Phase 3: Sediment Transport modelling for CCA2-3

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East Coast Railway Infrastructure Protection Projects
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Executive summary

The modelling studies for this project are divided into phases. Phase 1 of the ECRIPP has been completed and documented in Jacobs (2023). The Phase 1 modelling repeated the modelling carried out by Arup (2020) to address the limitations highlighted in the Arup (2020) work. Phase 2 modelling completed by Jacobs (2024) used LITLINE modelling to assess the coastline changes across CCA2-3.

This report improves on the Phase 2 modelling work to generate a more detailed understanding of sediment transport along the coastline, especially along CCA2-3 at Killiney. This report should be read alongside the Phase 3 Coastal Processes report prepared by Jacobs (2025) to provide full context and support a comprehensive interpretation of the findings.

A Coastal Area Model (CAM) which includes the effects of two-dimensional bathymetry variation on waves, tides, associated flows and sand transport, was set up for the whole of CCA2-3. The Coastal Area Model (CAM) was applied to simulate wave dynamics, hydrodynamic flow, and sediment transport along the CCA2-3 frontage, with the objective of predicting shoreline evolution under present-day (2025) and future (2075) conditions. Due to CAM's sediment grain size limitation (maximum 2mm, results were scaled using a LITDRIFT-derived relationship to account for coarser sediments. Rocky bed areas were modelled with zero sediment thickness and increased roughness.

Three model configurations were used:

- Type 1: 27 representative wave conditions without morphological feedback, representing initial system response.
- Type 2A: A single representative wave with morphological feedback and cross-shore transport enabled.
- Type 2B: A single representative wave with morphological feedback but cross-shore transport disabled. This configuration was used for shoreline change projections.

Representative wave conditions were derived from ERA5 data and transformed to the CAM boundary using a regional Spectral Wave model. Offshore wave directions from 325° to 215° were included, with tidal conditions based on Dublin observations. Hydrodynamic boundary conditions were sourced from the Irish Sea regional model.

At White Rock Beach, model outputs were used to assess potential impacts on current speeds and swimmer safety. Sediment transport results were evaluated for their influence on sediment supply to Whiterock Beach and the surf break, particularly the presence of a sand bar. Wave model outputs were also used to assess changes in wave breaking locations.

Wave modelling and sediment transport analysis indicate a net northward sediment drift along the frontage, with the most active transport occurring within 100 m of the shoreline. However, exposed bedrock in some areas limits sediment mobility.

Beach Morphology Projections:

- 2025:
  - Erosion between profiles P4–P7 (up to -1.1 m/yr).
  - Accretion between P4–P1, except erosion at P2 (-0.7 m/yr).
- 2075:
  - Similar trends persist, with erosion continuing at P4–P7 and accretion between P4–P1 (up to +0.8 m/yr).
  - Results are broadly consistent with 2025 projections.

White Rock Beach Dynamics:

- Tidal-only conditions: Revetment has negligible impact on current speeds.
- Wave-driven currents:
  - NE/ENE waves: Southward nearshore flow; minor changes in eddy position.
  - S waves: Northward flow; eddy shifts ~20 m northward.
  - Eddy shifts are not significant, attributed to minor wave direction variability.

Revetment Impacts:

- Reduces sediment supply to White Rock Beach by obstructing northward drift.
- Clockwise eddy facilitates offshore sediment loss; its position varies with wave direction.
- No sand bar observed within 400 m offshore.
- Wave decay impact from revetment is minimal (<0.10 m change).

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Acronyms and abbreviations

d	Water depth
CAM	Coastal Area Model
Dir	Direction
D_{16}	Diameter for which 16% of the sediment are finer than (representative of fine fraction in sample)
D_{50}	Diameter for which 50% of the sediment are finer than (represents the median sediment size)
D_{84}	Diameter for which 84% of the sediment are finer than (representative of coarse fraction in sample)
DHI	DHI Water and Environment (formerly Danish Hydraulic Institute)
E	East
ECRIPP	East Coast Railway Infrastructure Protection Projects
ENE	East-Northeast
ESE	East-Southeast
FM	Flexible Mesh
H_{m0}	Significant wave height based on the zeroth moment of the wave spectrum
H_{rms}	Root mean square wave height ($H_{rms} = H_{m0}/\sqrt{2}$)
HAT	Highest astronomical tide
HD	Hydrodynamic
ITM	Irish Transverse Mercator
k_n	Roughness height
LAT	Lowest astronomical tide
MIKE	Software by DHI
MHWN	Mean high water neaps
MHWS	Mean high water springs
MLWN	Mean low water neaps
MLWS	Mean low water springs
MSL	Mean sea level
MWD	Mean wave direction
N	North
NE	Northeast
NNE	North-Northeast
ODM	Ordnance Datum Malin
Qs	Sediment transport rate
RP	Return period
S	South
S_g	spreading coefficient for sediment size
SLR	Sea level rise
ST	Sand Transport
SW	Spectral Wave
T_m	Mean wave period (T01)
T_p	Peak wave period
WL	Water level

1. Introduction

1.1 Modelling studies

The modelling studies for ECRIPP (East Coast Railway Infrastructure Protection Projects) are divided into phases. Phase 1 of the ECRIPP has been completed and documented in Jacobs (2023a). The Phase 1 modelling repeated the modelling carried out by Arup (2020) to address the limitations highlighted in the Arup (2020) work. In summary, the Phase 1 study included:

- A wave model validated using measured wave data.
- Nearshore wave conditions incorporating the effect of spatial and temporal variation of water levels on the wave climate.
- Coastline position changes considering the effect of changing shoreline orientation on the annual longshore sediment transport rates.

Phase 2 of the ECRIPP has been completed and documented in Jacobs (2024). The Phase 2 modelling improved on the Phase 1 modelling work to generate a more detailed understanding of sediment transport along the coastline and to further refine future coastline predictions. As part of Phase 2 for CCA2-3, a shoreline evolution model (LITLINE) was used to generate future coastline positions and calculate the future erosion rates.

Phase 3 modelling reuses several of the datasets produced as part of Phase 1 modelling. These include:

- Nearshore wave conditions extracted from the calibrated wave model
- Sediment grain size samples from selected locations

This report should be read in conjunction with the Phase 3 Coastal Processes report by Jacobs (2025) to ensure a comprehensive understanding of the context and findings

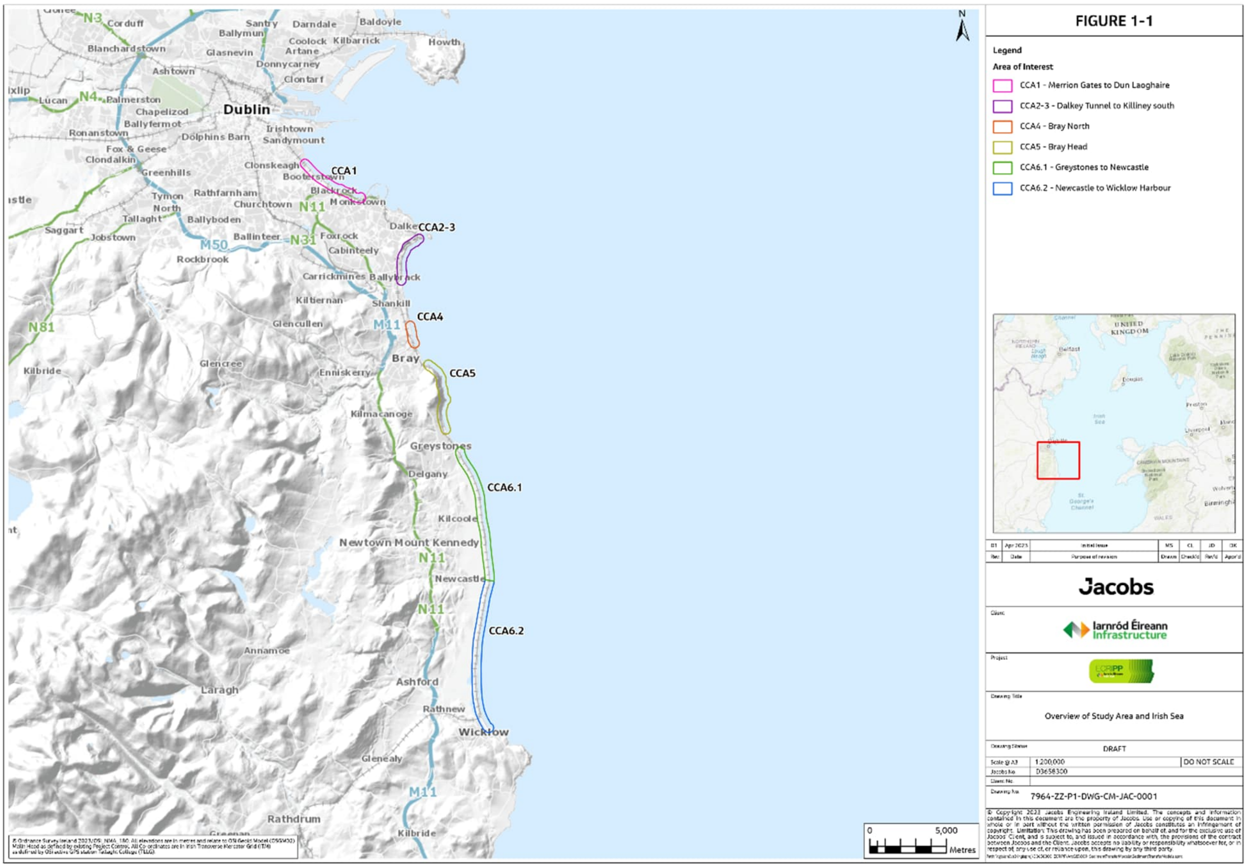

Figure 1-1. Overview of study area and smaller areas of interest

1.2 Study Area

CCA2-3 lies to the south of Dublin Figure 1-2. The coastline between Dalkey Island and Bray features rocky shores, pebble beaches, and cliffs. Near Dalkey island, the shore is rocky with cliffs heading south towards Killiney. Killiney Beach is a long, sandy/stony beach stretch bordered by sea walls, revetements and a railway line. The railway runs close to the coast, passing through cliffside areas. Further south of CCA2-3 as the land rises toward Bray Head, the terrain becomes steeper, ending at Bray's mixed shingle and sand beach, which is lined by a promenade. White Rock beach has a high amenity value and is a popular bathing beach during the summer months for surfing and a swimming access point is located north of the beach with a path down the cliff side.

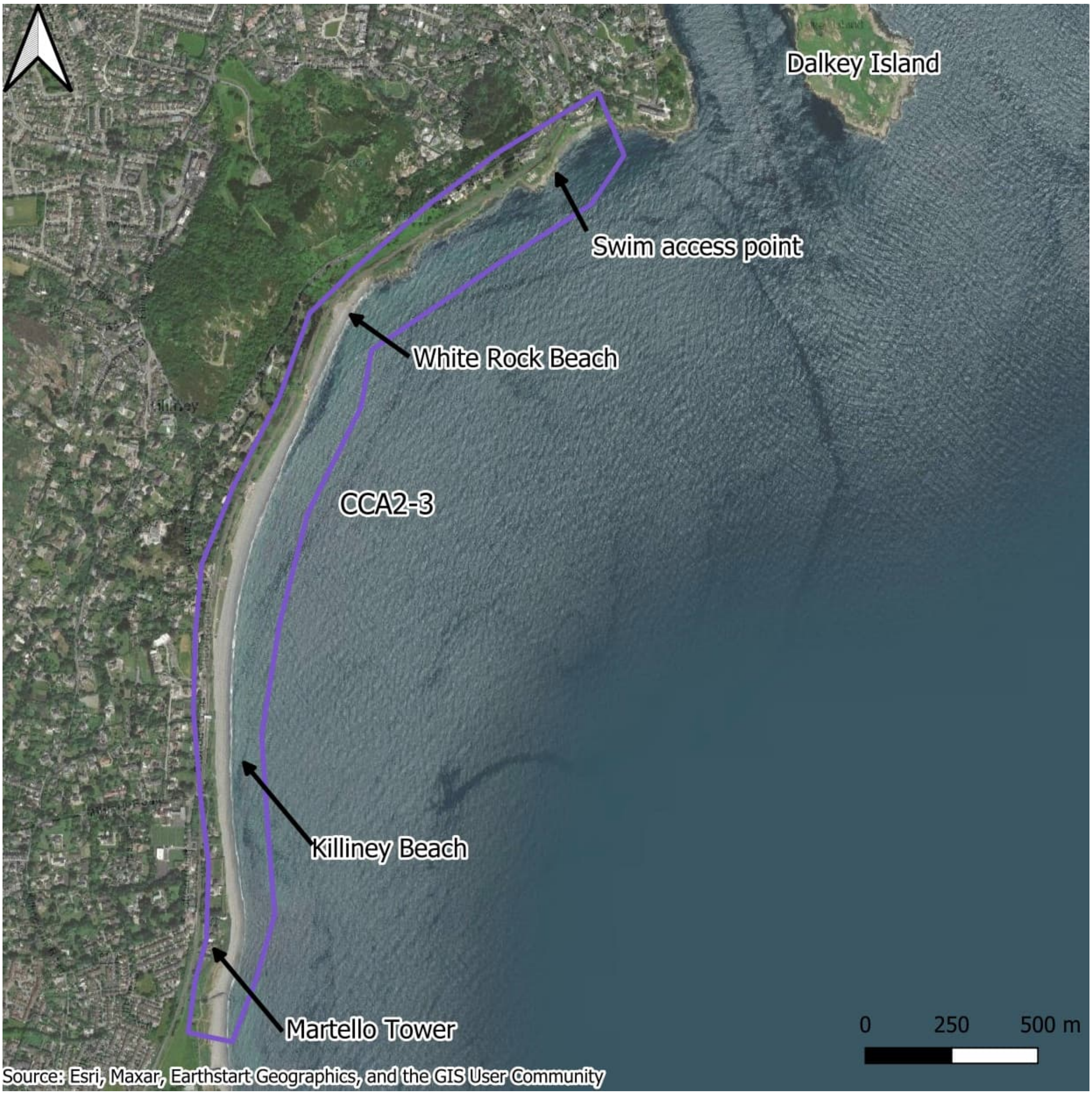

Figure 1-2. Location of CCA2-3

1.3 Purpose of document

This report documents the methodology, model setup (CAM model setup and model parameters used in the two-dimensional modelling of waves, flow and sediment transport) and key model results for CCA2-3. The annual longshore sediment transport rates and estimated bed level changes are presented for present day and future (Year 2075) scenario including the effect of climate change.

1.4 Conventions

Unless explicitly stated otherwise the following conventions are used in this report:

- Wind direction is provided as the direction the wind is blowing from. For example, a wind direction of 0°N refers to wind blowing from north. This follows the standard nautical convention.

- Wave direction is provided as the direction the wave is coming from. For example, a wave direction of 0°N refers to waves coming from north.

1.5 Datums

Unless explicitly stated otherwise the following reference datums are used in this report:

- Horizontal co-ordinates are referenced to the IRENET95 / Irish Transverse Mercator or latitude-longitude geographical grid.
- Vertical levels are relative to Mean Sea Level (m MSL), Mean High Water Springs (m MHWS) or Ordnance Datum Malin (m ODM). When using the Malin datum, levels will reference the OSGM15 levels.

2. Coastal Area Modelling

2.1 Methodology

The model used for this investigation is the MIKE 21 Coastal Area Model (CAM) – in the MIKE by DHI software package. The CAM consists of three modules (Hydrodynamic (HD), Spectral Wave (SW) and Sand Transport (ST)) running together and sharing simulation results. The HD model passes water level results to the SW model, and the SW model passes radiation stresses to the HD model along with wave height/period/direction information to the ST model.

The CAM is computationally intensive; therefore, it is not possible to carry out long term simulations. Instead, a representative wave approach is taken, where the yearly wave climate is reduced to a small number of representative wave conditions, which when combined represents the yearly sediment transport. The methodology used to carry out the Coastal Area Sediment Transport modelling is illustrated in Figure 2-1.

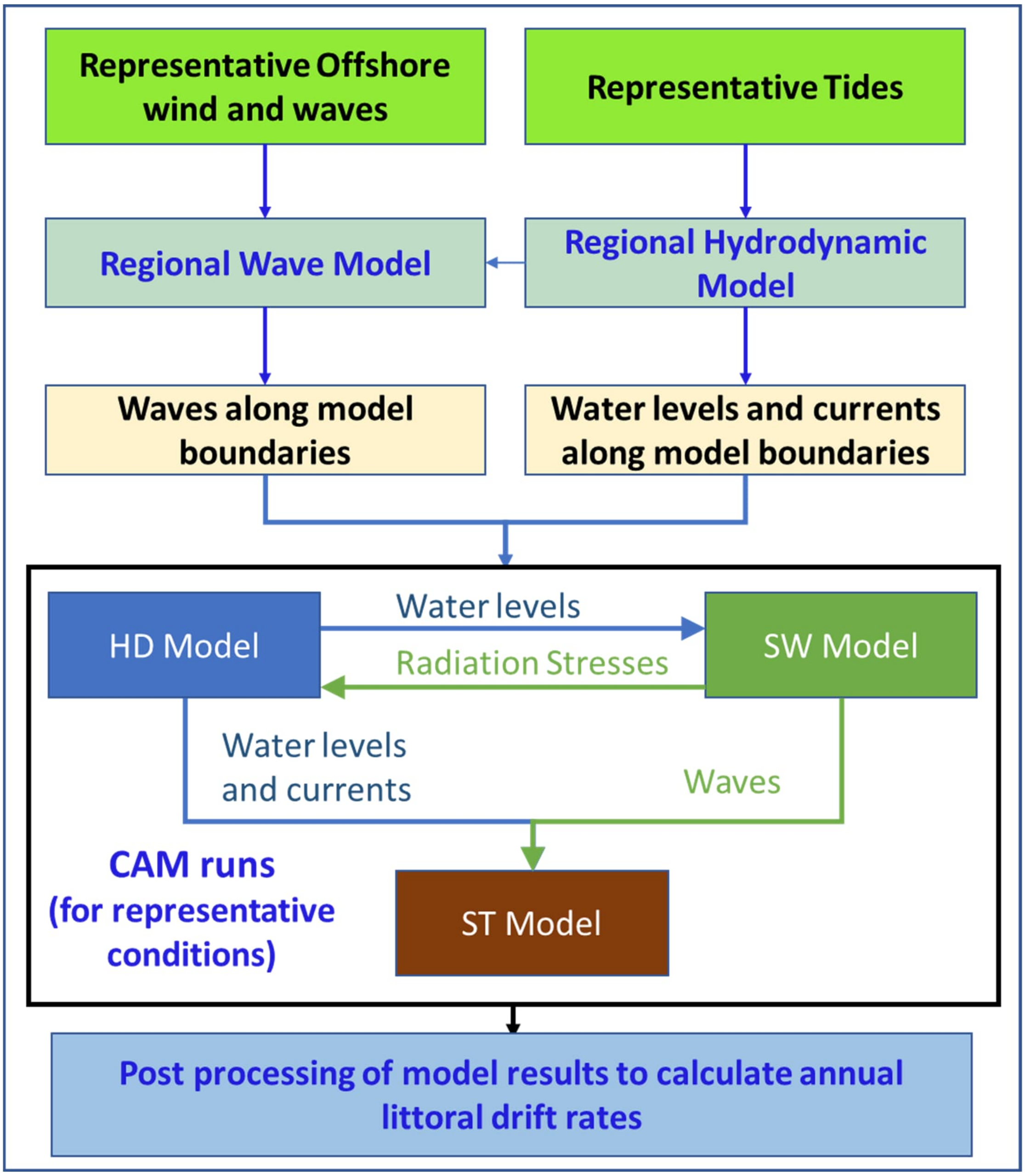

Figure 2-1. Overview of Coastal Area Modelling (CAM) methodology

The extents of the various models used in this process are presented in Figure 2-2. The process used to develop the boundary conditions for the CAM is described in detail in Jacobs (2024a). A brief description is given below.

The first step is to determine the representative tidal range; this was calculated based on the principal tidal levels at Dublin. An appropriate period is selected and simulated in the regional hydrodynamic model. The result feeds into the regional wave model and the local CAM, as boundary conditions.

Next, the representative waves are calculated at ERA5 Point 1 at the offshore boundary of the regional wave model. Representative waves from MWD from 325 deg clockwise to 215 deg, in 10-degree bins, were calculated. This provides Hm0, Tp, MWD and the equivalent frequency of the wave conditions. The equivalent frequency is calculated such that the representative wave event for a given sector gives the same sand transport contribution as the sum (empirical formula) of sand transport contributions for all waves in that sector.

The representative waves are transformed in the regional wave model to the boundary of the local CAM over the representative tidal cycle, using the output from the regional hydrodynamic model to define the water level variations across the domain.

The boundary conditions generated from the regional models are then applied to the CAM. The model is run for all representative wave cases and the case with tides only. The model results and equivalent frequencies are used to calculate the average annual sediment transport across transects along the section of coastline at Killiney Beach. Note that as the CAM does not include morphological feedback so the results can be considered an initial response.

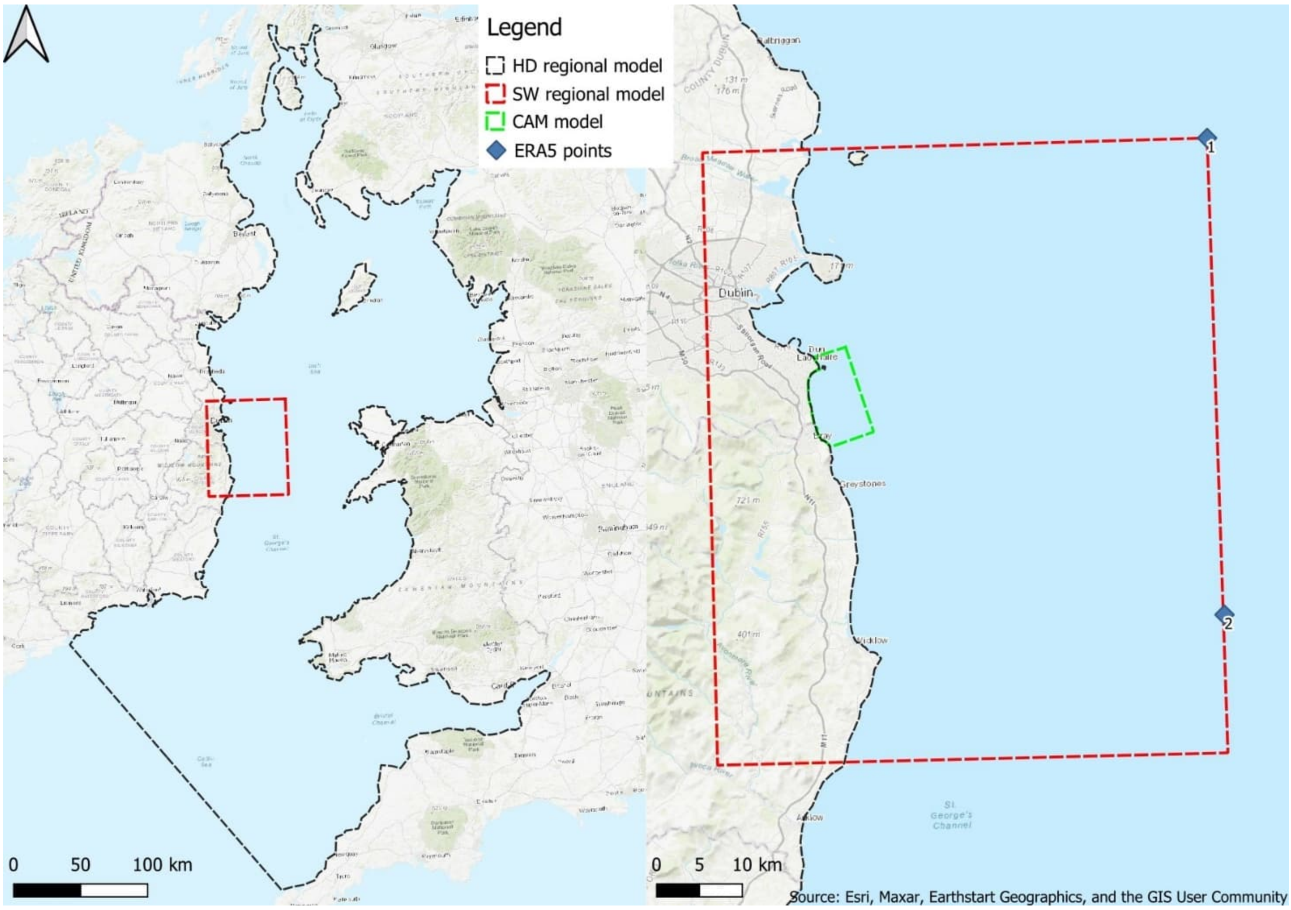

Figure 2-2. Outlines of regional hydrodynamic model, regional wave model and local CAM. The location of the offshore waves data and the area of interest covered in this report are also indicated.

2.2 Input Data

2.2.1 Boundary Conditions

The development of the boundary conditions for the CAM are presented in Jacobs (2024a). Representative waves are calculated at ERA5 point 1 on the boundary of the regional wave model and transformed over a representative tidal cycle to the boundary of the CAM. Table 2-1 shows the wave conditions at ERA5 Pt 1 and at nearshore point 8 (Figure 2-3). The values are averaged over the simulation period to account for variations in water level. Table 2-1 shows the extent to which the mean wave direction (MWD) changes from offshore (ERA5 point1) to the area offshore of CCA2-3 (point 8). For example, offshore waves from 5 degN (North) under the associated winds arrive at nearshore Pt 8 with a mean wave direction of 74 degN (ENE). The equivalent frequency of the tide only case is 26.42%.

