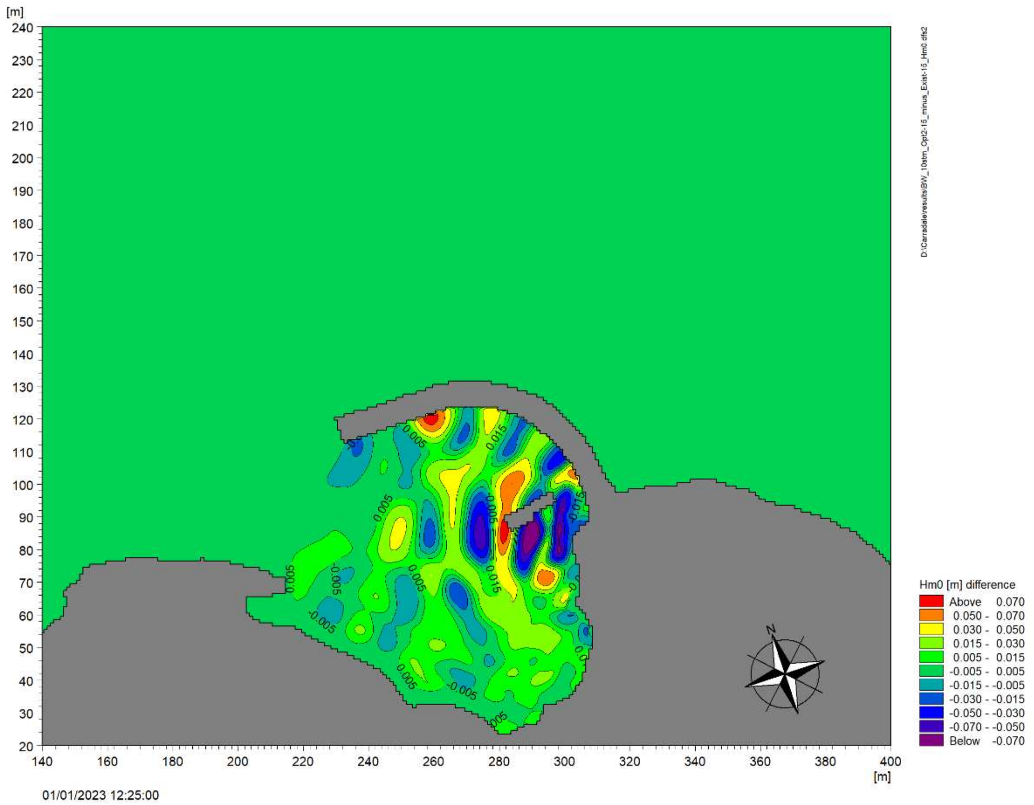


Figure 6-12 Significant wave height difference – 1 in 10 return period storm from 345°

It will be seen from Figures 6-7 to 6-12 that for 1 in 0.5 and 1 in 1 year storm conditions the differences in the wave heights at the berths along the pier will only change by up to 50mm. Even during a 1 in 10 year return period storm the change in wave heights at the berths along the pier will only be up to about 70mm which is an increase of about 8%. This is not significant as it results from a slight change in the position of the standing wave patterns rather than a general increase the wave heights in the harbour. Thus it is concluded that the proposed Option 2 scheme will not significantly change the wave heights in Carradale harbour.

6.3 Impact on the sediment transport regime

It will be seen from Sections 6.1 and 6.2 that the proposed scheme will not result in any significant change in either the tidal or wave climate regime in the approaches to Carradale or within the harbour itself. Since the proposed pontoon berth will not significantly alter the bed sediments within the harbour and there is no significant change in the tidal regime or wave climate within the harbour, it must be concluded that the proposed scheme will not have any impact on the sediment transport regime around or within Carradale harbour.

7 CONCLUSIONS

The wave climate at the approaches to and within Carradale Harbour, has been simulated using advanced computational modelling techniques.

Carradale harbour is most exposed to storm waves approaching from the 345^{o} to 45^{o} sector with the largest waves approaching the harbour entrance from about 24^{o} during a storm from 30^{o}. Simulations have been undertaken for the wave climate within the harbour during 1 in 0.5, 1, 10, 50 and 100 year return period events both for the existing harbour and for the harbour with two alternative floating pontoon berth arrangements.

The modelling showed that while the wave heights at the berthing pontoon in the Option1 scheme are not excessive, the access pontoon at the toe of the access bridge in this option is subjected to significant wave reflections and the wave heights at this pontoon are quite severe even during a relatively low return period event. In view of the excessive movement of the access pontoon in Option 1 during relatively low return period storm events this Option 1 is not recommended for the proposed facility in Carradale harbour.

The wave heights at the outer end of the Option 2 berthing pontoon during a 1 in 1 year return period event have significant wave heights of up to about 0.36m and up to 0.5m during a 1 in 10 year return period storm. These values are considered to be acceptable. However during a 1 in 50 year return period event the wave climate is expected to have significant wave heights of about 0.6 metre and maximum wave heights of about 1m. Thus boats may have difficulty remaining on this berth during 1 in 50 year return period events

The results of the hydraulic modelling showed the Option2 scheme would have no impact on the tidal regime and only minor changes in the wave climate within the harbour itself. Since the proposed scheme does not include significant change in the sea bed sediments around the harbour, the Option 2 scheme will not significantly impact the sediment transport or any of the other coastal processes in the area.

APPENDIX

Video of wave disturbance patterns during 1 in 50 year return period storm:

50stm_30deg_Opt2.mp4

Appendix B – Photographs

Photo 1 – View of Carradale Harbour from existing slipway

Photo 2 – View of existing quayside at proposed pontoon access bridge location