Table 2-1. Representative wave conditions at ERA5 Point 1 and at nearshore Point 8

ERA5 Pt 1 MWD (deg)	ERA5 Pt 1 Hm0 (m)	ERA5 Pt 1 Tp (s)	Equivalent Frequency (%)	CAM Average Hm0 (m) at Pt 8	CAM Average Tp (s) at Pt 8	CAM Average MWD (deg) at Pt 8
325	2.07	5.8	0.51	0.23	2.3	34
335	2.17	6.0	0.53	0.30	3.3	55
345	2.23	6.2	0.64	0.42	4.6	66
355	2.28	6.3	0.65	0.56	5.6	71
5	2.47	6.4	0.47	0.79	6.3	74
15	2.53	6.5	0.35	1.01	6.8	77
25	2.49	6.5	0.30	1.19	6.9	79
35	2.28	6.3	0.37	1.27	6.9	81
45	2.26	6.1	0.43	1.43	6.8	83
55	2.39	6.1	0.43	1.65	6.9	86
65	2.62	6.5	0.50	1.89	7.1	88
75	2.79	6.7	0.53	2.09	7.2	91
85	2.79	6.9	0.53	2.16	7.2	94
95	2.35	6.8	0.36	2.02	7.2	97
105	2.33	6.6	0.29	1.95	7.0	100
115	2.28	6.5	0.26	1.86	7.0	103
125	2.16	6.3	0.30	1.71	6.9	106
135	2.38	6.6	0.31	1.74	7.0	108
145	2.47	6.8	0.37	1.66	7.0	111
155	2.53	6.9	0.49	1.55	7.0	113
165	2.63	7.0	0.73	1.44	6.9	115
175	2.84	7.3	1.16	1.27	6.8	118
185	2.83	7.3	2.47	1.02	6.5	121
195	2.84	7.5	3.28	0.78	6.2	122
205	2.50	7.5	2.65	0.54	5.2	125
215	2.26	7.2	1.83	0.38	3.9	133

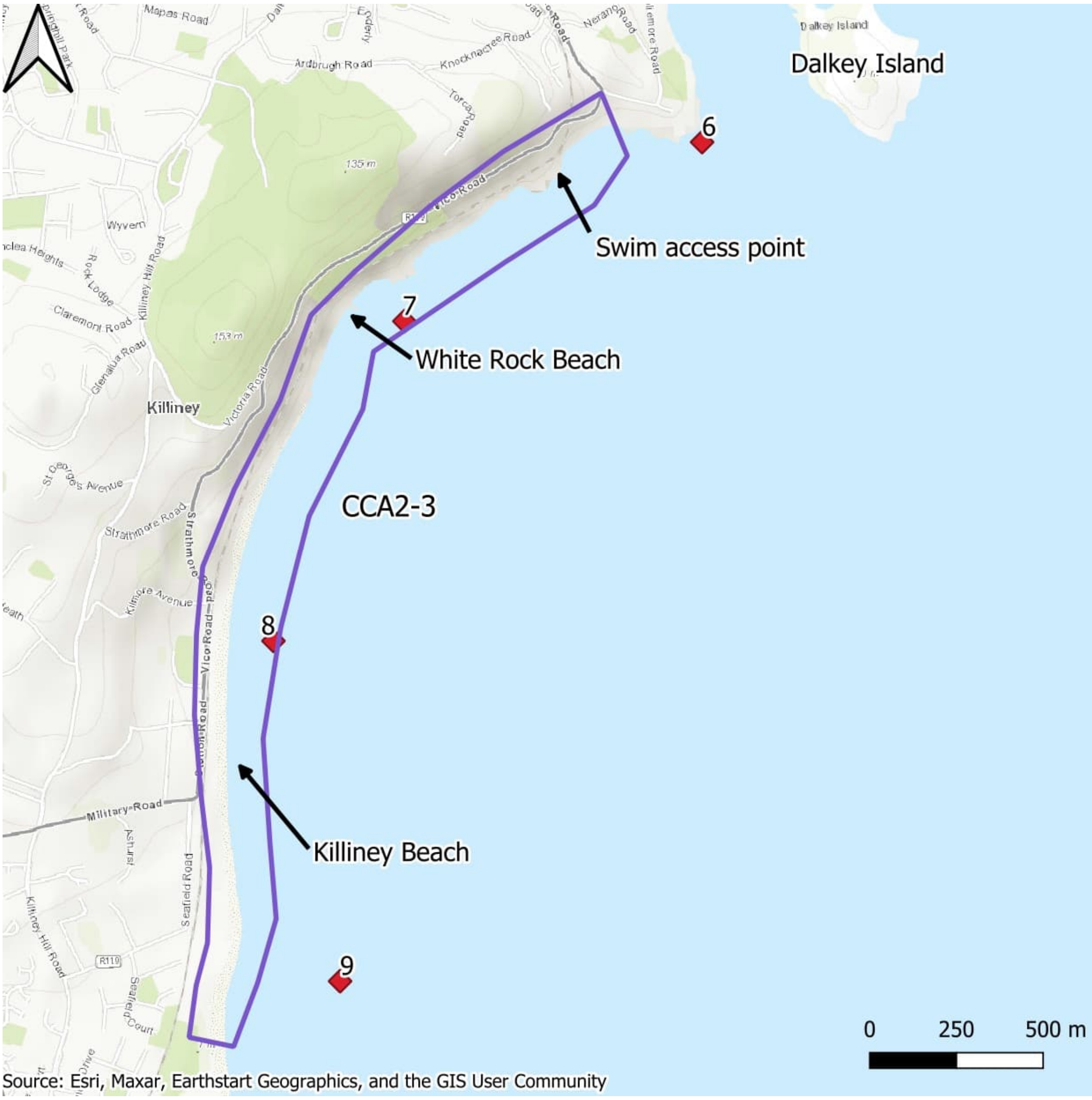

Figure 2-3. Nearshore points from Phase 1 work. Wave conditions in Table 2-1 and Table 2-2 are extracted at point 8.

The calculation of the representative waves was repeated with a climate change allowance for increased storminess applied. The guidance is to increase extreme wave heights and wind speeds by 10%. As the representative waves are calculated from all waves, the 10% increase was applied to the time series for wave heights and windspeeds that were greater than the mean +1 standard deviation only, before the calculation of the representative waves was repeated. Table 2-2 is a repeat of Table 2-1 for the climate change runs. The equivalent frequency of the tide only case under climate change is 26.7%.

Table 2-2. Representative wave conditions at ERA5 Point 1 and at nearshore Point 8 for climate change runs

ERA5 Pt 1 MWD (deg)	ERA5 Pt 1 Hm0 (m)	ERA5 Pt 1 Tp (s)	Equivalent Frequency (%)	CAM Average Hm0 (m) at Pt 8	CAM Average Tp (s) at Pt 8	CAM Average MWD (deg) at Pt 8
325	2.32	6.3	0.44	0.25	2.3	31
335	2.45	6.5	0.47	0.33	3.4	54
345	2.36	6.2	0.57	0.45	4.6	65
355	2.39	6.3	0.56	0.59	5.6	70
5	2.83	6.6	0.36	0.92	6.7	75
15	2.83	6.6	0.33	1.14	7.0	77
25	2.91	6.7	0.26	1.40	7.3	80
35	2.42	6.3	0.31	1.36	7.0	81
45	2.44	6.2	0.37	1.47	7.0	82
55	2.59	6.2	0.38	1.67	7.1	84
65	2.69	6.3	0.40	1.86	7.1	87
75	3.28	6.9	0.42	2.30	7.5	90
85	2.99	6.8	0.44	2.22	7.3	93
95	2.44	6.7	0.28	2.15	7.3	97
105	2.64	6.7	0.20	2.20	7.3	100
115	2.06	6.2	0.26	1.74	6.9	104
125	2.18	6.2	0.29	1.76	7.0	106
135	2.37	6.4	0.28	1.79	7.0	108
145	2.54	6.7	0.33	1.79	7.1	110
155	2.86	7.0	0.38	1.82	7.2	112
165	3.03	7.2	0.63	1.69	7.2	114
175	3.25	7.4	1.07	1.53	7.1	117
185	3.19	7.4	2.42	1.21	6.8	120
195	3.26	7.7	3.05	0.97	6.8	120
205	2.81	7.6	2.55	0.66	5.7	123
215	2.55	7.3	1.75	0.46	4.3	130

2.2.2 Bathymetry and LIDAR

Bathymetric data sources were utilised in the CAM, including multibeam echosounder survey data obtained from INFOMAR. These datasets cover most of the offshore area and offer a resolution of 2 to 5 metres.

Data from INFOMAR surveys was received relative to LAT (Lowest Astronomical Tide). Within the INFOMAR survey the individual surveys were given priority based on age with overlapping areas removed from the older dataset. A complete list of the surveys from INFOMAR used here are displayed in Table 2-3. The extent of the individual INFORMAR surveys is shown in Figure 2-4.

In addition, LiDAR data from the Geological Survey Ireland collected between 2015 and 2020 with 2m resolution was used (Figure 2-4). The LIDAR data is relative to OD Malin (OSGM15). Any visible sea surface in the LiDAR data was removed before the data was added to the model.

Table 2-3. list of survey data received from INFOMAR within the CCA6 model area

Survey name	Survey resolution	Year
ton16012mw	2m	2016
geo16012	2m	2016
ky1001dn5mw	5m	2010
ky0902dn5mw	5m	2009
cv03015mw	5m	2003

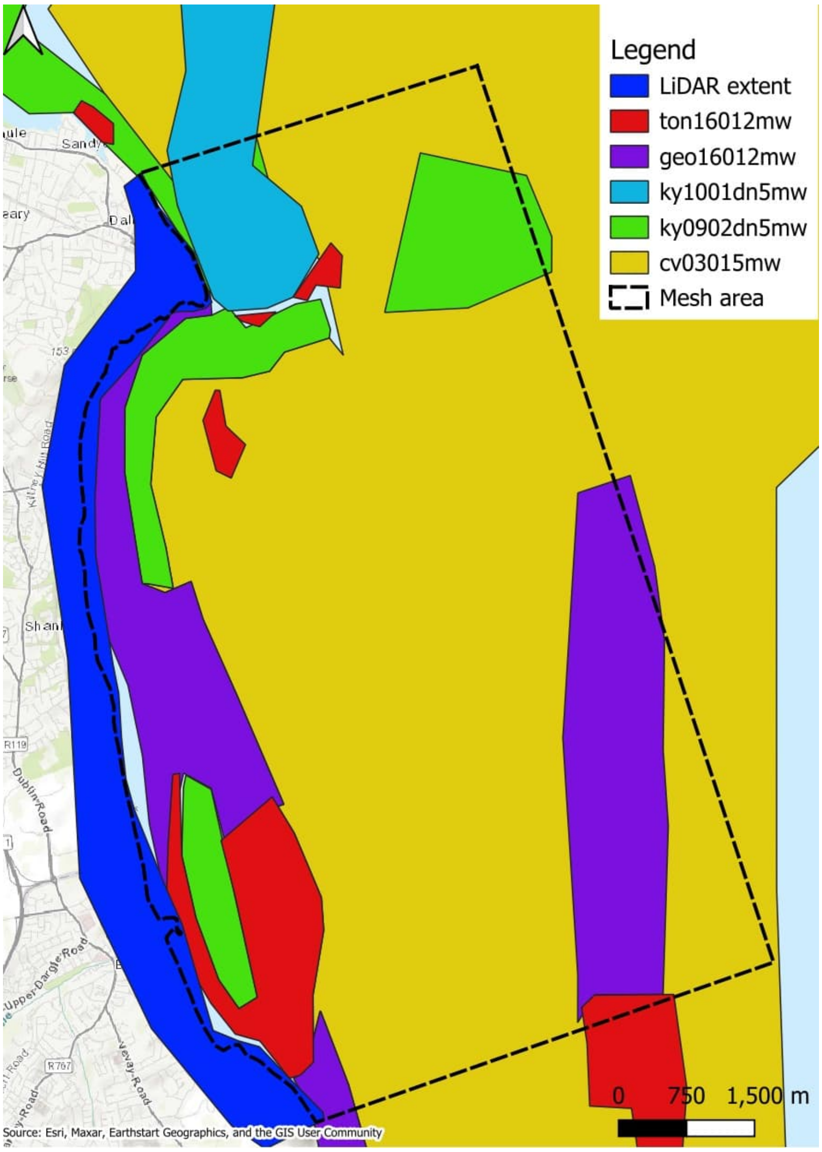

Figure 2-4. Extent of INFORMAR surveys and LIDAR used in the CCA2-3 CAM modelling.

The bathymetry data was converted from LAT to OSGM using a two step process. First, a surface interpolated from the Admiralty Total Tide levels in the Irish Sea for both LAT and MSL was used to convert the bathymetry to be relative to MSL. The data was then further converted from MSL to OD Malin (OSGM) using the relationship between MSL and OD Malin in the 2018 Irish Coastal Wave and Water Level Modelling Study (ICWWS). For the area covered by the CAM model the conversion is -0.227 m.

2.2.3 Sediment Data

Sediment data was collected in 2018 by ARUP for the East Coast Erosion Study. Two profiles were sampled in CCA2-3 with five (5) samples taken along each profile. At each profile two samples were from the emerged beach and three samples on the submerged beach. The average D_{50} for the emerged grain size is 15mm. A grainsize greater than 2mm is out of range of the CAM model capabilities. As such, the CAM model will use a grainsize of 2mm and the transport rates scaled using a relationship derived using LITDRIFT model results. Appendix A provides a detailed explanation of how the relationship is derived.

2.2.4 Bed Conditions

From observation of satellite imagery from Google Earth areas of the seabed are darker compared to the lighter beach material, this indicates rocky terrain with little or no sediment cover. These rocky seabed zones were modelled differently from sediment-covered areas to better reflect their physical characteristics. Specifically, they were assigned a lower Manning's M roughness value, this corresponds to a higher surface roughness. This adjustment accounts for the increased resistance to water flow typically associated with uneven, rocky surfaces. Additionally, a sediment thickness of zero metres was applied to these areas, reflecting the absence of mobile sediment material. Figure 2 - 5 shows the bed roughness and thickness used in modelling.

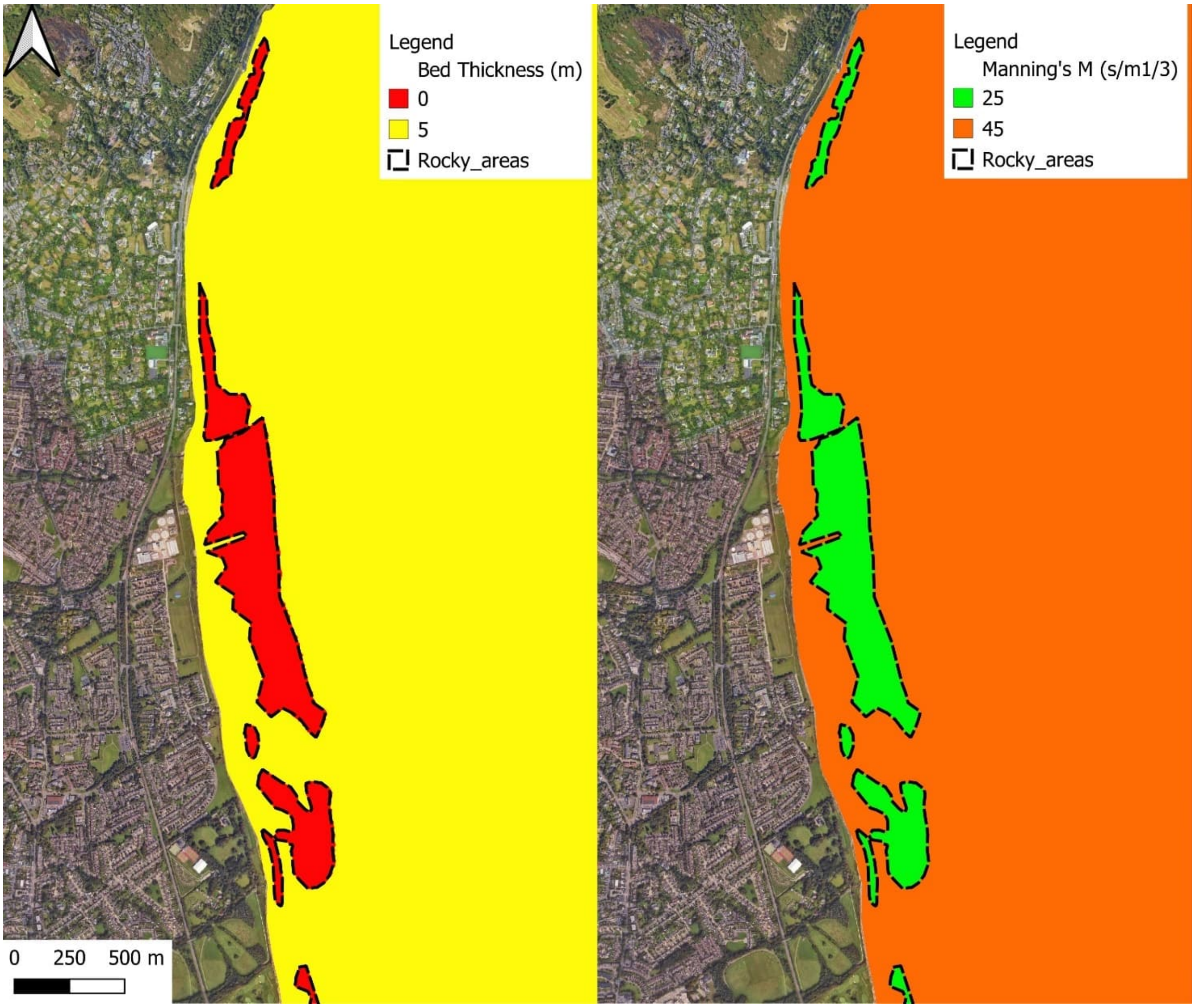

Figure 2 - 5. Bed thickness map (sediment transport model) and roughness map (flow model) for CCA2-3

2.3 Model setup

The model area for the CAM is shown in Figure 2-2. The model mesh is shown in Figure 2-6 and the resolution in the various zones are documented in Table 2-4.

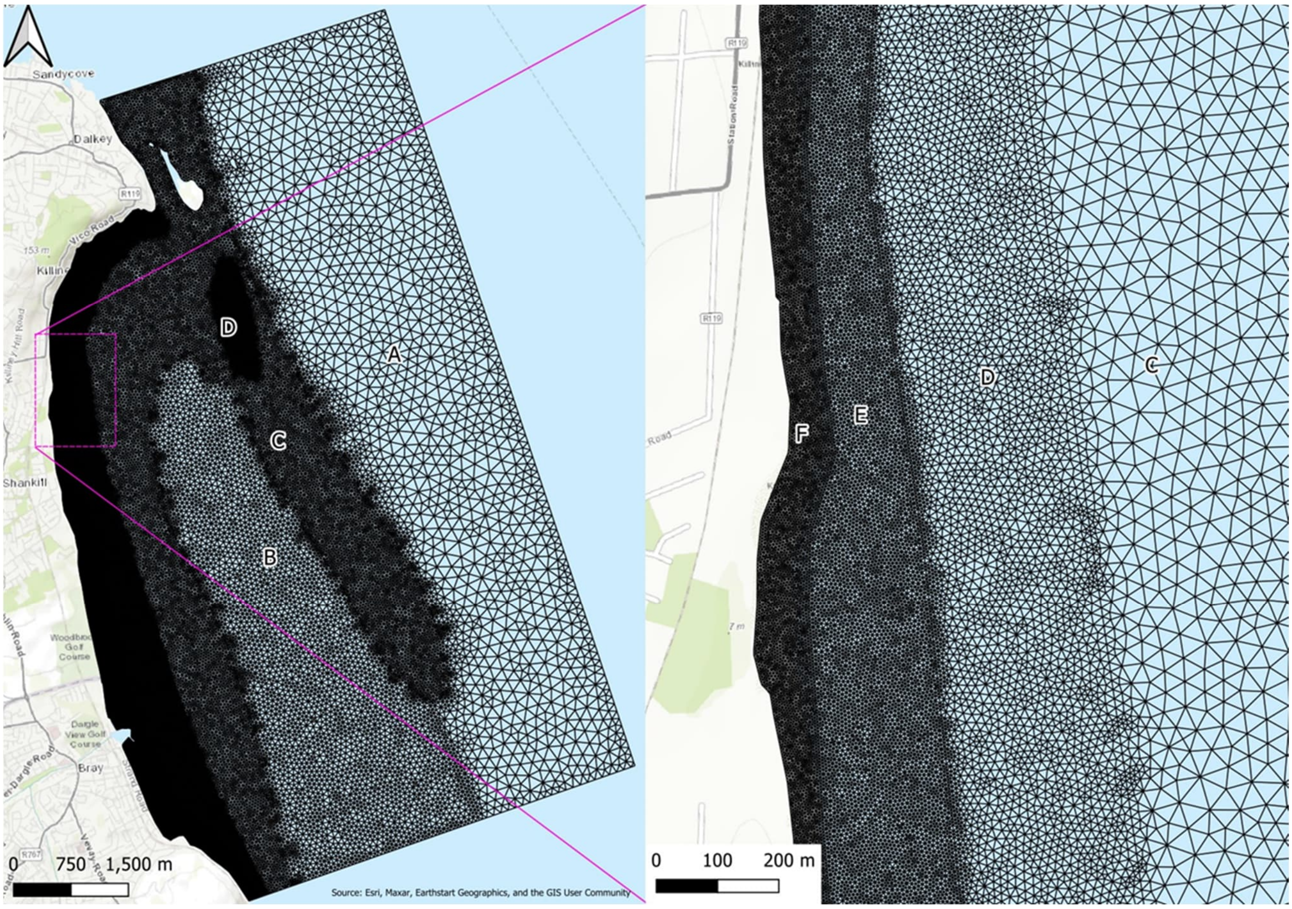

Figure 2-6. CAM Mesh – Letters denote zones of varying mesh resolution documented in Table 2-4

Table 2-4. Varying resolutions used in the CAM mesh

Zone	Max Area	Centre to centre (m)
A	16000	140-150
B	3000	40-50
C	1000	25-30
D	150	10-15
E	30	4-5
F	15	2-3

The final mesh with the updated bathymetry interpolated onto it is shown in Figure 2-6.

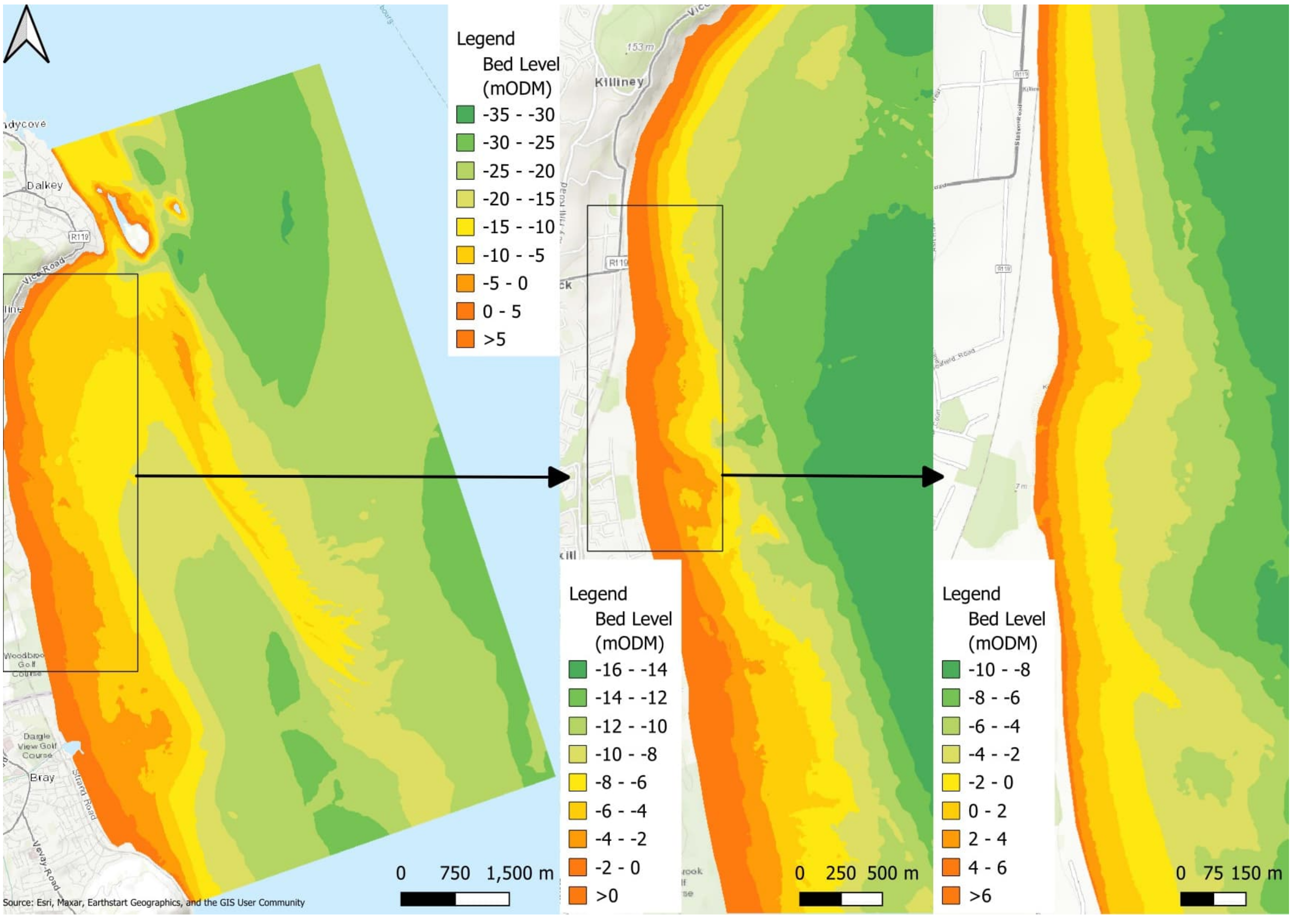

Figure 2-7. CAM mesh with bathymetry

The internal time step of the model is 900 seconds, this is how often model results are passed between the three models. The model setup parameters for the HD model, SW model and ST model are summarised in Table 2-5, Table 2-6 and Table 2-7 respectively.

Table 2-5: Settings for HD model used in the CAM

Parameter	Value and remarks
Bathymetry and Mesh	LIDAR and Bathymetric survey used as outlined in Section 2.2.2. Bed levels are relative to OSGM. Resolution in the surf zone is 2-3m (distance between element centres).
Boundaries	Water levels and currents from the regional hydrodynamic model (see Annex I for details)
Radiation stresses	From SW Model
Bed resistance (Manning's M)	Variable. 25 in rocky areas and 45 across remainder of model as outlined in section 2.2.4
Eddy Viscosity (Smagorinsky)	0.1
Structures	None

Table 2-6: Settings for SW model used in the CAM

Parameter	Value and remarks
Bathymetry and Mesh	LIDAR and Bathymetric survey used as outlined in Section 2.2.2. Bed levels are relative to OSGM. Resolution in the surf zone is 2-3m (distance between element centres).
Wave forcing	Nineteen (27) representative waves (see Annex I for details). Variation along the boundary calculated based on regression analysis (see Annex I for details)
Wind forcing	Wind data at ERA5 point 1 based on correlation with waves (see Annex I for details)
Water level	From the HD model
Currents	Effect of currents on waves not included
Model formulation type	Directionally Decoupled Parametric and Quasi-Stationary formulation
Wave breaking	Wave breaking constant gamma = 0.8
Bottom Friction	Kn = 0.01 m
Structures	None

Table 2-7: Settings for ST model used in the CAM

Parameter	Value and remarks
Bathymetry and Mesh	LIDAR and Bathymetric survey used as outlined in Section 2.2.2. Bed levels are relative to OSGM. Resolution in the surf zone is 2-3m (distance between element centres).
Sediment properties	Graded sand (D50= 2mm , Sg = 1.7); 4 sediment fractions
Sediment thickness	Variable. 0m in rocky areas and 5m across remainder of model as outlined in section 2.2.4
Wave forcing	From SW model
Water level	From the HD model
Currents	No currents
Morphological feed back	Off

2.4 Killiney Strand Results

The magnitude and direction of sediment transport is controlled by both wave-driven and tidal currents. Wave agitation also has an important role to play in determining the magnitude of the transport rates. Therefore, before exploring the sediment transport rates, the results of the wave and hydrodynamic models will be considered.

2.4.1 Waves

Wave height vector plots for selected wave conditions are presented in Figure 2-9 through Figure 2-11 for the entire model area and in Figure 2-12 and Figure 2-14 zoomed into Killiney Beach. These plots show that the largest boundary wave at ERA5 point 1 (2.83m from 185deg) does no result in the largest nearshore wave heights. The largest nearshore waves instead come from easterly directions. Waves with a southerly component rotate to have a more easterly component nearshore. The bay near CCA2-3 is naturally sheltered from northerly waves, creating a wave shadow zone along the cliffs west of Dalkey Island.

In the nearshore zone, waves break over shallow bathymetric features, with this effect most clearly observed during easterly wave events at Killiney Beach, where localized increases in wave height indicate active wave breaking due to shoaling. The timing of the plot tidal stages are shown in Figure 2-8.

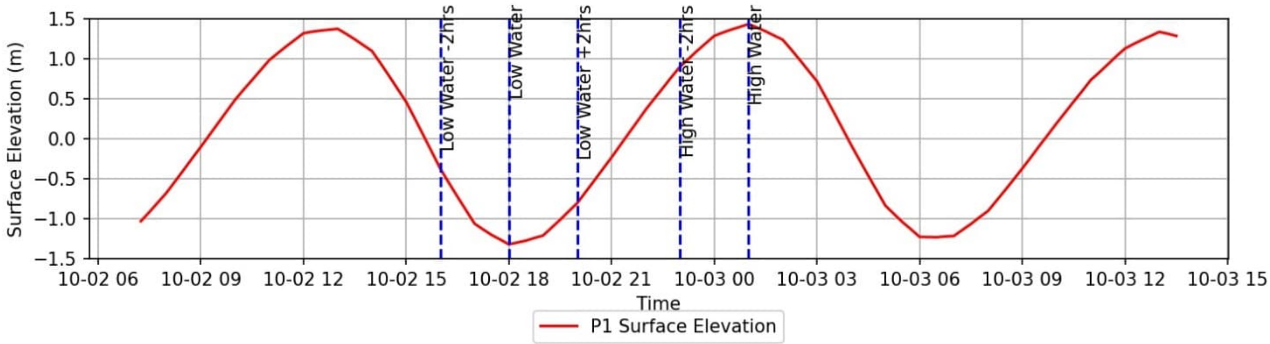

Figure 2-8. Timing of tide stages plotted

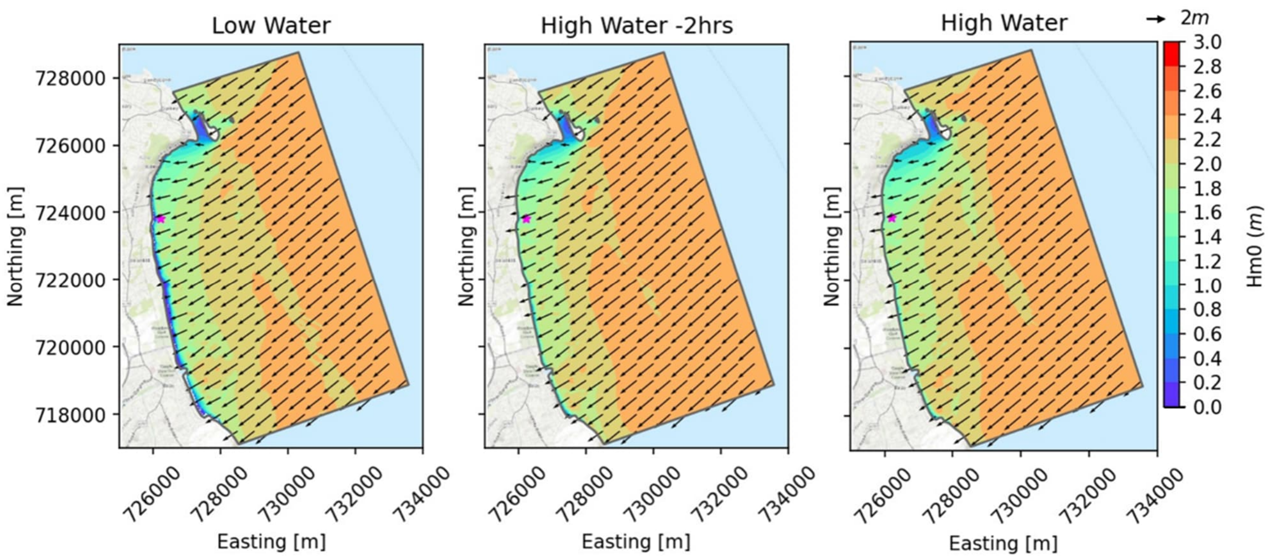

Figure 2-9. Hm0 for waves from 45deg (MWD at ERA5 Pt 1) at different tide stages for whole model (tide stages at pink star).

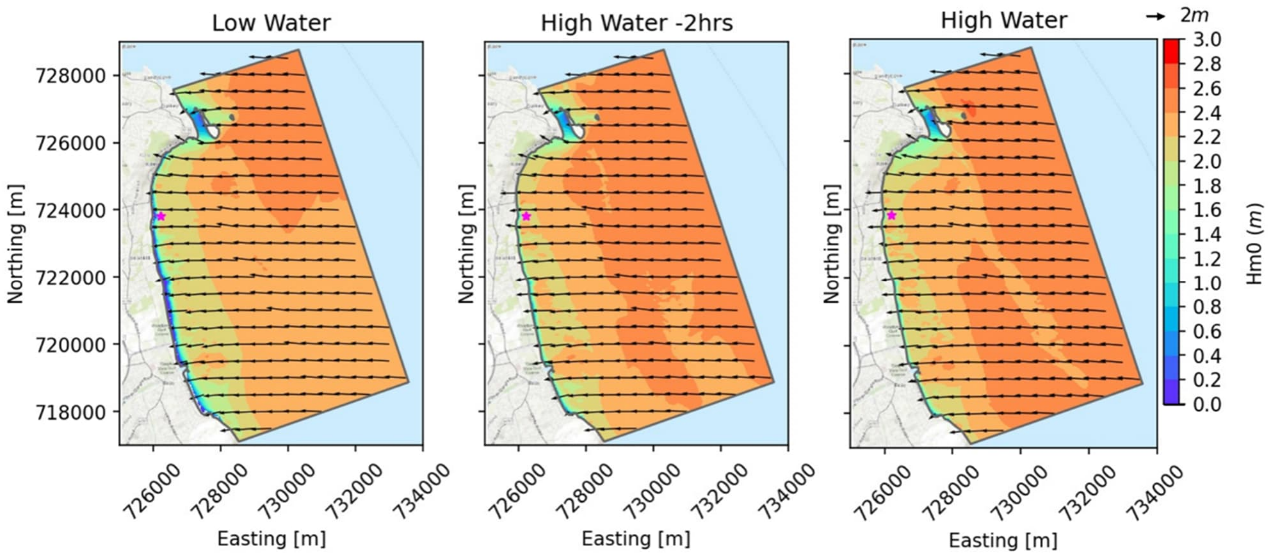

Figure 2-10. Hm0 for waves from 95deg (MWD at ERA5 Pt 1) at different tide stages for whole model (tide stages at pink star).

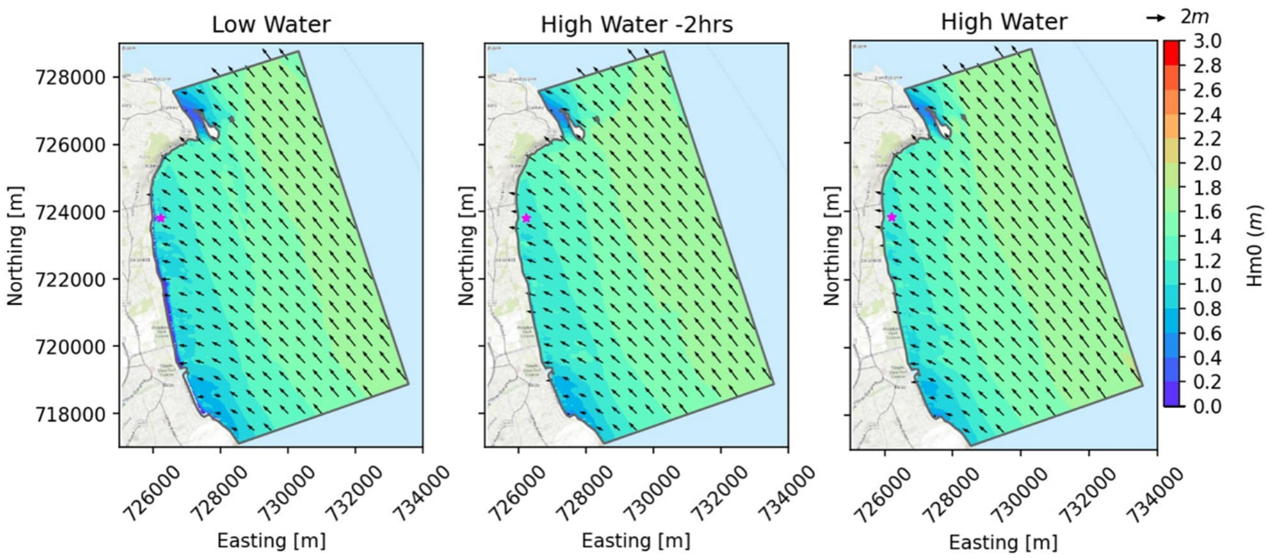

Figure 2-11. Hm0 for waves from 185deg (MWD at ERA5 Pt 1) at different tide stages for whole model (tide stages at pink star).

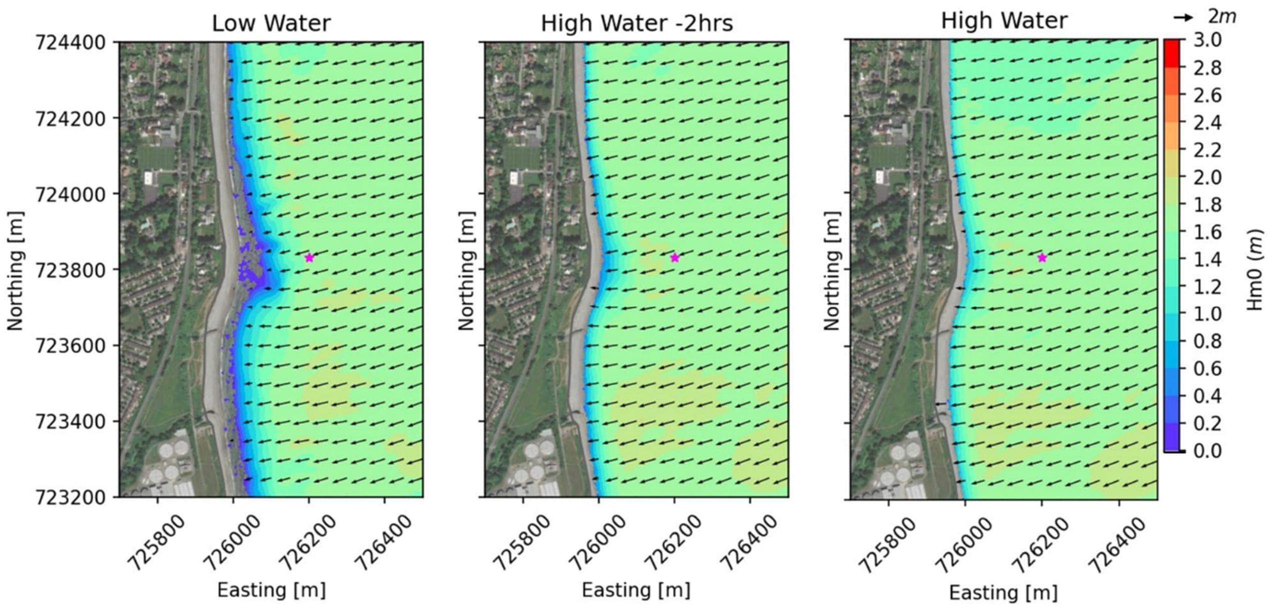

Figure 2-12. Hm0 for waves from 45deg (MWD at ERA5 Pt 1) at different tide stages for Killiney beach (tide stages at pink star).

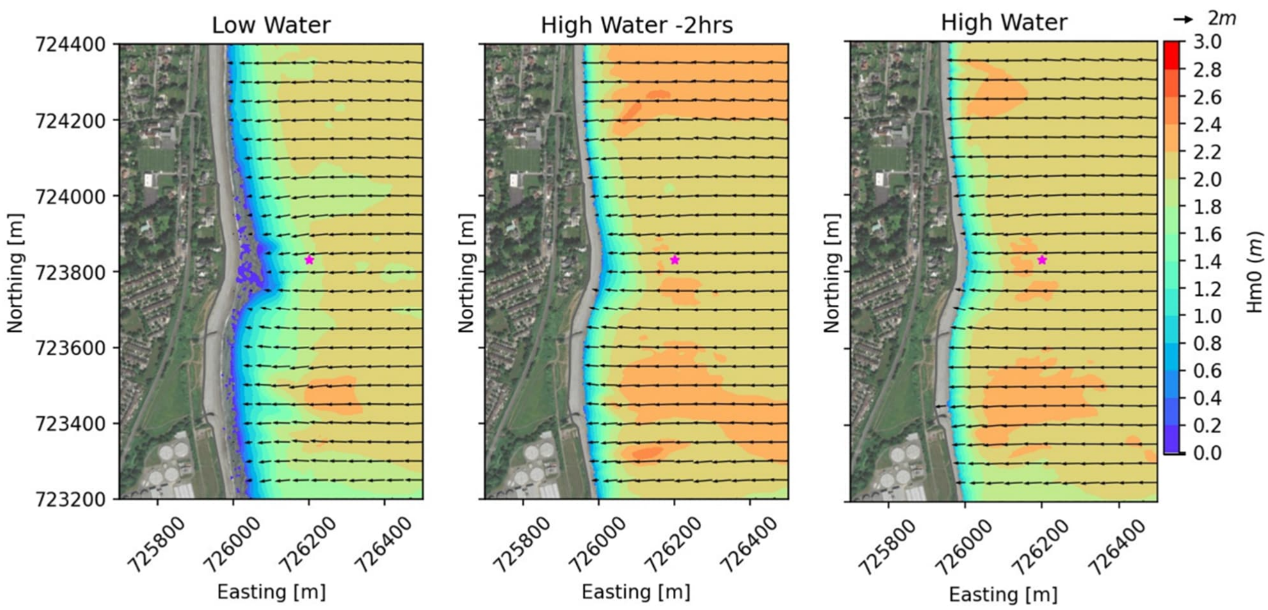

Figure 2-13. Hm0 for waves from 95deg (MWD at ERA5 Pt 1) at different tide stages for Killiney beach (tide stages at pink star).

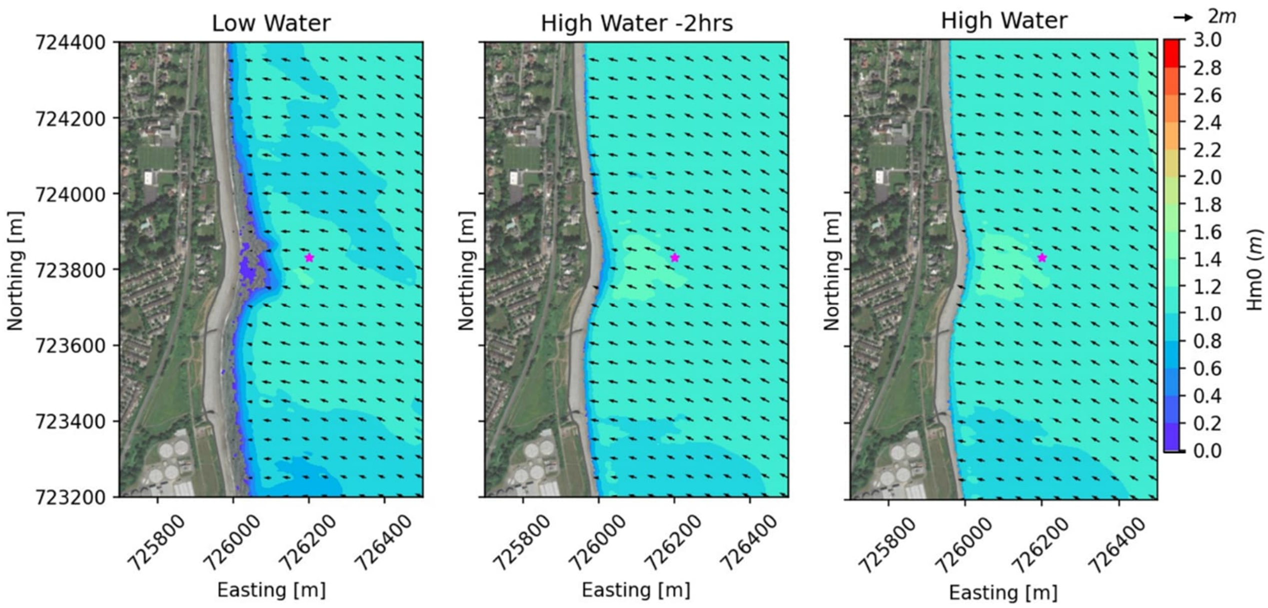

Figure 2-14. Hm0 for waves from 185deg (MWD at ERA5 Pt 1) at different tide stages for Killiney beach (tide stages at pink star).

2.4.2 Currents

Two dimensional plots of current speeds at different tidal stages for the whole model are shown below in Figure 2-15 through Figure 2-19.

The results indicate that nearshore current speeds and directions vary throughout the tidal cycle. Currents generally flow northward during low water and southward during high water. For wave conditions with a southerly component, the northward-flowing currents persist for a longer duration than the southward ones. Notably, a large-scale clockwise circulation is observed around White Rock Beach and along the cliffs in the period leading up to low water (2hrs before low water).

Results for the nearshore currents around the Martello Tower at the south of CCA2-3 are shown in Figure 2-20 to Figure 2-22. The nearshore currents (within 200 m of the coastline) are significantly influenced by wave direction. Results near the Martello Tower indicate that around high tide, a strong current develops parallel to the shoreline. This current flows northward when waves approach from the south, and southward when waves come from the north. As previously demonstrated, there is a shift in current direction in deeper waters between low and high tide. During this transition, the strength of the nearshore currents diminishes from their peak values. The strongest nearshore currents near the Martello Tower occur during northerly wave conditions, with speeds ranging between 0.9 and 1 m/s.

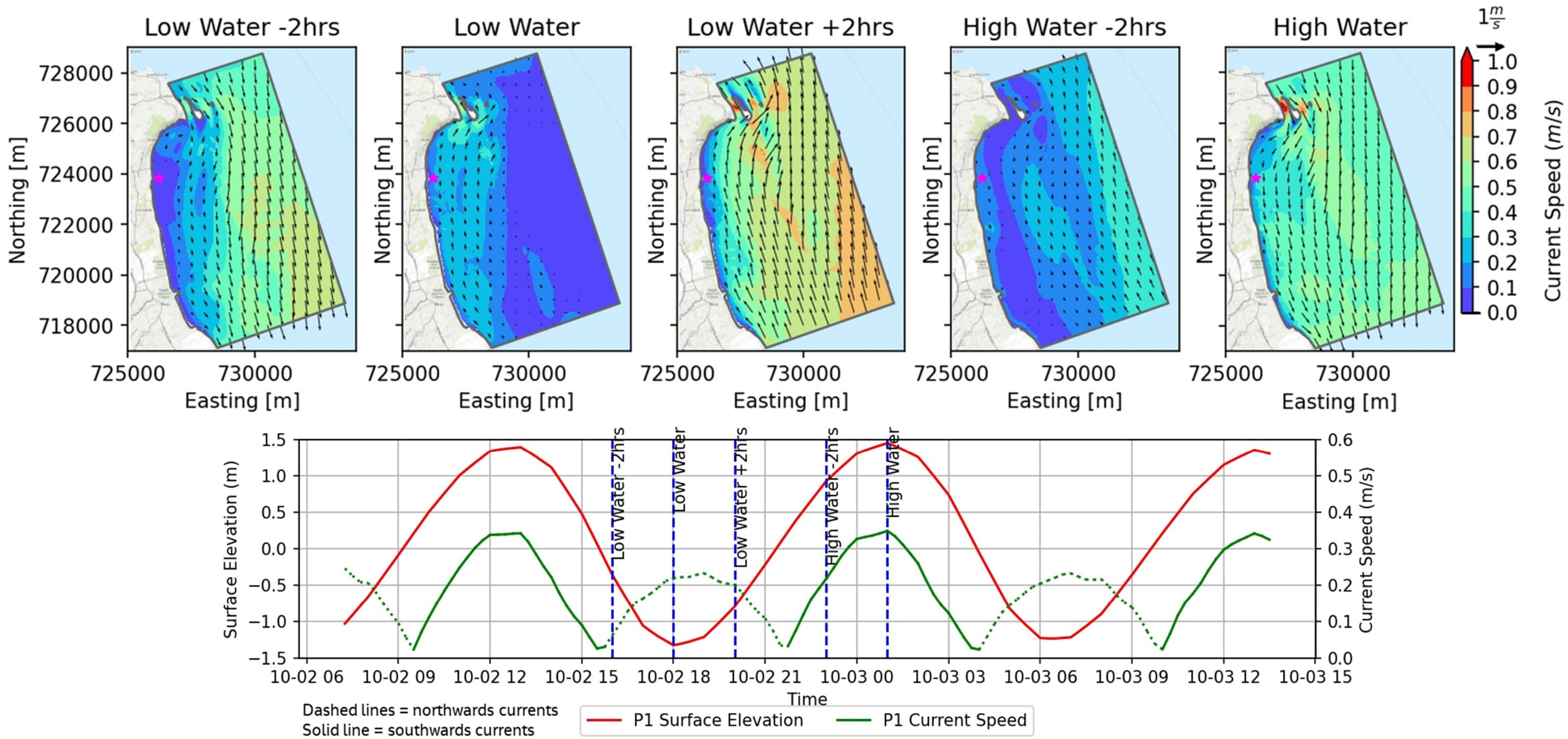

Figure 2-15. Current speed at various tidal stages for tide only conditions, nearshore current and water level extracted at pink star

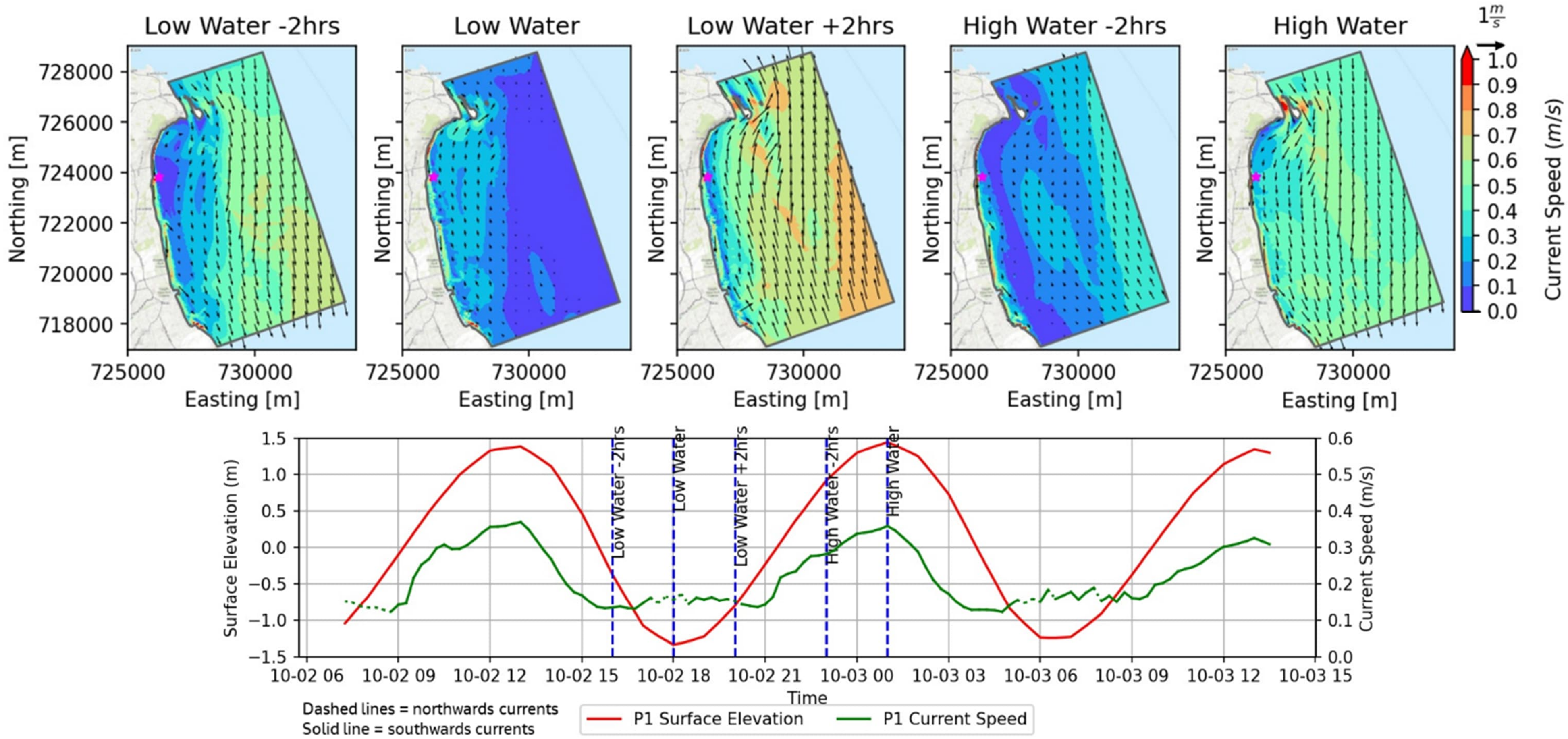

Figure 2-16. Current speed at various tidal stages for waves from 45deg (MWD at ERA5 Pt 1), nearshore current and water level extracted at pink star

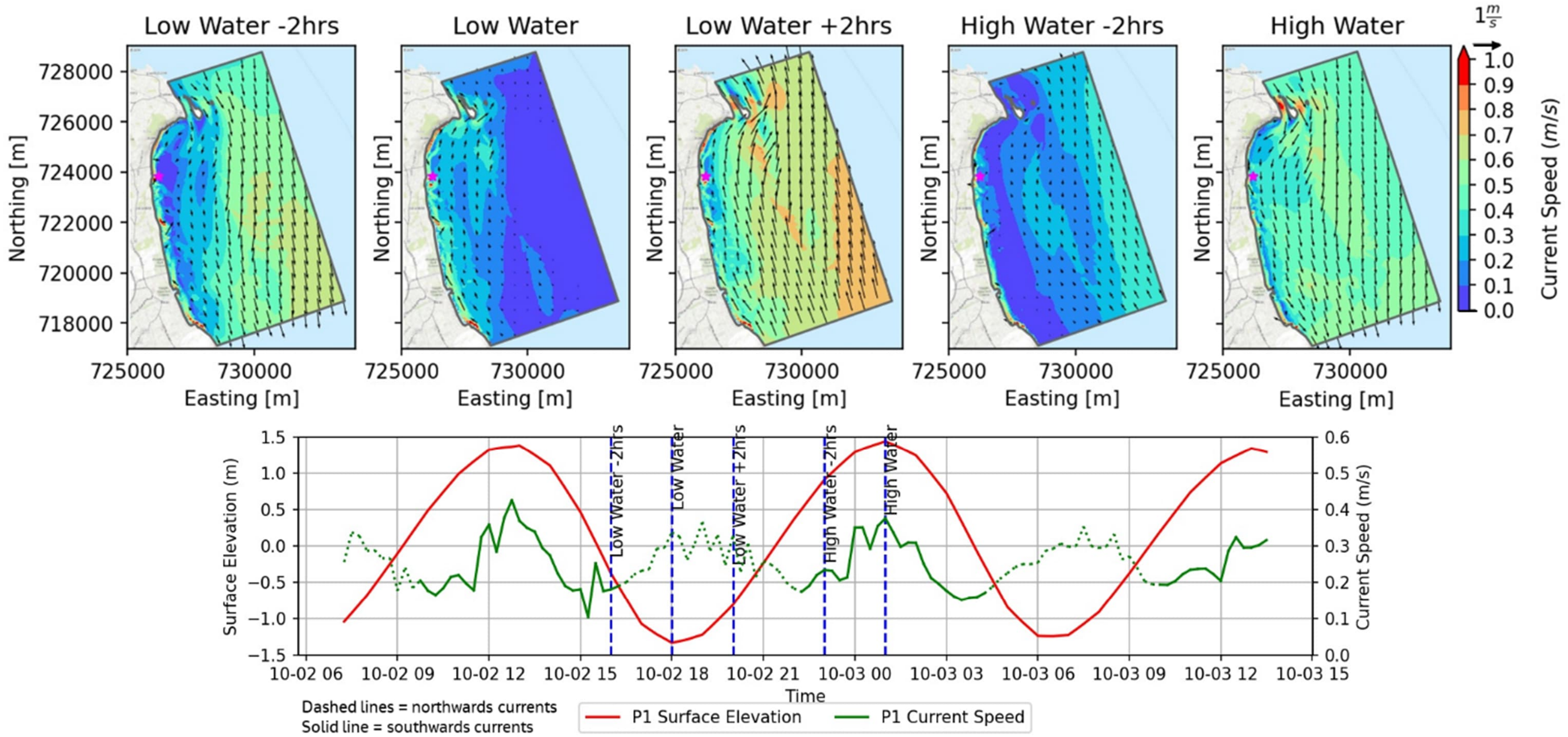

Figure 2-17. Current speed at various tidal stages for waves from 95deg (MWD at ERA5 Pt 1), nearshore current and water level extracted at pink star

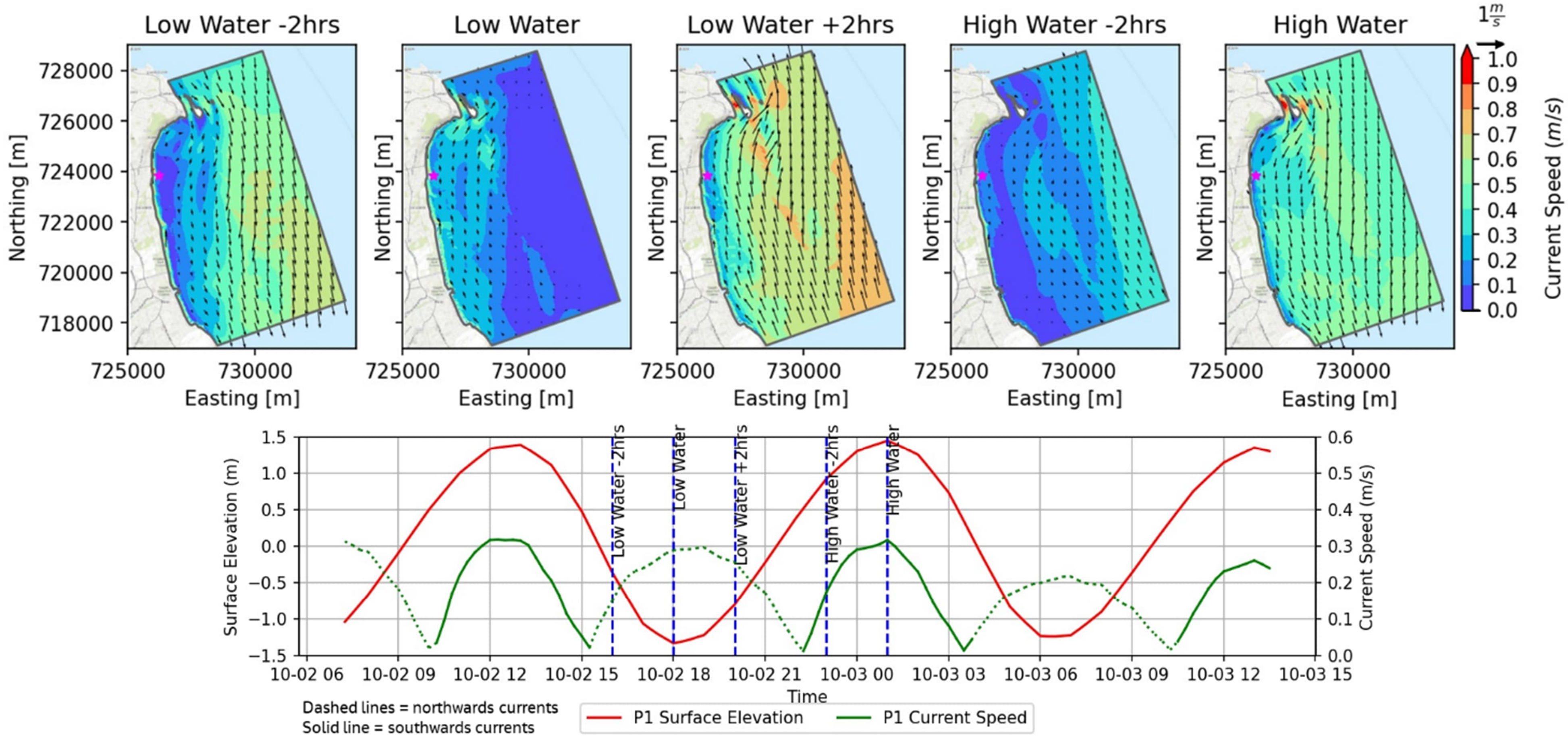

Figure 2-18. Current speed at various tidal stages for waves from 185deg (MWD at ERA5 Pt 1), nearshore current and water level extracted at pink star

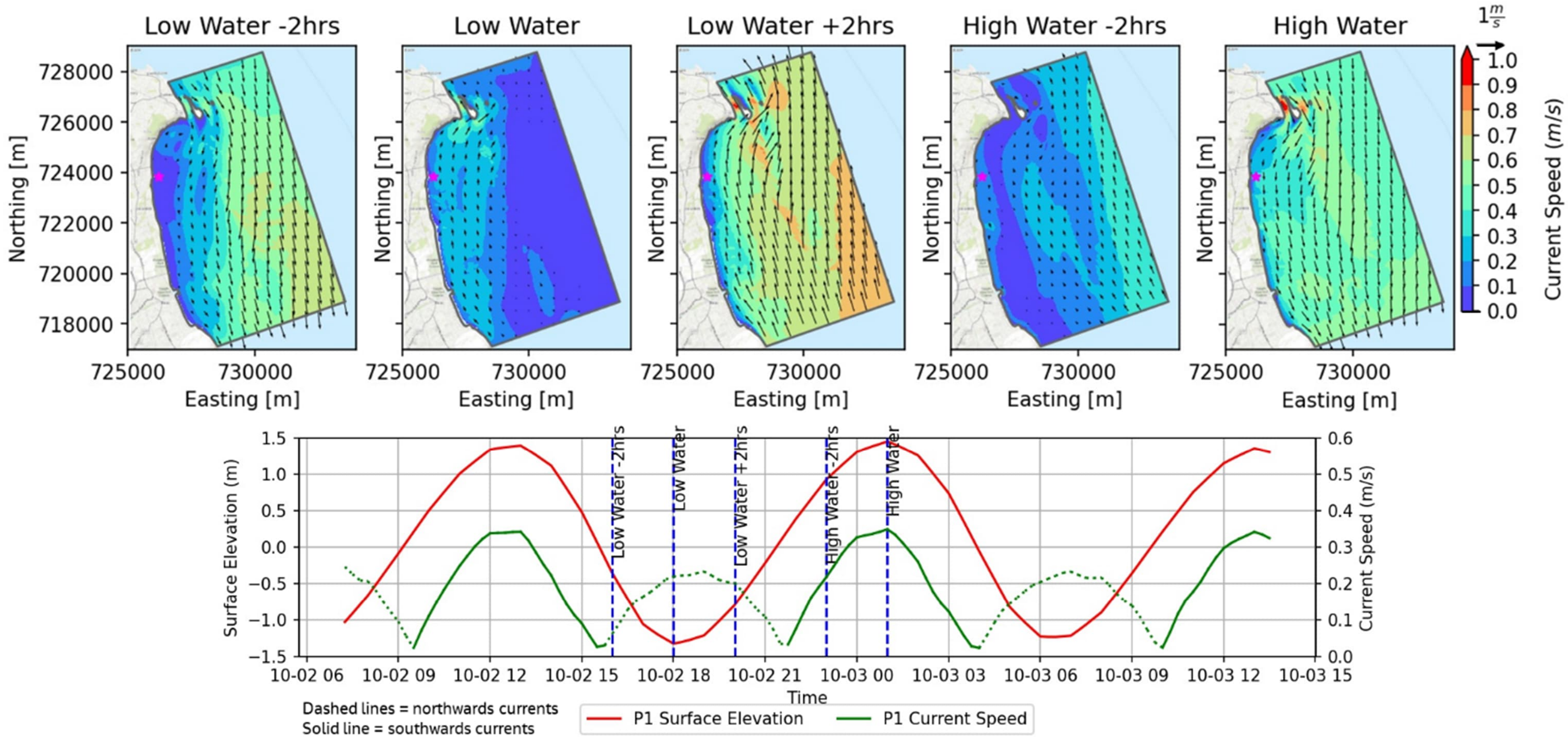

Figure 2-19. Current speed at various tidal stages for tide only conditions, nearshore current and water level extracted at pink star

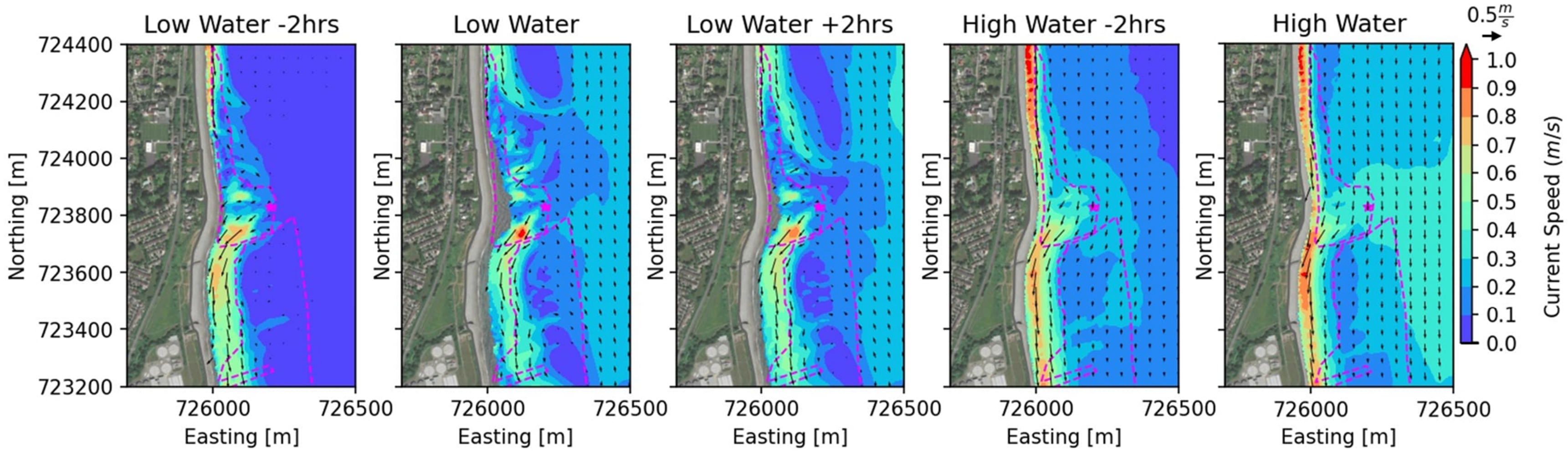

Figure 2-20. Current speed at various tidal stages for waves from 45deg (MWD at ERA5 Pt 1). (tide stages at pink star, rocky areas outlined pink).

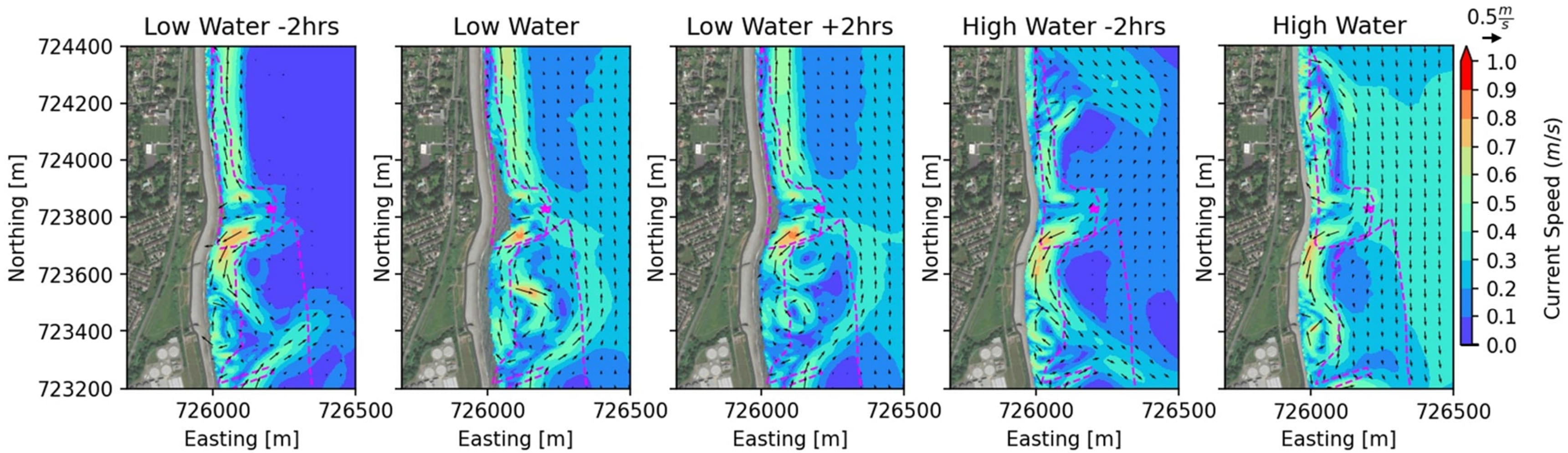

Figure 2-21. Current speed at various tidal stages for waves from 95deg (MWD at ERA5 Pt 1). (tide stages at pink star, rocky areas outlined pink).

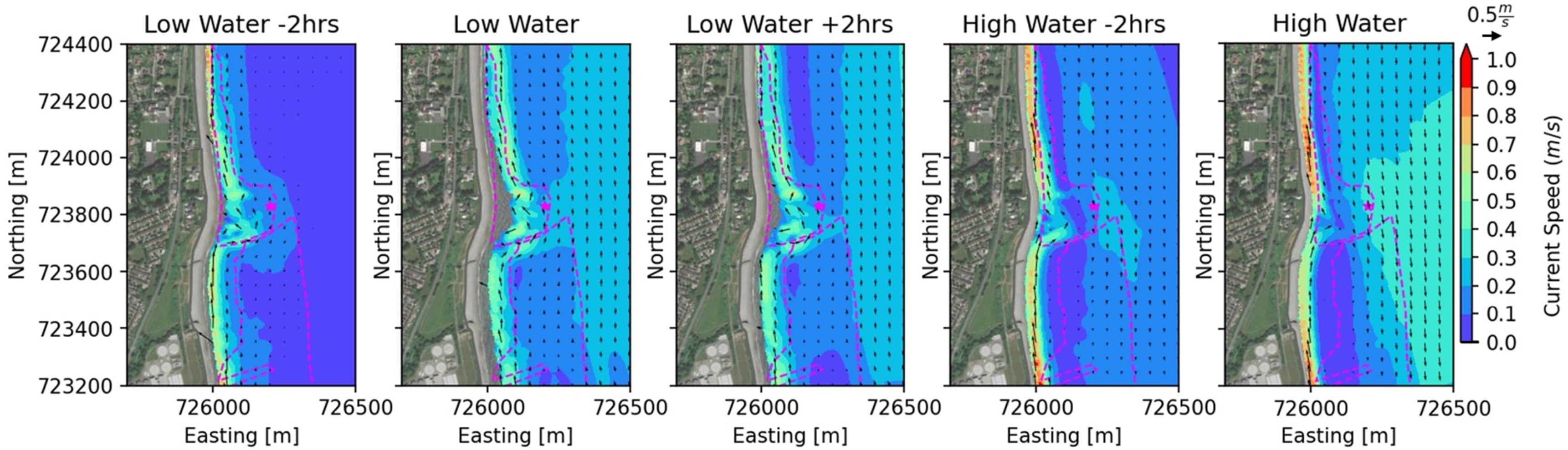

Figure 2-22. Current speed at various tidal stages for waves from 185deg (MWD at ERA5 Pt 1). (tide stages at pink star, rocky areas outlined pink).

2.4.3 Sediment Transport

Figure 2-23 through Figure 2-28 display snapshots of sediment transport, along with associated currents and wave conditions, taken two hours before high tide and at high tide for representative wave directions from the northeast (45°), east (95°), and south (185°) at ERA5 Point 1. These three representative wave conditions were selected because they correspond to the primary directions most likely to influence sediment transport in the nearshore zone. Sediment transport results are presented using 2mm grainsize (D50).

The results show that areas with no sediment thickness—the rocky bed regions—experience little to no sediment transport, even when material is introduced into these areas over time. Across all wave conditions, sediment transport is most pronounced at high tide, coinciding with peak current velocities. The highest transport rates occur within the first 100 meters from the shoreline. Rocky outcrops, particularly around the Martello Tower, act as barriers, reducing current strength and consequently limiting sediment transport.

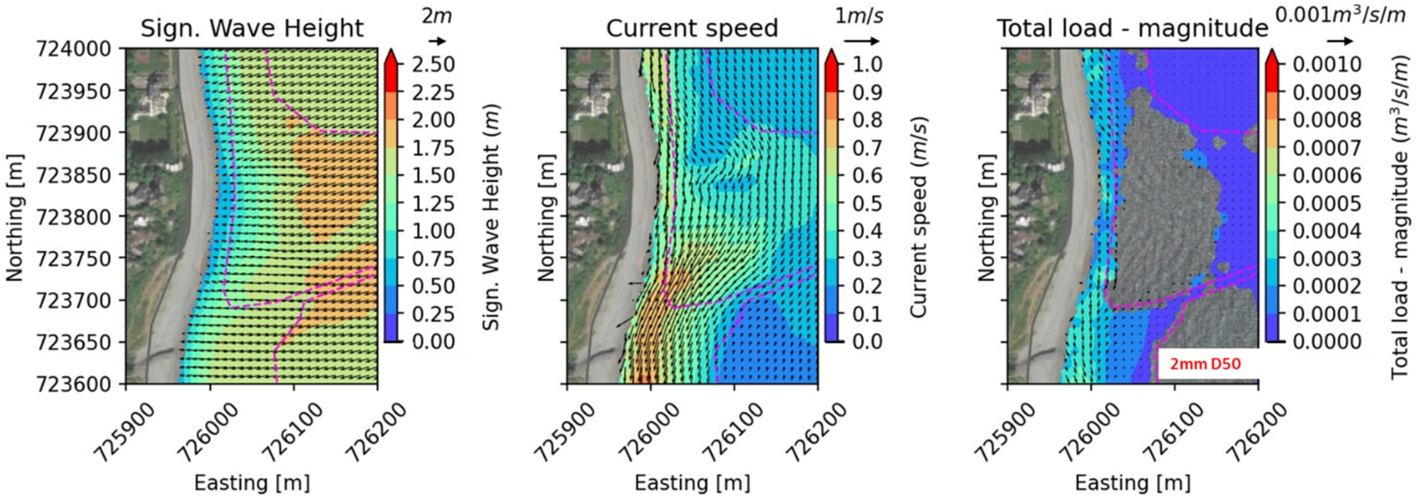

Figure 2-23. Wave height, current speed and total load – magnitude (using 2mm D50) at high water -2hrs for waves from 45deg (MWD at ERA5 Pt 1)

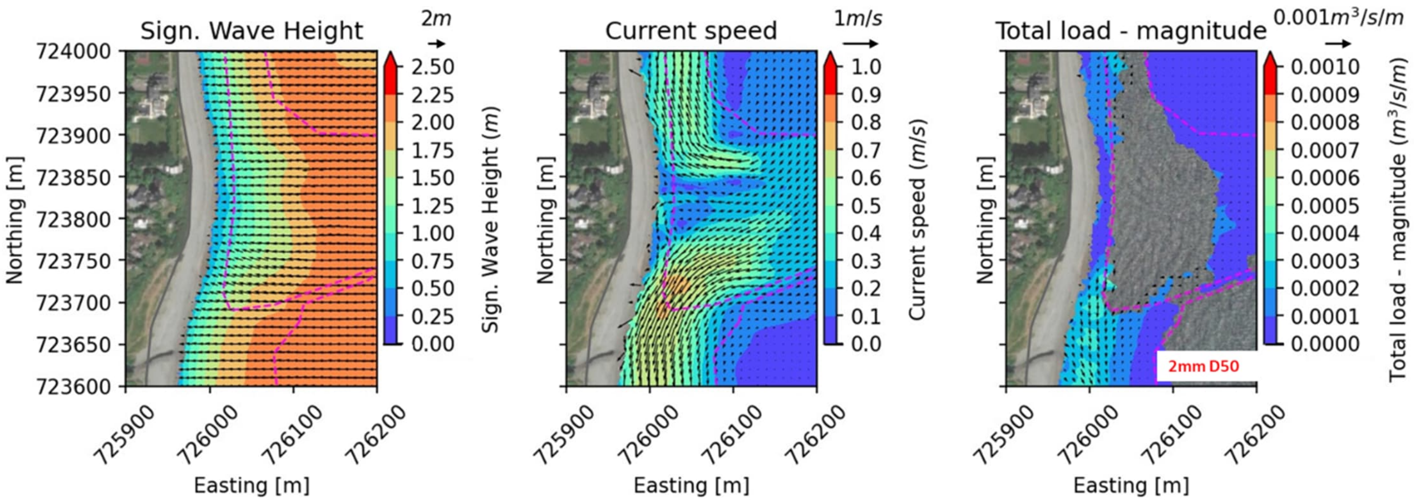

Figure 2-24. Wave height, current speed and total load – magnitude (using 2mm D50) at high water -2hrs for waves from 95deg (MWD at ERA5 Pt 1)

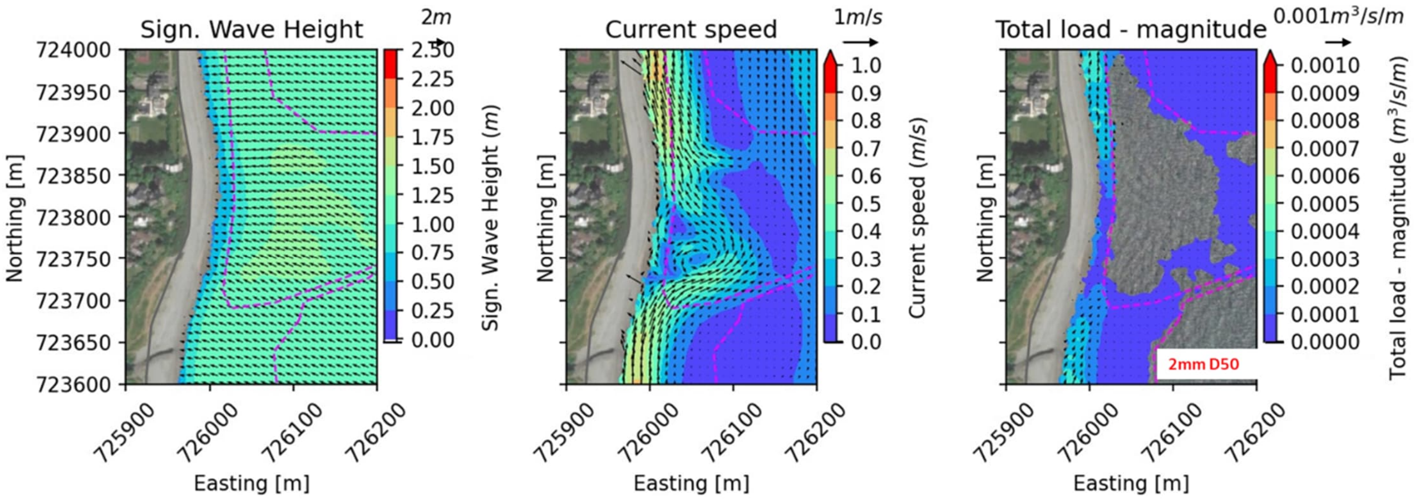

Figure 2-25. Wave height, current speed and total load – magnitude (using 2mm D50) at high water -2hrs for waves from 185deg (MWD at ERA5 Pt 1)

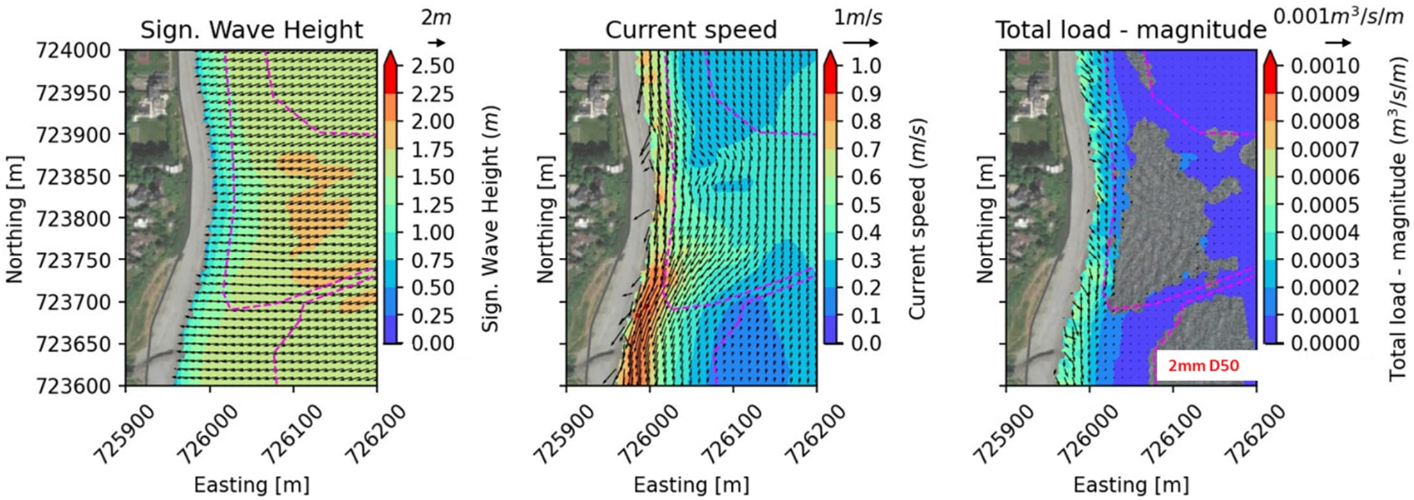

Figure 2-26. Wave height, current speed and total load – magnitude (using 2mm D50) at high water for waves from 45deg (MWD at ERA5 Pt 1)

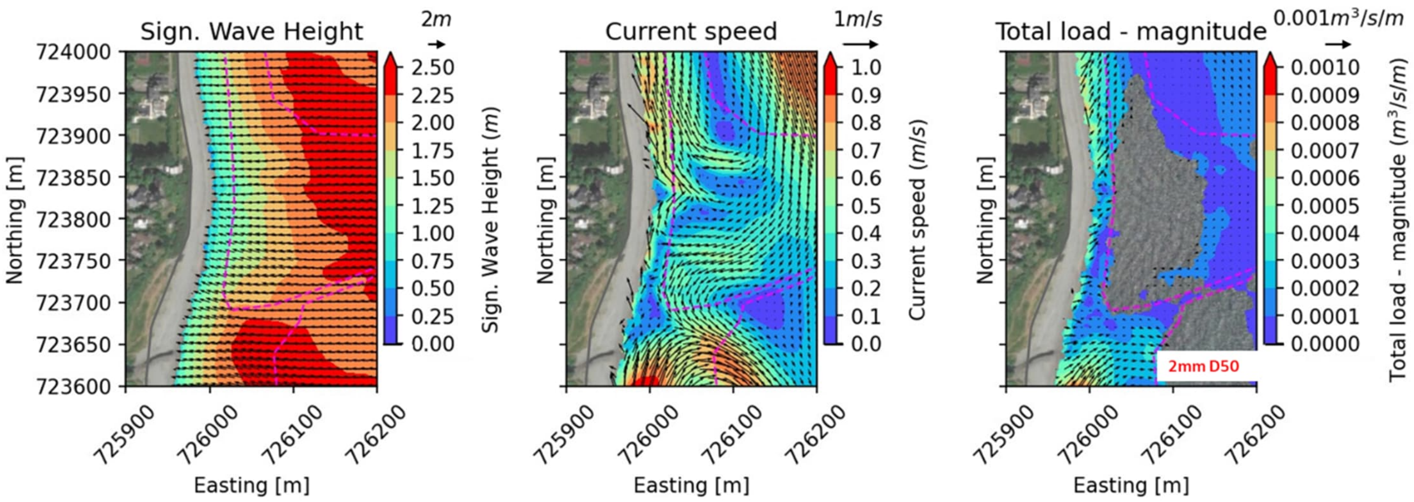

Figure 2-27. Wave height, current speed and total load – magnitude (using 2mm D50) at high water for waves from 95deg (MWD at ERA5 Pt 1)

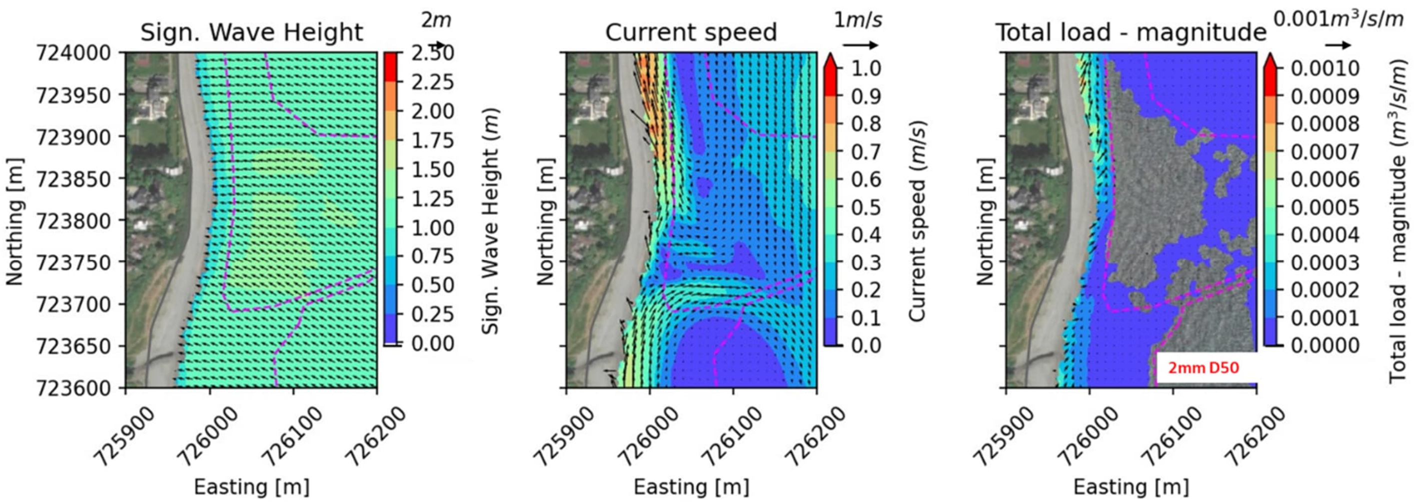

Figure 2-28. Wave height, current speed and total load – magnitude (using 2mm D50) at high water for waves from 185deg (MWD at ERA5 Pt 1)

2.4.4 Annual Transport Rates

2.4.4.1 Representative wave approach

The average annual sediment transport is calculated from the 26 wave cases and the tide only case, using the equivalent frequencies to scale the results from the individual cases. Across the whole of the CCA2-3 frontage the sediment transport is dominated by wave driven currents. The tide only contribution is insignificant (zero), that is not to say that tides have no influence on transport patterns, the rising and falling tides are important, however the tidal currents alone are not strong enough to initiate sediment transport, waves play an important role. The total accumulated transport across the eight profiles around the Martello Tower are shown in Figure 2-29. With the individual contribution from each wave condition noted in Table 2-8.

The results indicate a net northward sediment transport occurring north of the Martello Tower, with an increasing trend in northward movement up to point P4, followed by a subsequent decrease. This pattern suggests a zone of erosion between points P7 and P4, transitioning to accretion north of P4. However, it is important to note that these results do not account for onshore sediment transport.

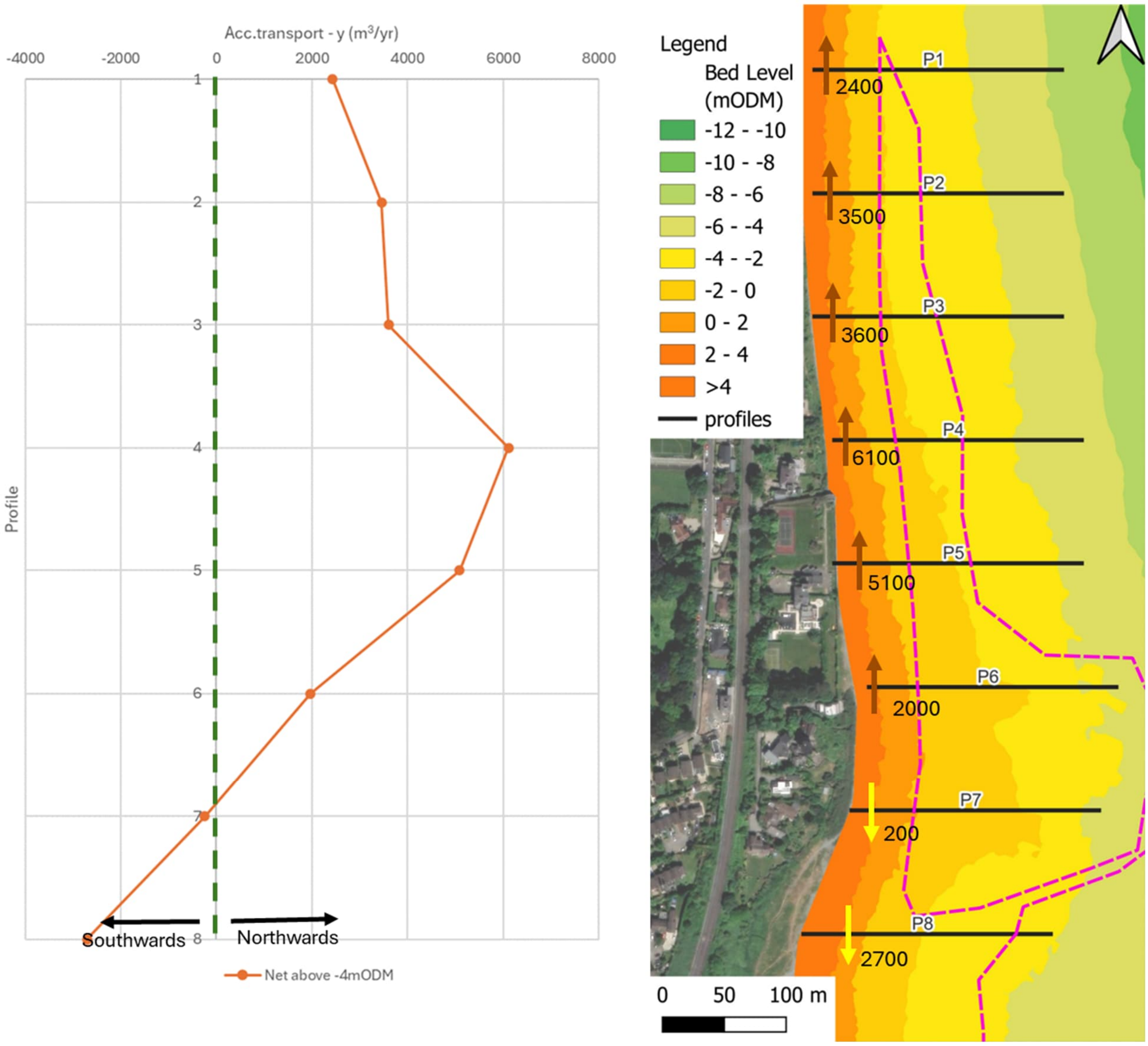

Figure 2-29. Accumulated transport across profiles for all waves above -4mODM

Table 2-8. Accumulated transport (m^3/yr – rounded to nearest 10) above -4mODM across profiles for representative wave conditions at nearshore profiles*

(degN)	P1	P2	P3	P4	P5	P6	P7	P8
325	-80	-80	-80	-70	-90	-70	-50	-100
335	-100	-100	-100	-80	-110	-70	-60	-140
345	-150	-150	-150	-100	-150	-90	-90	-220
355	-200	-200	-200	-140	-200	-110	-130	-290
5	-210	-210	-210	-150	-190	-110	-140	-280
15	-210	-200	-200	-140	-160	-100	-130	-260
25	-210	-210	-200	-130	-150	-90	-130	-250
35	-260	-250	-240	-160	-160	-110	-160	-300
45	-330	-310	-280	-160	-160	-110	-180	-370
55	-350	-320	-270	-140	-120	-80	-190	-400
65	-440	-380	-300	-140	-90	-70	-230	-520
75	-440	-350	-240	-10	50	-20	-220	-580
85	-320	-180	-50	160	190	50	-170	-560
95	40	130	140	230	230	70	-60	-280
105	160	190	190	220	180	50	-40	-180
115	180	190	190	220	170	60	-20	-90
125	220	240	230	270	210	80	0	-50
135	280	300	280	320	250	100	30	-30
145	350	370	350	400	310	140	60	70
155	440	480	460	520	410	190	120	180
165	600	660	630	730	560	270	180	280
175	780	860	820	970	800	390	270	390
185	1080	1190	1150	1400	1290	620	390	520
195	960	1060	1030	1270	1200	580	370	420
205	420	460	440	550	550	270	180	120
215	230	250	230	270	280	130	170	190
Tide only	0	0	0	0	0	0	0	0
sum	2440	3440	3620	6110	5100	1970	-230	-2730

*(positive values indicate northwards transport, negative value indicate southwards transport) values scaled from 2mm grainsize transport using factor 0.16 for 15mm grainsize

The models were also run with climate change allowances applied, SLR of +0.5m and an increase in offshore wave heights and wind speed (both +10%) for waves above the mean +1 standard deviation. The boundary conditions for these waves are shown in section 2.2.1. The impact of climate change on the net sediment transport rates at the selected profiles around the Martello Tower is shown in Figure 2-30. Climate change leads to an overall increase in net annual sediment transport across all profiles, except at P8, where transport rates decrease. Despite these changes in magnitude, the direction of sediment transport remains consistent across all profiles when compared with present day results. The rise in sea level allows waves to interact with the beach for longer durations and reduces the depth limitation on wave action. Northward transport rates from profiles P1 to P6 show non-uniform increases compared to present-day values, increases range from 800 to 1300 m^3/year, with the most significant increase observed at P4. The specific contribution of each wave condition to total accumulated transported is detailed in Table 2-9.

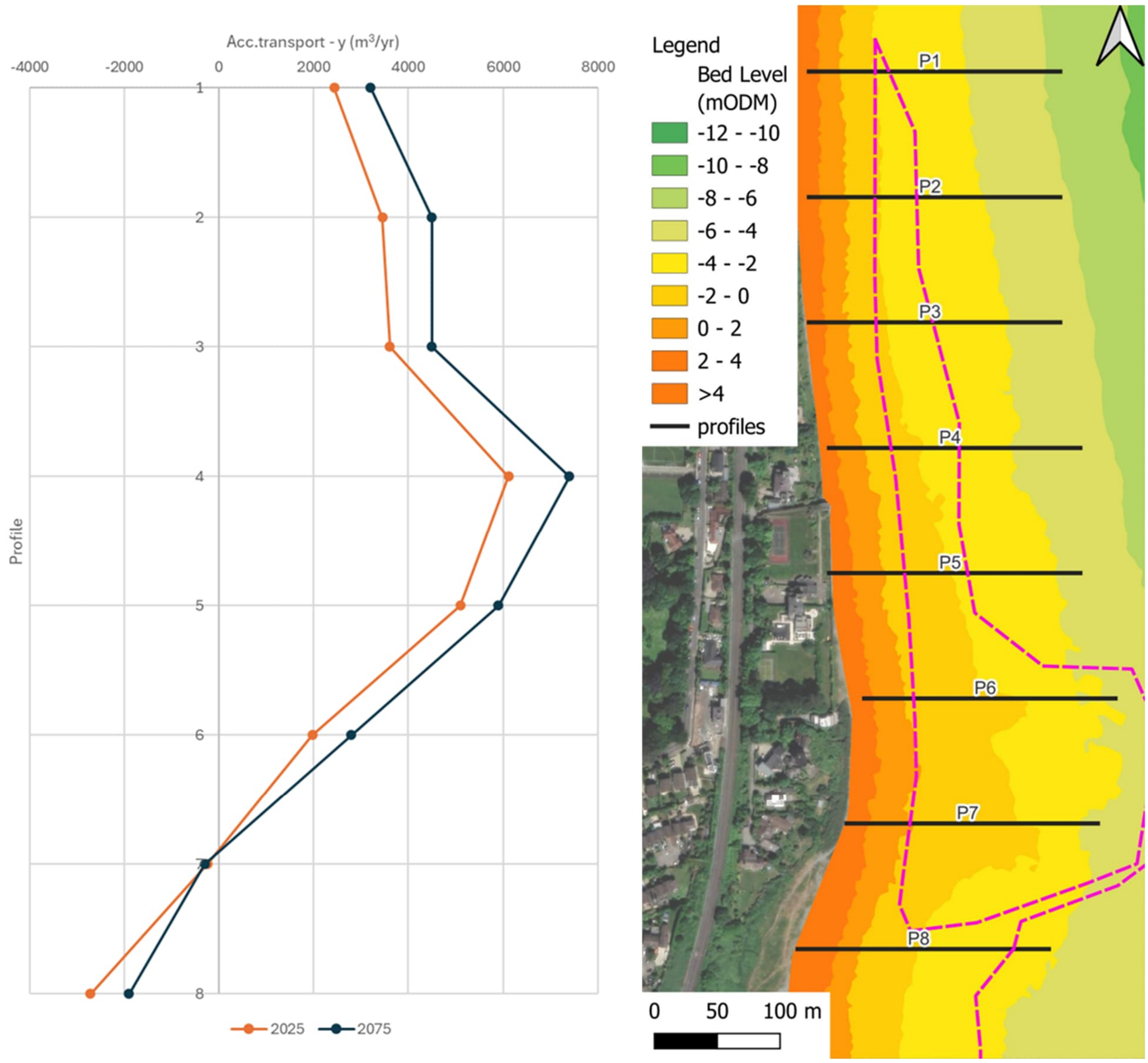

Figure 2-30. Accumulated transport across profiles for all waves above -4mODM (comparison of present day and 2075)

Table 2-9. Accumulated transport (m³/yr – rounded to nearest 10) above -4mODM across profiles for representative wave conditions at nearshore profiles*

(degN)	P1	P2	P3	P4	P5	P6	P7	P8
325	-70	-80	-80	-70	-90	-80	-60	-100
335	-100	-110	-110	-80	-120	-90	-80	-140
345	-150	-150	-160	-100	-150	-110	-110	-210
355	-190	-200	-210	-140	-190	-140	-140	-260
5	-220	-220	-220	-150	-180	-130	-170	-270
15	-250	-250	-250	-170	-180	-140	-190	-300
25	-250	-250	-240	-160	-150	-130	-190	-280
35	-250	-260	-250	-160	-160	-130	-180	-290
45	-320	-320	-300	-190	-180	-150	-230	-360
55	-370	-360	-310	-180	-160	-140	-240	-400
65	-410	-350	-290	-160	-120	-110	-240	-450
75	-500	-420	-330	-130	-60	-80	-280	-570
85	-350	-260	-150	70	120	20	-180	-520
95	-70	40	80	160	170	70	-70	-280
105	90	140	150	190	150	50	-40	-180
115	160	180	170	220	170	70	-20	-70
125	220	250	240	290	230	100	0	-40
135	260	290	270	320	250	120	30	0
145	350	390	360	430	330	170	70	130
155	450	500	470	540	410	240	120	200
165	690	790	730	850	650	380	230	360
175	1000	1140	1070	1260	990	600	350	530
185	1440	1650	1590	1990	1680	960	500	710
195	1240	1420	1370	1750	1500	850	420	550
205	520	600	570	740	680	400	180	160
215	260	310	290	350	340	200	190	210
Tide only	0	0	0	0	0	0	0	0
sum	3180	4470	4460	7470	5930	2800	-330	-1870

*(positive values indicate northwards transport, negative value indicate southwards transport) values scaled from 2mm grainsize transport using factor 0.16 for 15mm grainsize (2075)

2.4.4.2 Single wave condition morphological changes

Using the representative wave approach, results indicate that the dominant wave direction influencing longshore transport along the analysed frontage is 185°. Between profiles P3 and P6, the total volume of sediment transported is approximately 3 to 4 times greater than the annual transport associated with waves from 185°, under both present-day and future climate conditions. The average across these four profiles is 3.66 for present-day conditions and 3.25 for the year 2075. Based on these ratios, a single morphological simulation can be conducted for both periods using waves from 185°, representing an equivalent year of transport. One wave condition was chosen due to the long computation time associated with the morphological runs. The simulation duration required to replicate one year of transport is 33 days for present-day conditions and 29 days for 2075.

Changes to the model are required to the setup used in the representative wave approach. These are as follows:

- Morphological feedback turned on in the model setup
- Morphological speedup factor of 5 used
- Model duration changed from one day to a period of 7 days (boundary conditions used in representative wave approach repeated 7 times)
- Cross shore process were removed from the sediment transport table setup. Cross shore processes are suitable for simulating individual wave events, however it becomes less reliable for long-term modelling. This is because it overlooks the contribution of smaller, constructive waves that play a key role in beach accretion. These smaller waves are difficult to capture with practical model resolutions, and current modelling techniques still struggle to accurately represent beach-building processes.

With the above model adjustments, a 35-day simulation period was run (equivalent to 7 days accelerated by a factor of 5). Results can then be extracted at the appropriate intervals—33 days for present-day conditions and 29 days for 2075—to represent and analyse one year of morphological change.

Changes in the position of the Mean Sea Level (MSL) contour and overall beach position were assessed. The shift in beach position was calculated as the volume of eroded material landward of the rocky area, divided by the beach height—defined as the elevation difference between the bed level at the edge of the rocky area and the height of the active beach profile. Both change in MSL location and beach position were scaled based on a factor of 0.16 as previously noted (Appendix A). Results for changes in MSL are shown in Figure 2-31 and changes in beach position are shown in Figure 2-32. Further, the morphological bed level results for both present day and 2075 using a grainsize of 2mm are shown in Appendix B.

Results for the location of the MSL contour show:

- Under present-day conditions, the results indicate a trend for net erosion across the four profiles (P4–P7) surrounding the Martello Tower. Erosion is greatest at profile P7 (-1.7m/yr) decreasing northwards to slight accretion at P4 (+0.2m/yr).
- When climate change projections are incorporated into the model, profiles P4 and P5 exhibit a seaward shift of the MSL contour, both increasing at a rate of +0.3 m/year. Compared to present-day conditions, the rate of erosion at profiles P6 and P7 decreases, reducing to -0.4 m/year and -0.7 m/year, respectively

Results for the change in beach position show:

- Under present day conditions around Martello Tower change in beach position shows erosion at the four profiles (P4-P7). Greatest erosion seen at P6 (-1.1m/yr) other locations see erosion under -0.5m/yr.
- When climate change is factored into the model, erosion rates remain nearly uniform across the profiles, with the only notable increase occurring at profile P5, where the rate rises to -0.8 m/yr.

Results for the beach position are considered more appropriate to take over the position of the MSL contour. This is due to the beach position taking into account the volume change across the profile instead of one fixed location.

It is important to note that a conservative assumption has been applied to the extent of the rocky bed when analysing the profiles. Outside these rocky areas, the model assumes an unlimited depth of erodible material.

However, this is likely unrealistic, as the rocky substrate may extend beneath the mobile bed, becoming exposed and thereby limiting the potential for vertical erosion. This would likely result in a lower estimated volume of material loss, which in turn would reduce the calculated rates of change in beach position.

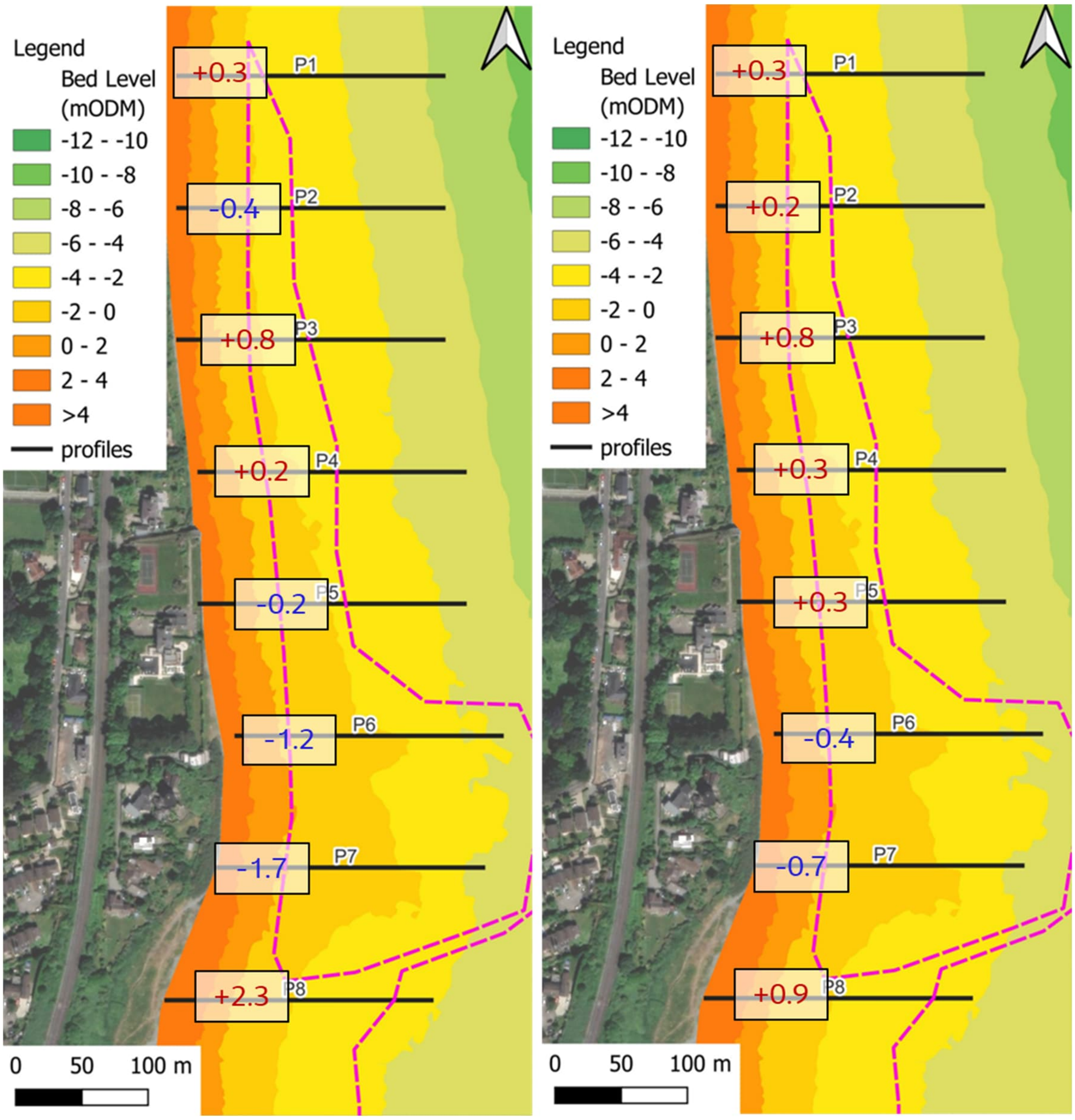

Figure 2-31. Predicted annual change in MSL position 2025 (left) and 2075 (right)

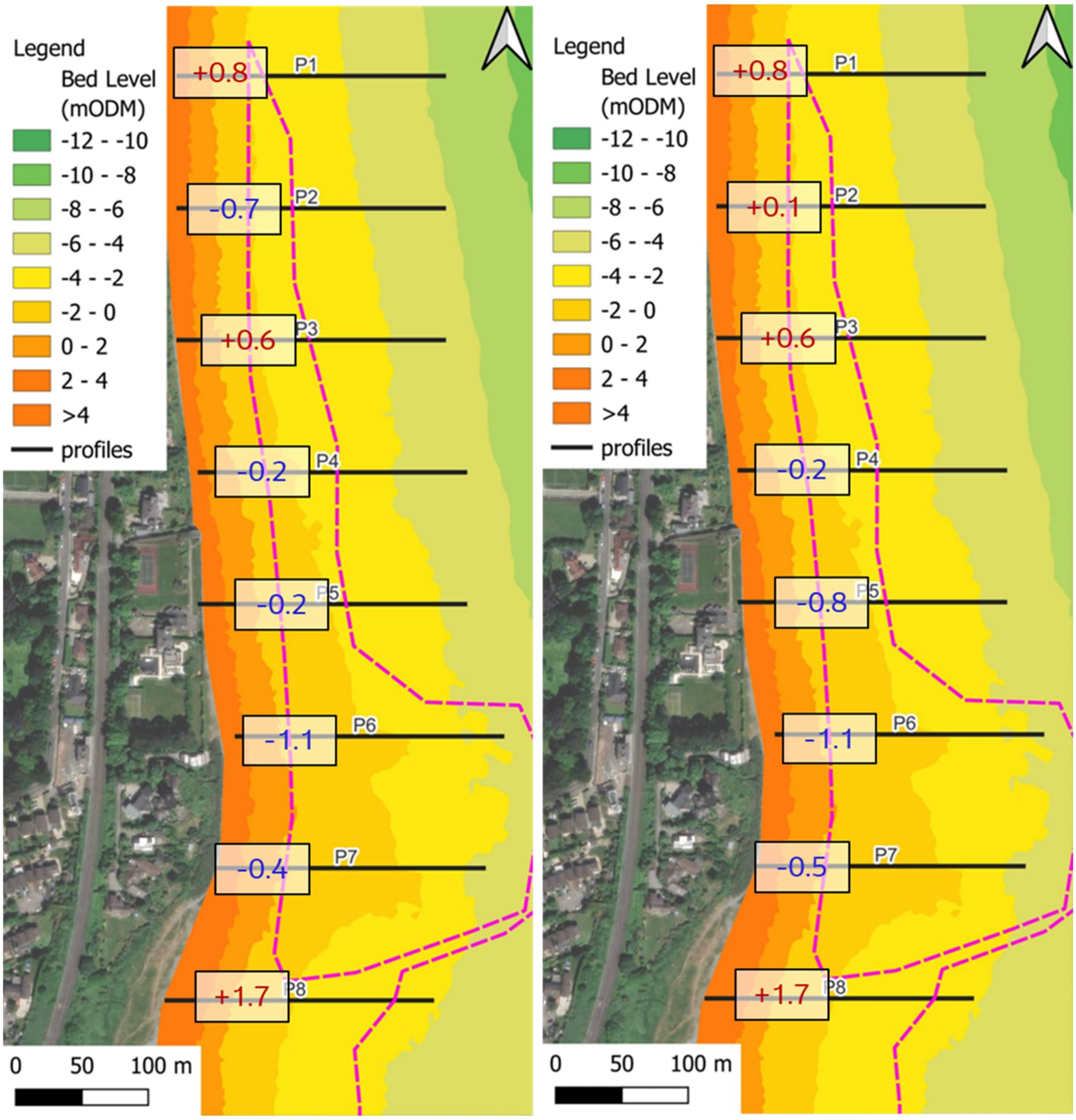

Figure 2-32. Predicted annual change in beach position 2025 (left) and 2075 (right)

2.5 White Rock Beach Results

A revetment has been proposed at the base of the cliff face to the south of White Rock Beach to provide protection to the base of the cliff. Detailed two-dimensional (2D) model simulations were carried out to assess wave dynamics, flow patterns, and sediment transport under both pure tidal conditions and selected wave events with and without the proposed revetment in place. The flow outputs from these simulations were analysed to evaluate their impact on current speeds and to assess potential implications for swimmer safety. The sediment transport results were used to investigate the influence on sediment supply to White Rock Bay, results also analysed the potential effects on the surf break location. The location of White Rock Beach and the revetment location is shown in Figure 2-33. A cross section through the revetment is shown in Figure 2-34.

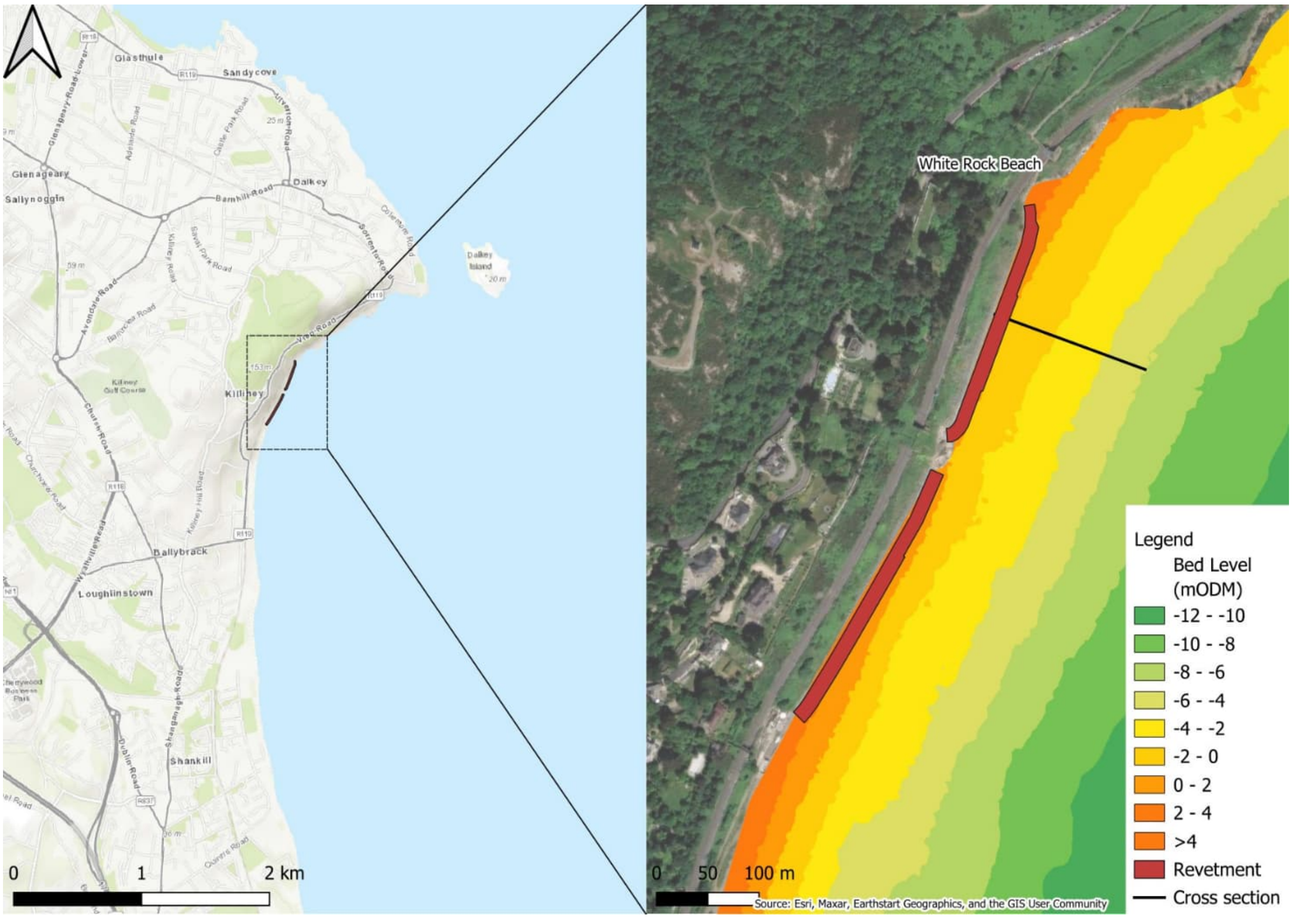

Figure 2-33. White Rock Beach revetment location

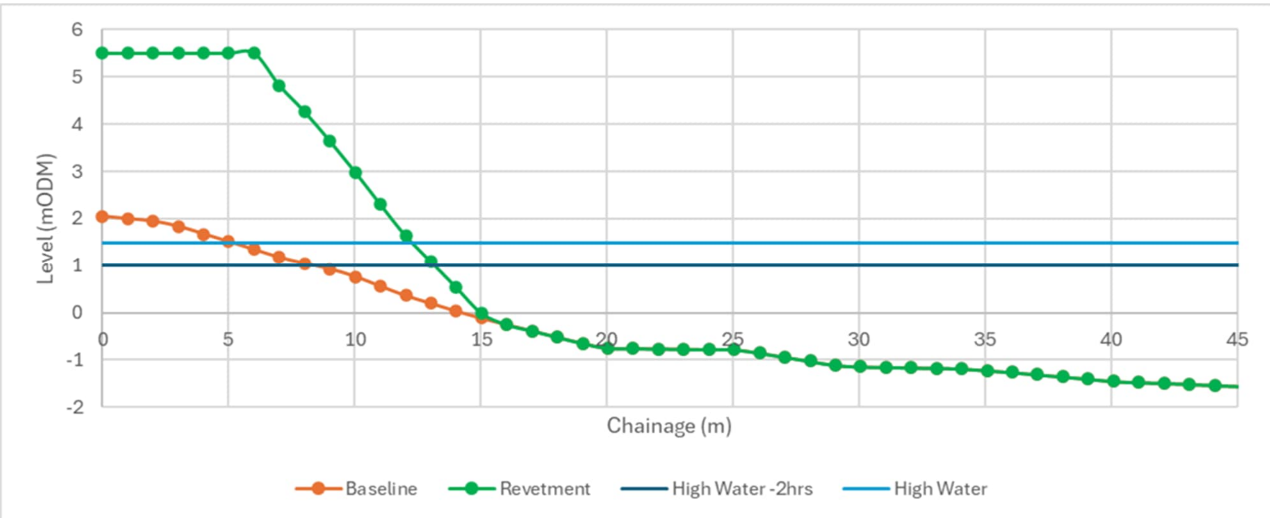

Figure 2-34. White Rock Beach revetment cross section

2.5.1 Currents

Two-dimensional plots illustrating current speeds at various tidal stages around White Rock Beach are presented below for selected wave directions (Figure 2-35 through Figure 2-38). The plots compare the baseline scenario, the scenario with the revetment installed, and the resulting differences between the two. Further, plots comparing the maximum current speeds for different wave directions are shown in Figure 2-39 through Figure 2-41.

Results show that under pure tidal conditions (i.e., no waves), the impact of the revetment is negligible, with changes in current speed being less than 0.05 m/s at all stages of the tide. Currents alone are not enough to initiate sediment transport along this section of coastline.

In scenarios that include wave action, the impact of the revetment on current speeds is generally negligible—less than 0.05 m/s—across most tidal stages. However, a more noticeable effect is observed near high water, particularly from two hours before high tide up to high tide itself. This is due to the surf zone, where waves break, shifting closer to the shoreline at high tide. As a result, the footprint of the proposed revetment overlaps with part of this surf zone, leading to observable changes in flow conditions. Zoomed plots for the White rock Beach area for high water -2hrs and high water are shown in Appendix D.

The extent of this impact at water levels above high water –2 hrs depends on the direction of offshore waves. For waves approaching from the northeast to east-northeast, the effect is limited to the area adjacent to the revetment footprint, with changes in current speed remaining minor—less than 0.1 m/s. In contrast, for waves coming from the south, the influence extends both adjacent to the revetment and offshore of White Rock Beach. In this case, the change in current speed is more pronounced, reaching up to 0.2 m/s. Detailed analysis of waves from the south (185 +/- 10 deg) revealed that this increase is due to a shift in the position of a clockwise circulation cell located offshore of White Rock Beach. Importantly, the maximum current speed within the circulation cell itself remains unchanged. Results are shown in Appendix C.

When looking at the maximum current speeds the revetment primarily affects the area directly adjacent to its footprint, where a reduction of less than 0.1 m/s is observed

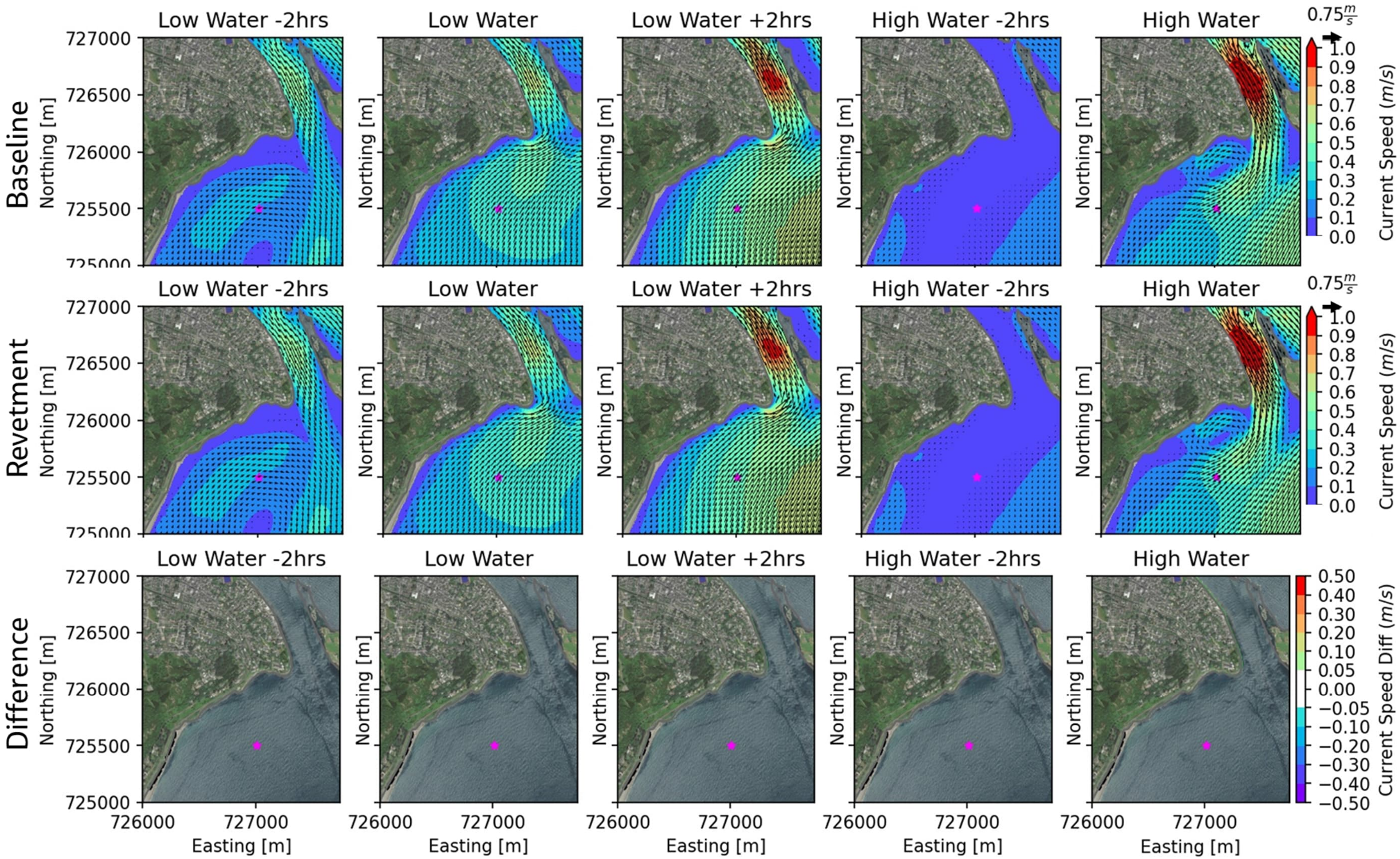

Figure 2-35. Tide only conditions current speeds, top=baseline, middle=revetment, bottom=difference (revetment-baseline). Tide conditions taken at pink star

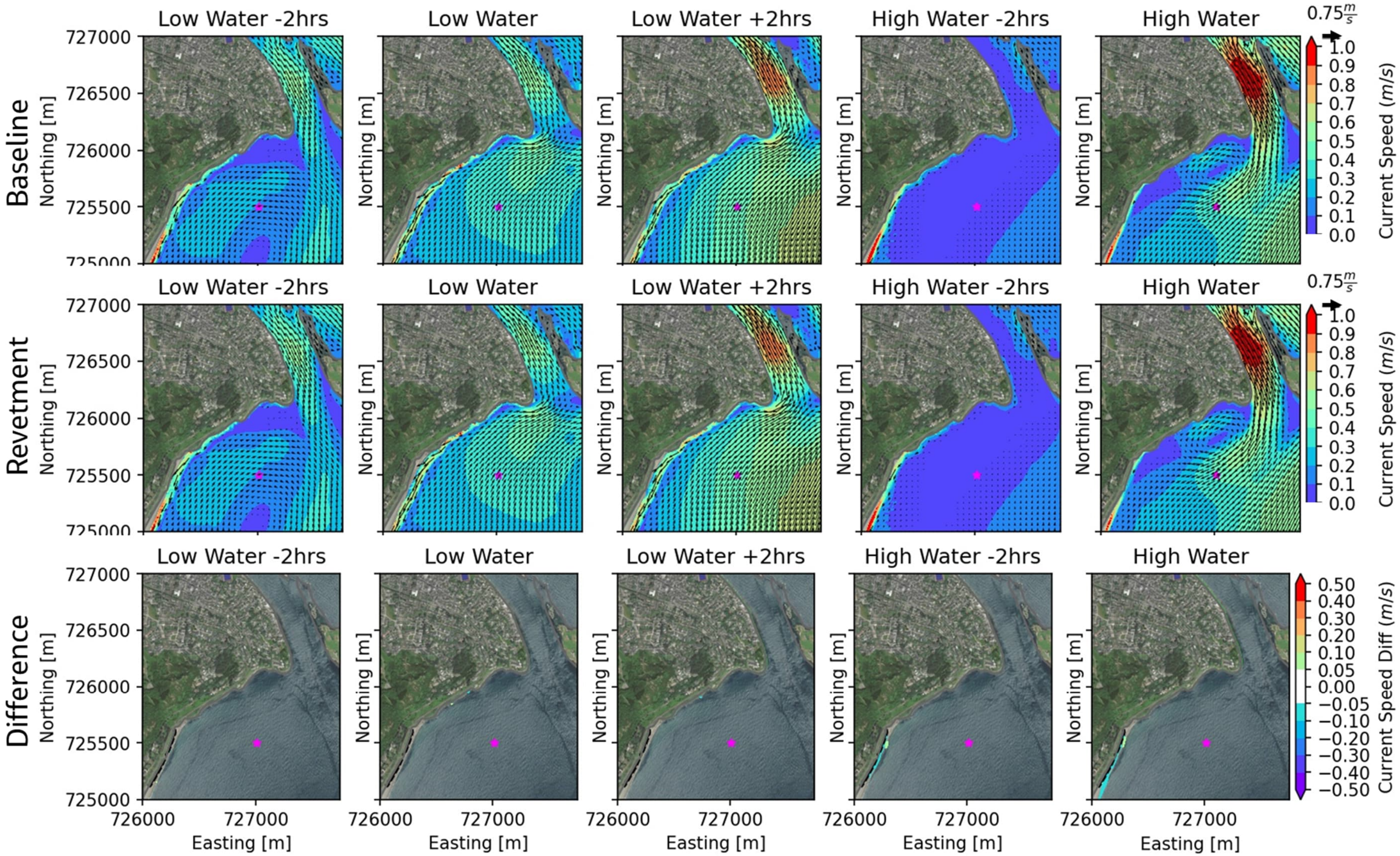

Figure 2-36. Waves from 45 deg current speeds, top=baseline, middle=revetment, bottom=difference (revetment-baseline). Tide conditions taken at pink star

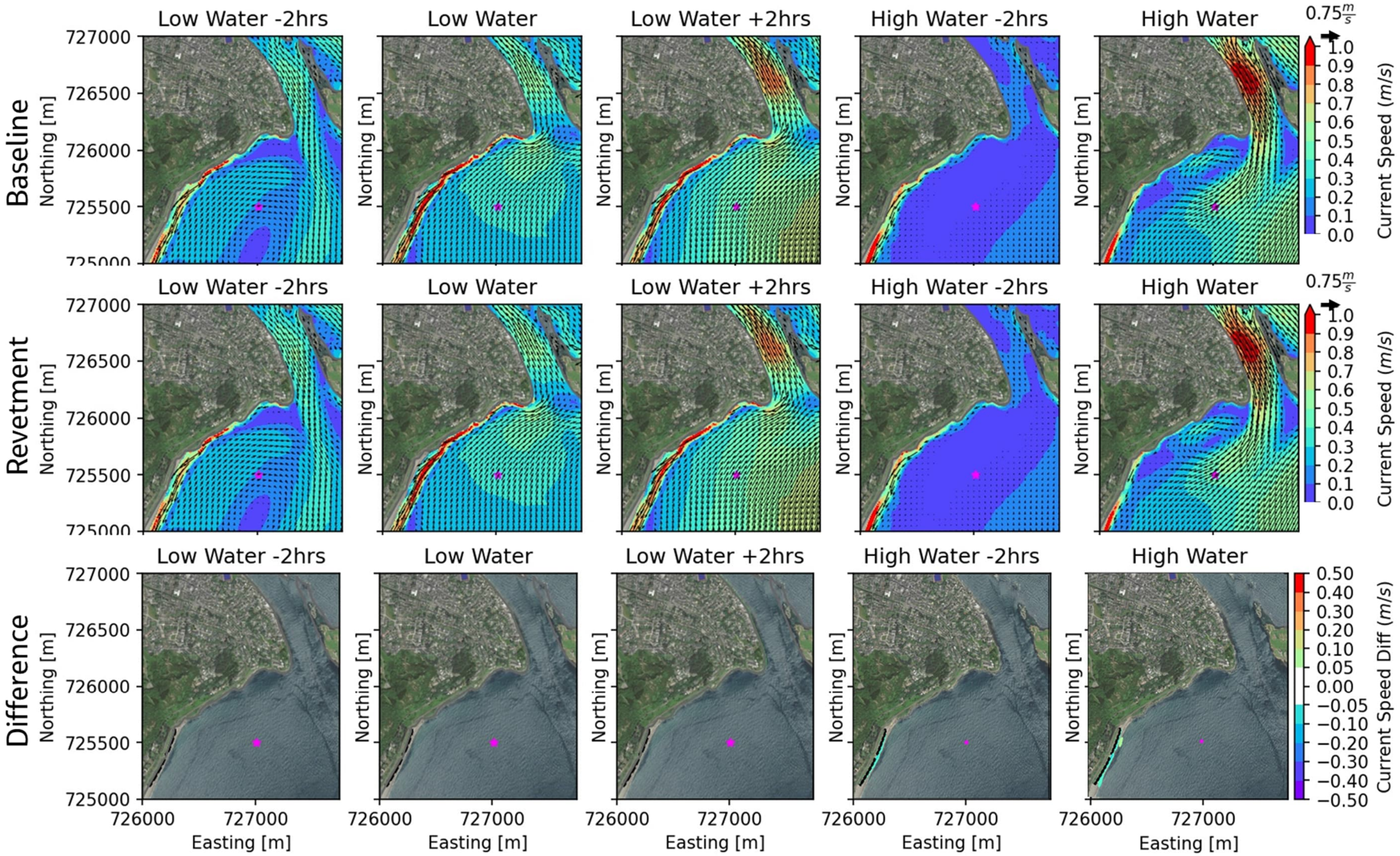

Figure 2-37. Waves from 75 deg current speeds, top=baseline, middle=revetment, bottom=difference (revetment-baseline). Tide conditions taken at pink star

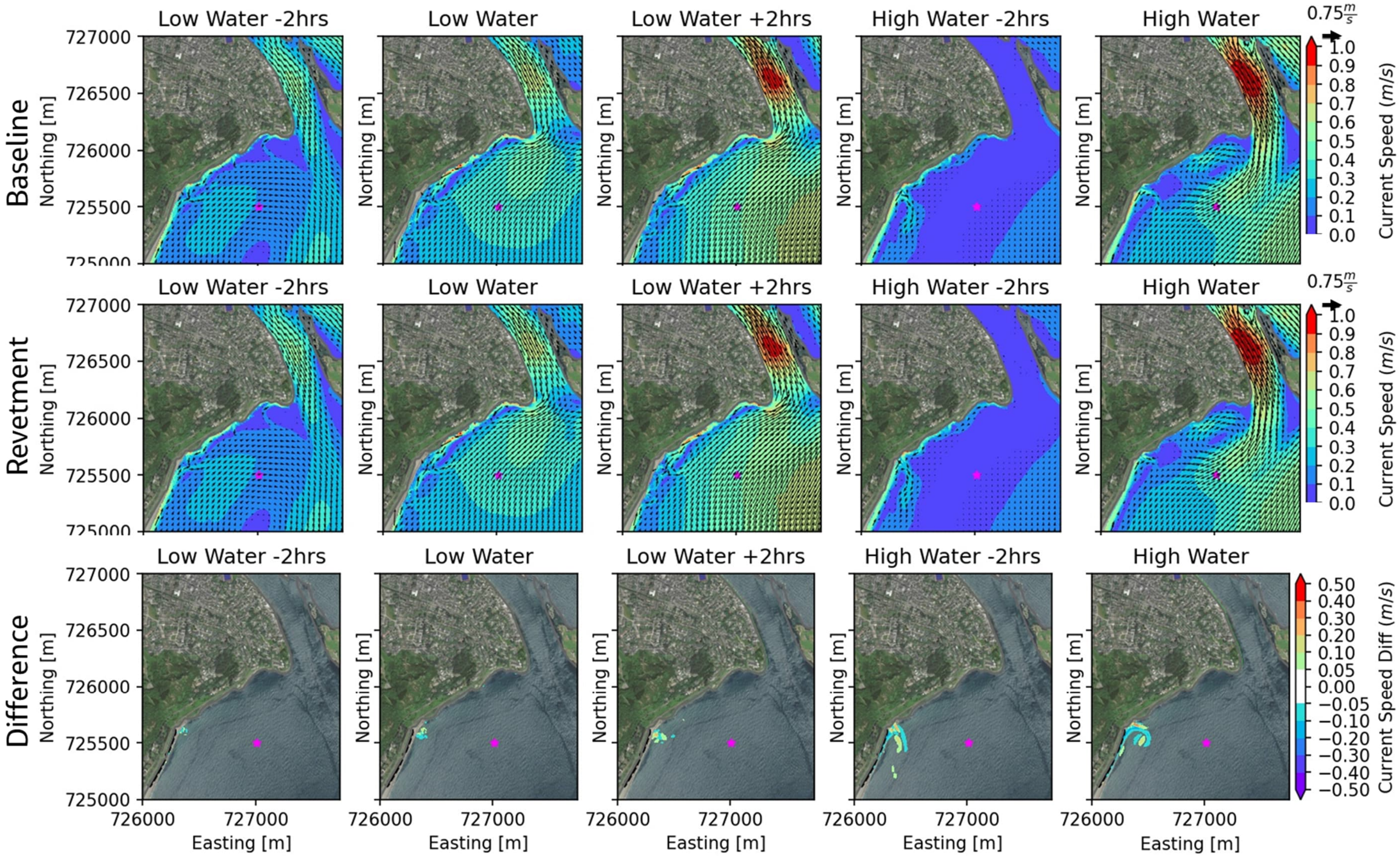

Figure 2-38. Waves from 185 deg current speeds, top=baseline, middle=revetment, bottom=difference (revetment-baseline). Tide conditions taken at pink star

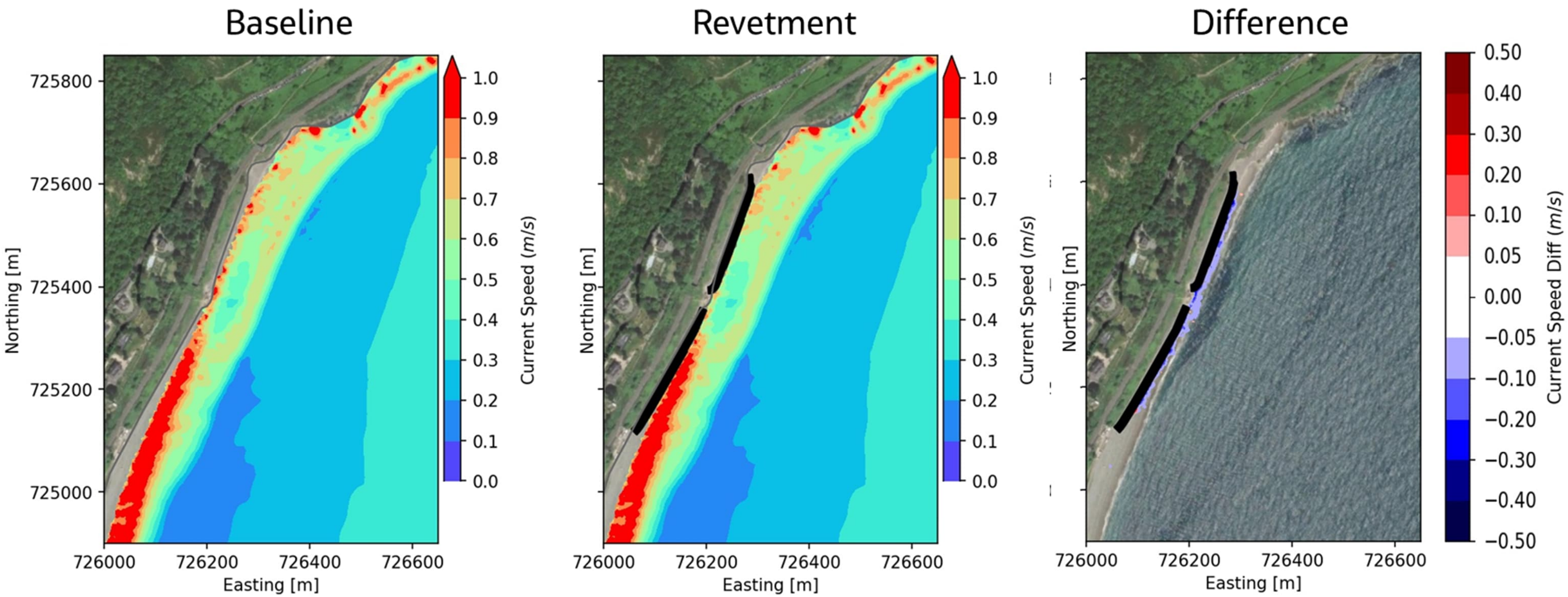

Figure 2-39. Waves from 45 deg max current speeds, left=baseline, middle=revetment, right=difference (revetment-baseline).

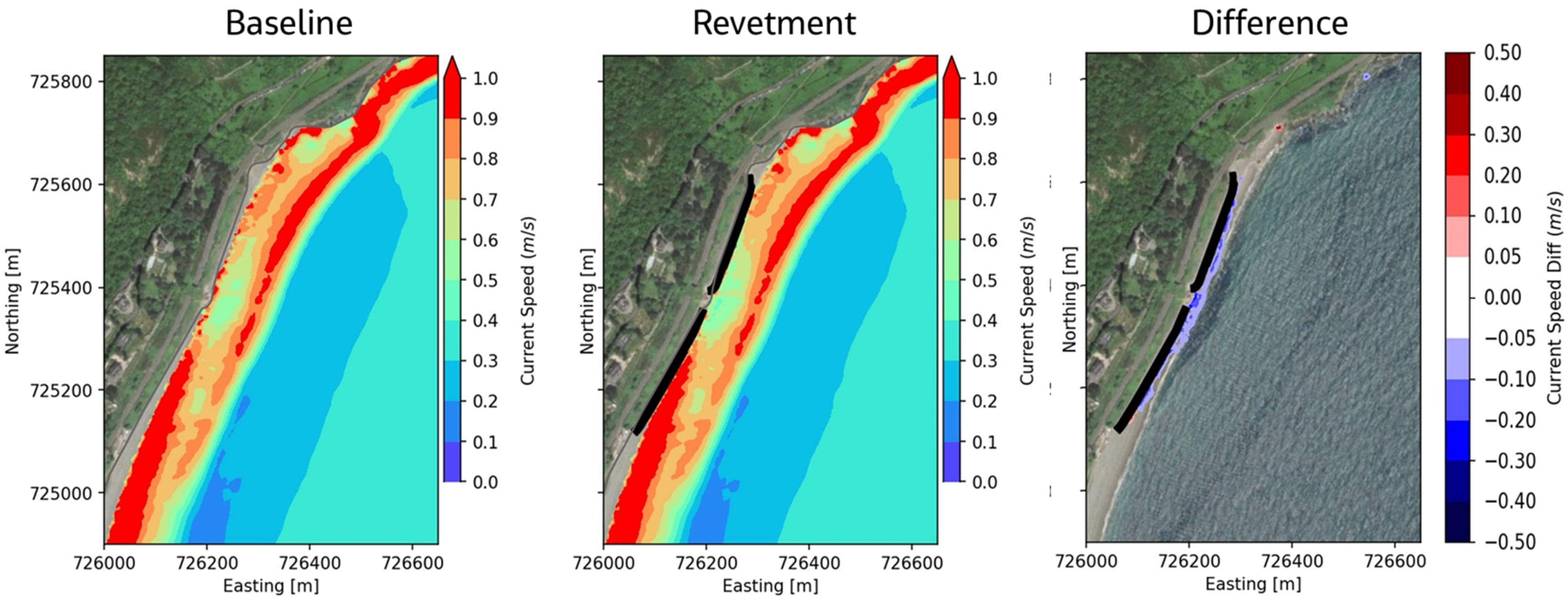

Figure 2-40. Waves from 75 deg max current speeds, left=baseline, middle=revetment, right=difference (revetment-baseline).

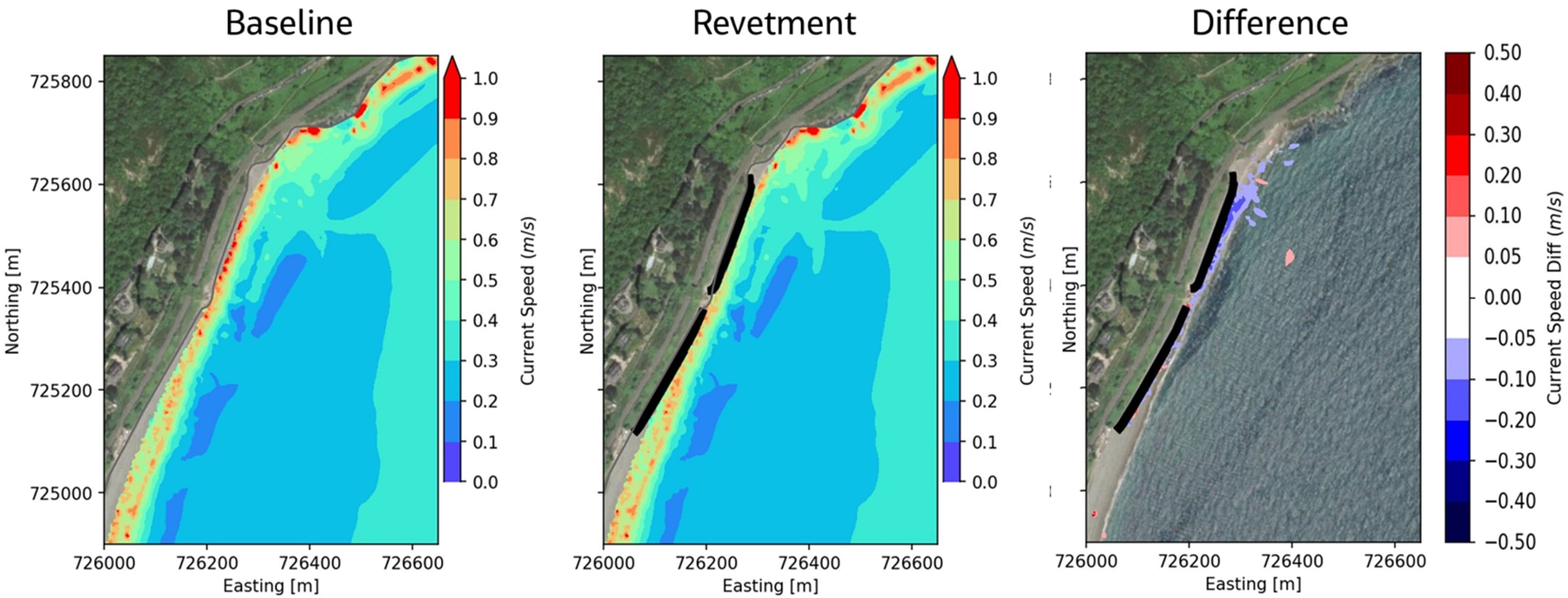

Figure 2-41. Waves from 185 deg max current speeds, left=baseline, middle=revetment, right=difference (revetment-baseline).

2.5.2 Sediment Transport

Sediment transport into White Rock Beach is dominated by southerly waves. The coastline to the north of White Rock Bay is predominantly rocky and is therefore not considered a significant source of sediment for the beach. The results for this section focus exclusively on wave conditions that drive northward longshore sediment transport.

To evaluate northward sediment transport into White Rock Beach, three cross-shore profiles were analysed under southerly wave conditions (175, 185, and 195 deg). Additionally, total sediment transport above -4m ODM was calculated, and the results were compared between the baseline scenario and the revetment configuration. The profiles used to extract sediment transport are shown in Figure 2-42.

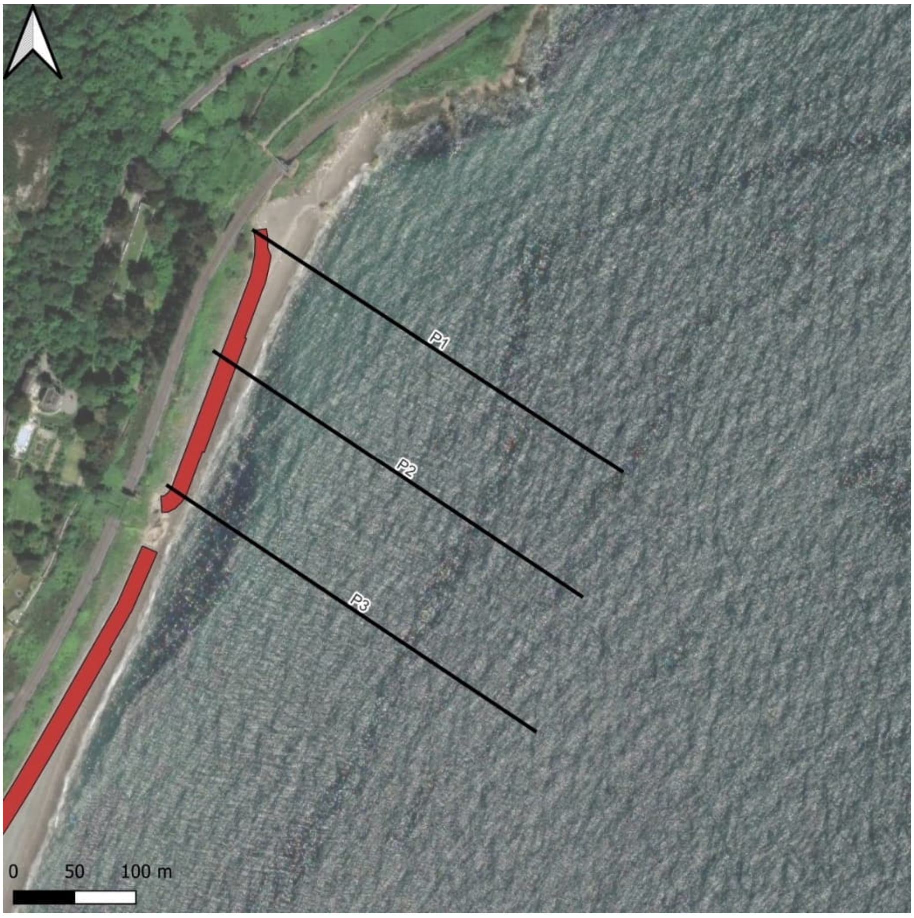

Figure 2-42. Profiles used in sediment transport into White Rock Beach.

Figure 2-43 through Figure 2-45 present the modelled northward sediment transport using a 2 mm grain size. These results have not been adjusted to account for the relative frequency of the wave conditions. Table 2-10 summarises the change in total transport volume between the baseline and revetment scenarios. In this case, the results have been scaled by wave frequency and adjusted to represent transport for a 15 mm grain size. Table 2-11 also presents the percentage change between the profiles by wave direction.

Model results indicate a reduction in sediment feed into White Rock Beach. This decrease is primarily attributed to the footprint of the proposed revetment, which obstructs part of the northward littoral drift that typically supplies sediment to the bay. A clockwise eddy forms in front of the bay under southerly wave conditions, providing a mechanism for beach sediment to be transported offshore. However, the position of this eddy along the coast can vary depending on the incident wave direction and energy. With a reduced supply of sediment from updrift sources—and no significant changes to offshore sediment transport—it is possible that White Rock Beach may experience increased erosion over time.

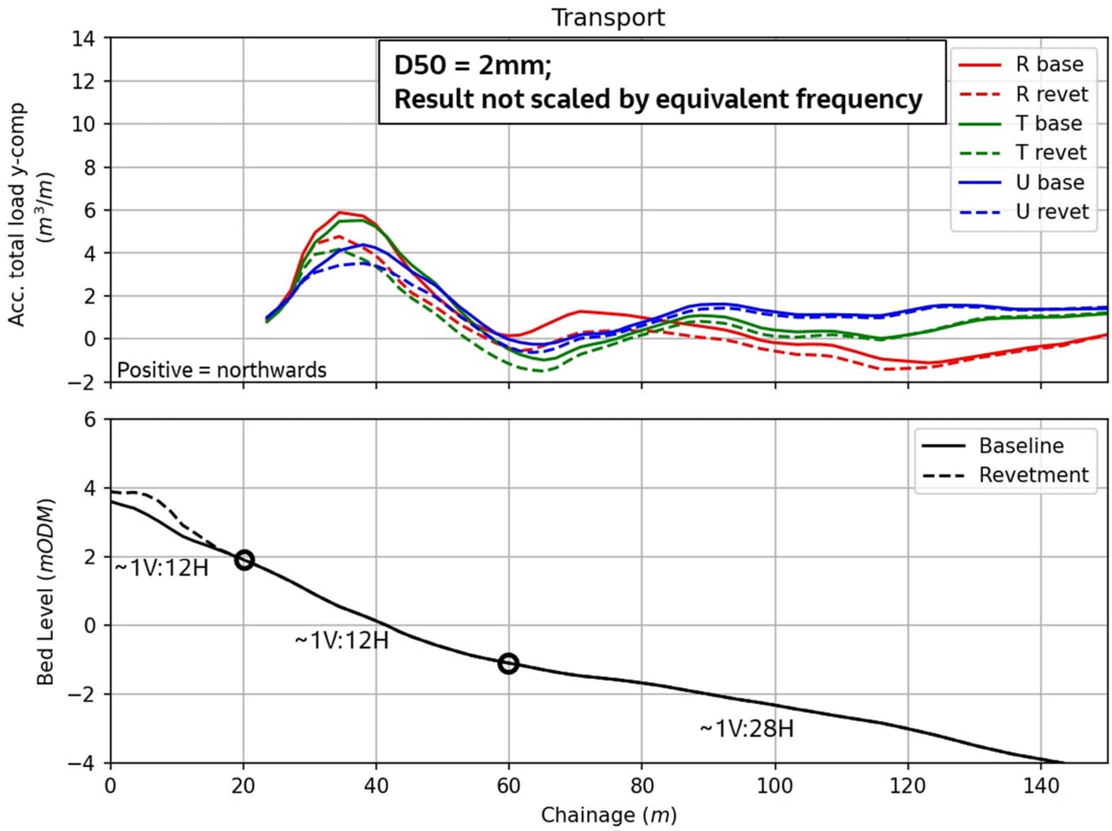

Figure 2-43. P1 transport into White Rock Beach (Accumulated total load y-comp)

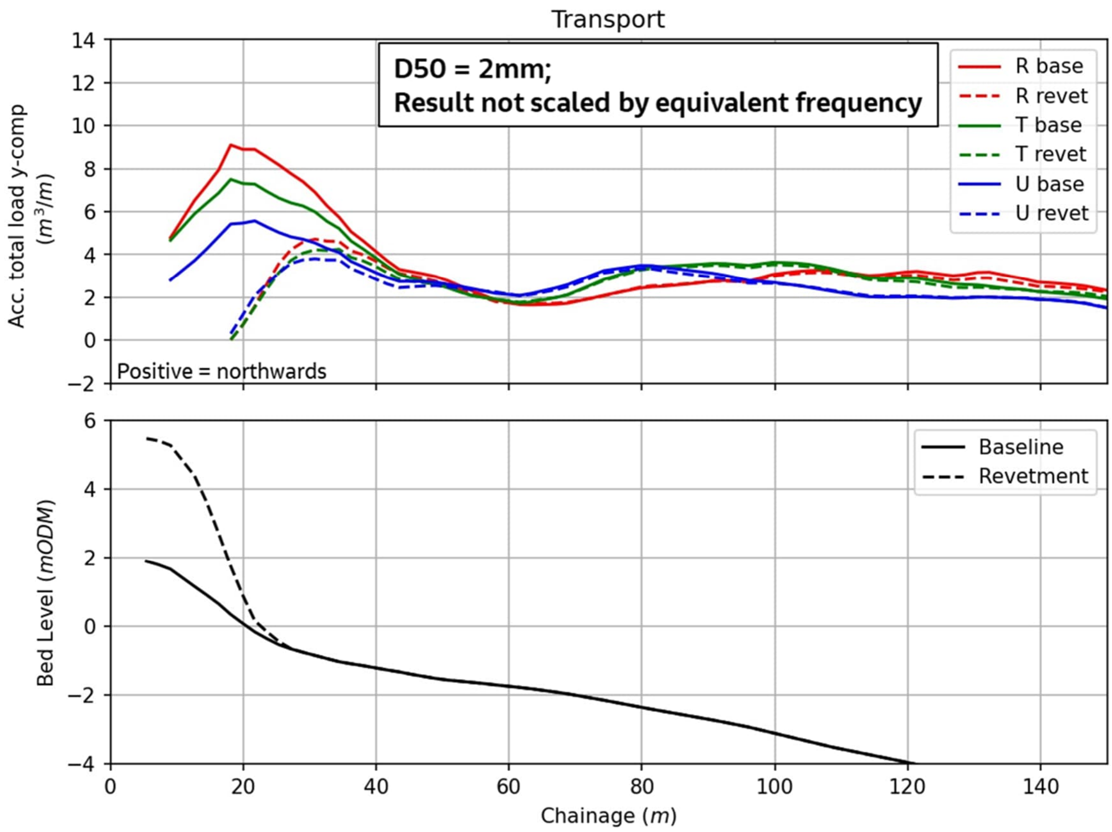

Figure 2-44. P2 transport into White Rock Beach (Accumulated total load y-comp)

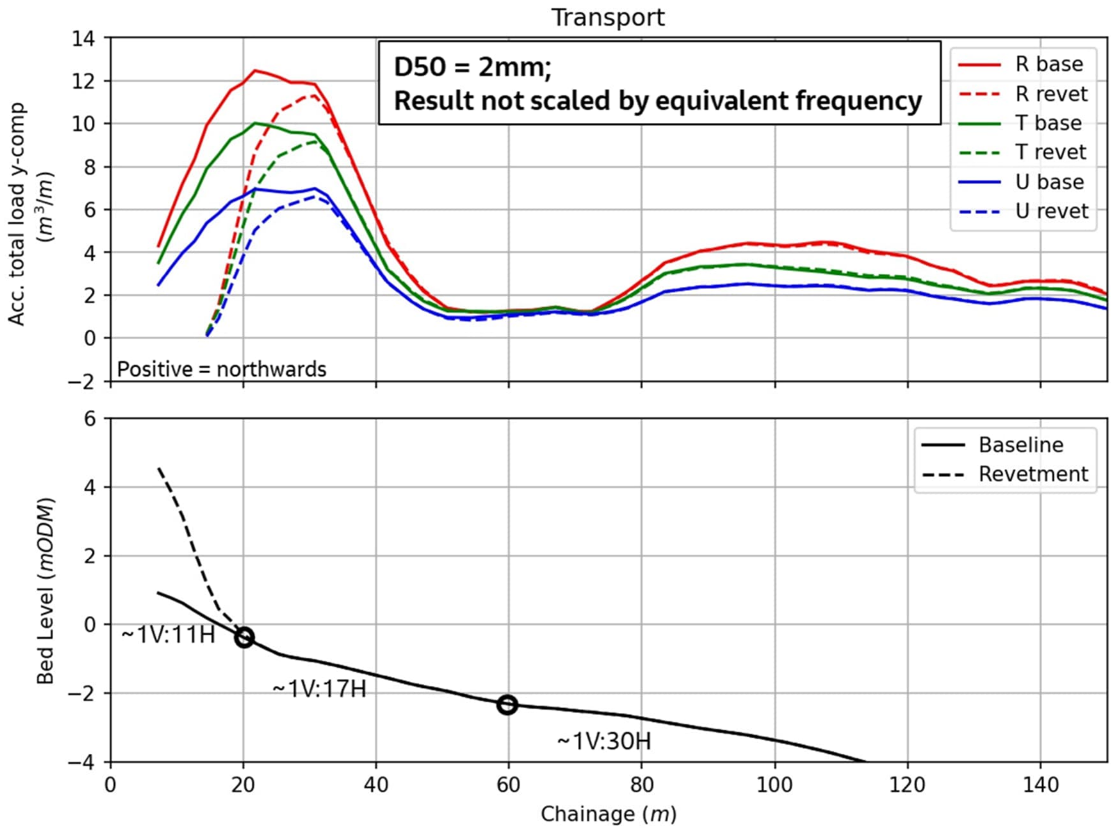

Figure 2-45. P3 transport into White Rock Beach (Accumulated total load y-comp)

Table 2-10. Transport across profiles for wave conditions (scaled for 15mm D50)

	P1 (m3/yr)		P2 (m3/yr)		P3 (m3/yr)	
Wave	Baseline	Revetment	Baseline	Revetment	Baseline	Revetment
R (175 deg)	74	30	278	187	354	275
T (185 deg)	195	120	581	422	603	472
U (195 deg)	330	277	648	514	589	466
Sum (R,T,U)	599	427	1507	1123	1546	1213
%change		-29%		-25%		-22%

Table 2-11. Transport across profiles for wave conditions percentage change

Percentage change (%)			
Wave	P1	P2	P3
R (175 deg)	-59	-33	-22
T (185 deg)	-39	-27	-22
U (195 deg)	-16	-21	-21

2.5.3 Wave Height Variation in the Surf Zone

To evaluate the wave height variations at White Rock Beach, three cross-shore profiles were analysed for varying wave directions. The profiles used to extract sediment transport are shown in Figure 2-46. Results for the varying wave directions are shown in Figure 2-47 through Figure 2-51.

Model results indicate no significant change in the wave breaking location, defined as the point where significant wave height (Hm0) begins to decrease rapidly. The impact of the revetment on wave height within the surf zone varies depending on the direction of offshore wave approach:

- For offshore waves from the northeast to east-northeast (Wave E-45 and Wave H), the change in wave height is less than 0.05 m, which is considered negligible.
- For offshore waves from the south (Wave R, T, and U), the change is less than 0.10 m, indicating a small impact.

Additionally, no sand bar is evident in the bathymetry within 400 metres seaward of the shoreline near White Rock Beach. The proposed revetment is expected to have a small overall impact on the wave breaking location.

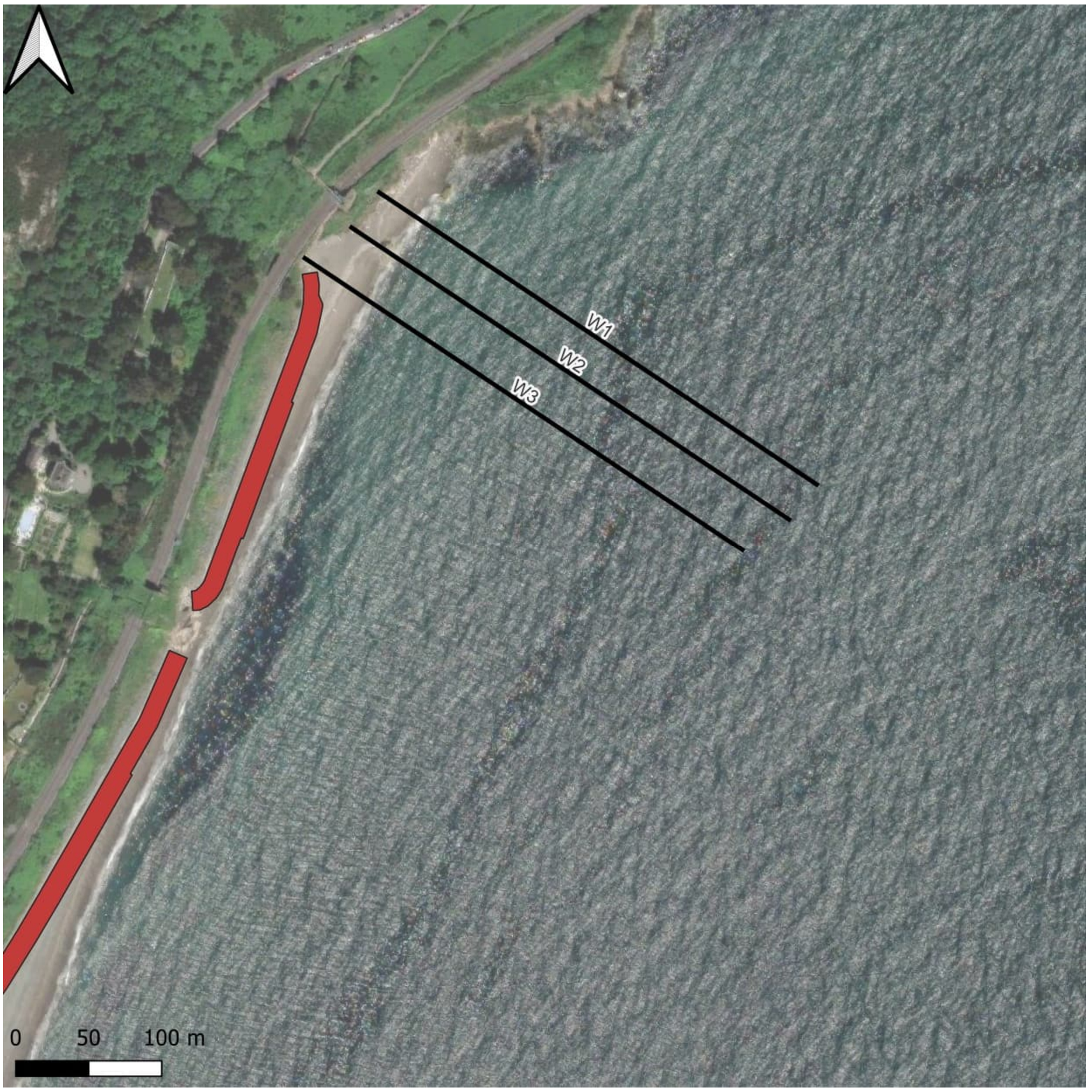

Figure 2-46. Profiles used in wave height analysis at White Rock Beach.

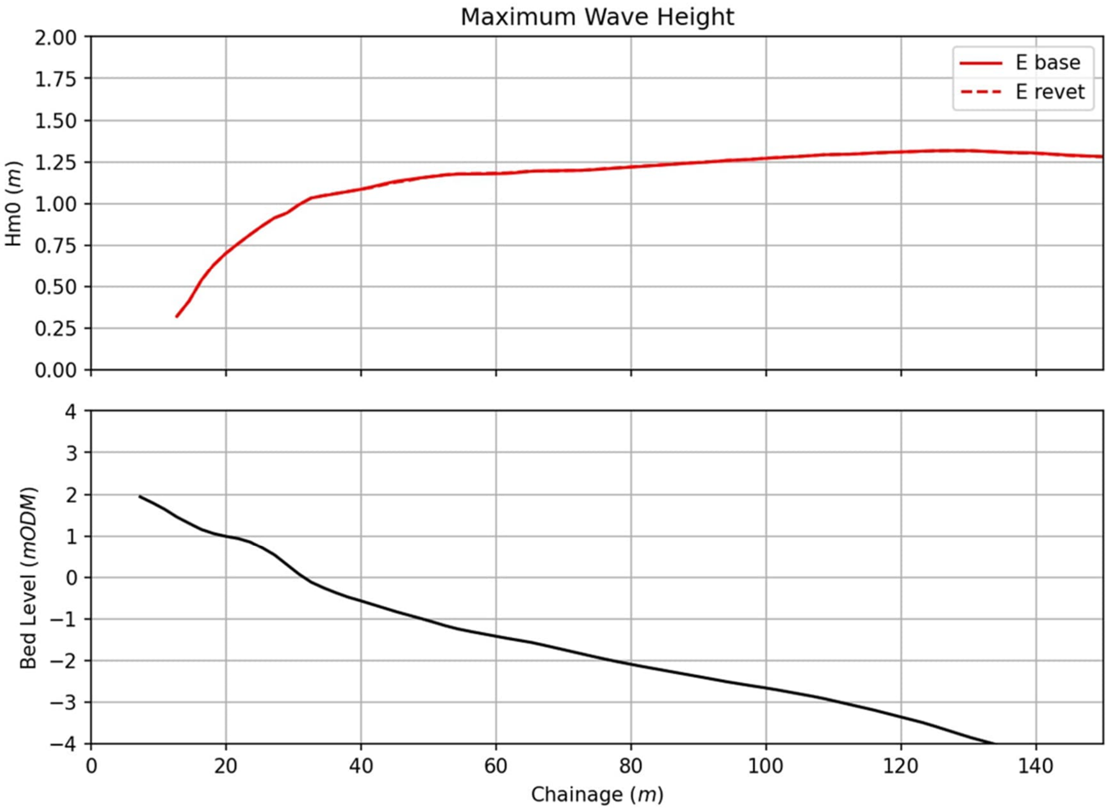

Figure 2-47. W2 maximum wave height over the simulation period at White Rock Beach wave E (45 deg).

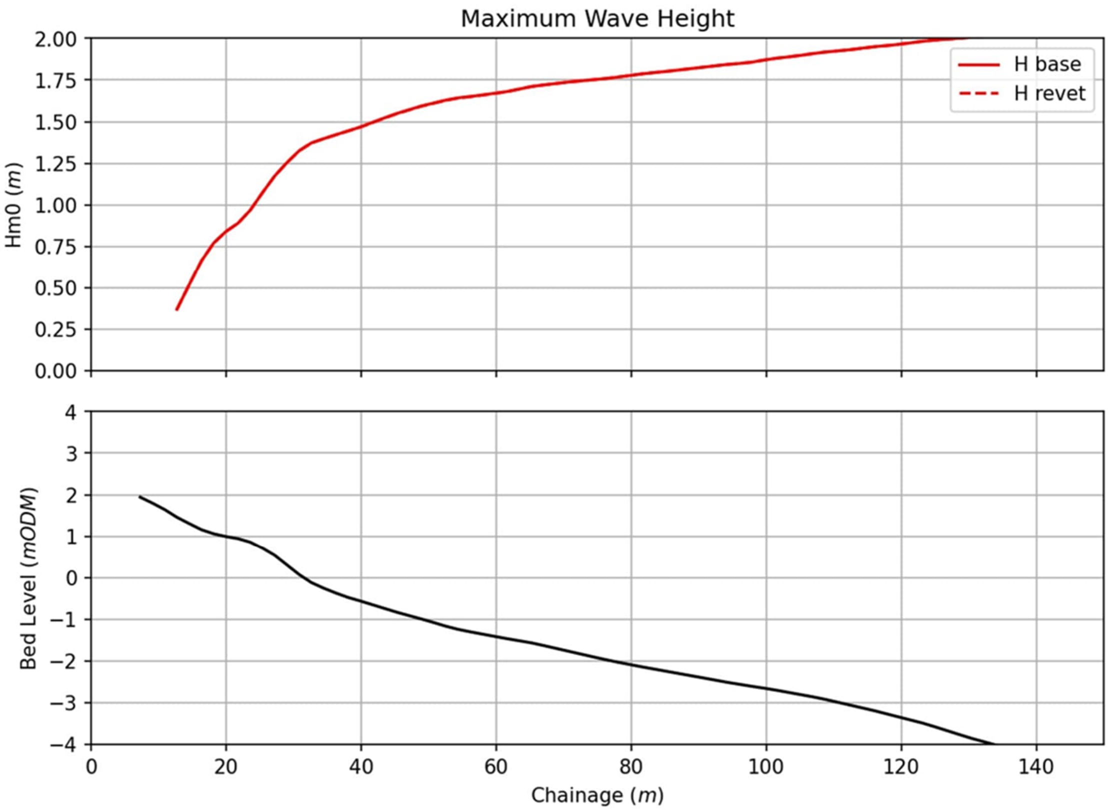

Figure 2-48. W2 maximum wave height over the simulation period at White Rock Beach wave H (75 deg).

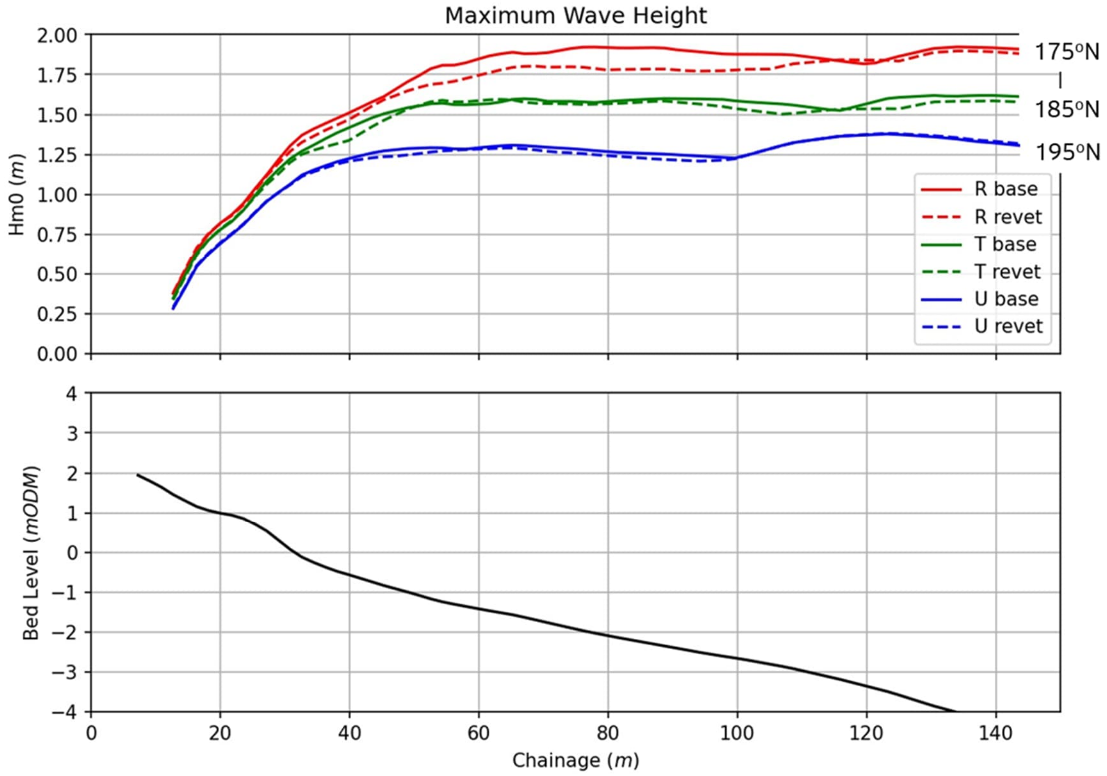

Figure 2-49. W1 maximum wave height over the simulation period at White Rock Beach southerly waves.

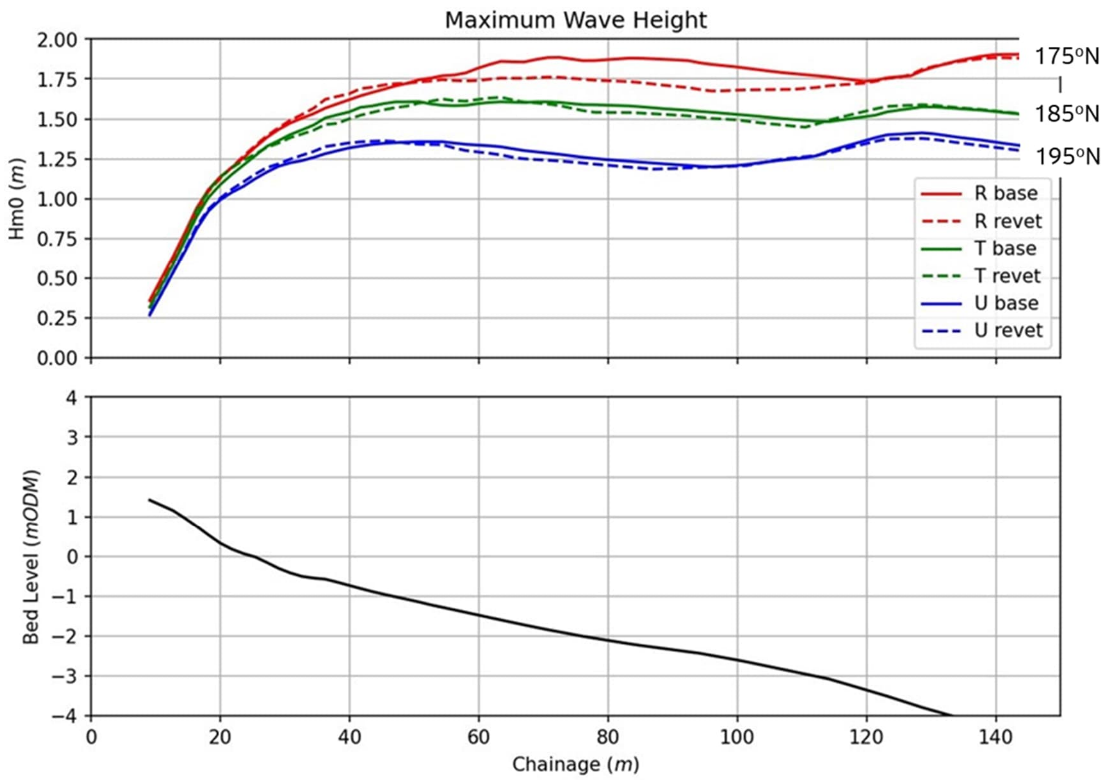

Figure 2-50. W2 maximum wave height over the simulation period at White Rock Beach southerly waves.

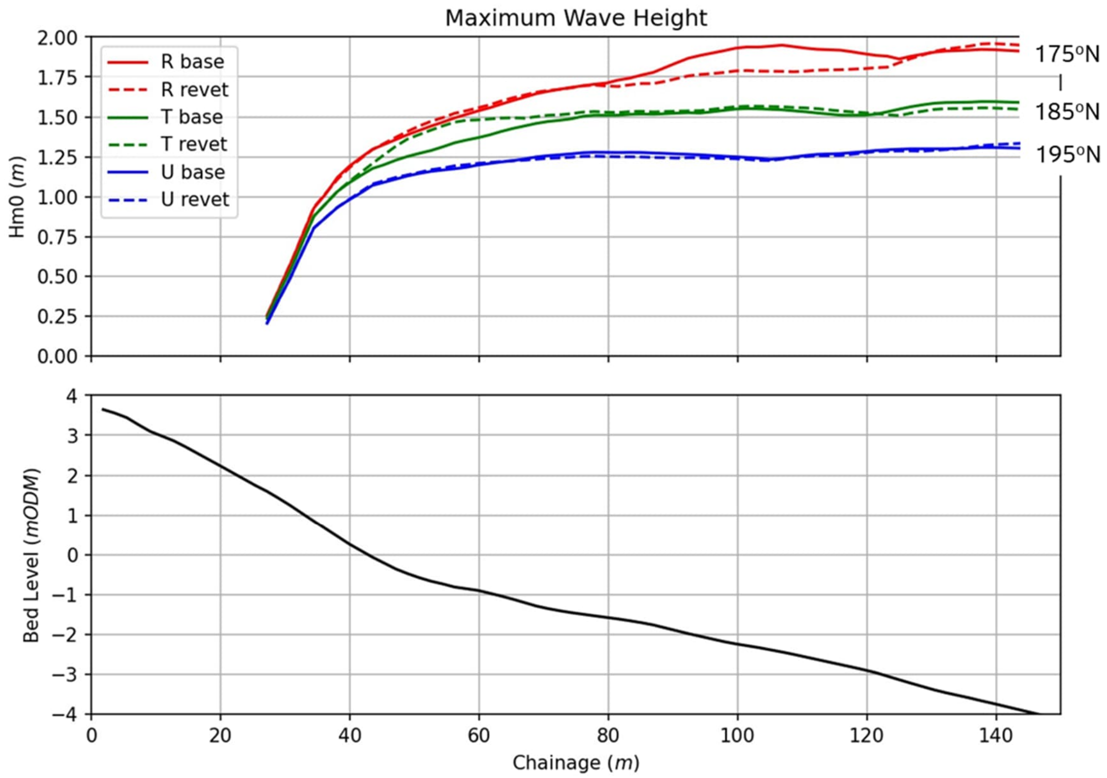

Figure 2-51. W3 maximum wave height over the simulation period at White Rock Beach southerly waves.

2.6 Summary, Limitations and Conclusions

2.6.1 Summary

The Coastal Area Model (CAM) has been used to simulate wave action, hydrodynamic flow, and sediment transport along the CCA2-3 frontage, and to predict annual shoreline changes under present-day (2025) and future conditions (2075). Rocky bed areas were simulated with an increased roughness and a sediment thickness of zero. However, due to CAM's sediment grain size limitation (maximum of 2mm), the model was run using 2mm sediment. The results were then scaled using a relationship derived from LITDRIFT, which is capable of handling coarser sediment sizes.

The model was applied in the following configurations:

- Type 1: Using 27 representative wave conditions without morphological feedback (see section 2.4.4.1). These results can be considered an initial response.
- Type 2A: Using a single representative wave, incorporating morphological feedback, with cross-shore transport processes enabled.
- Type 2B: Using a single representative wave, incorporating morphological feedback, with cross-shore transport processes disabled (see section 0).

The Type 2B configuration was used to project shoreline changes for both the present day (2025) and the future (2075).

In the representative wave approach, the full annual wave climate is simplified into a limited set of representative wave conditions that, when combined, approximate the overall yearly sediment transport. These representative waves were derived at ERA5 Point 1 and transformed to the CAM model boundary using a regional Spectral Wave (SW) model. Offshore wave conditions with a mean wave direction (MWD) ranging from 325 deg clockwise to 215 deg were included in the analysis. Representative tidal conditions were based on tidal ranges observed at Dublin. Water level and current boundary inputs for the CAM were sourced from the regional hydrodynamic model of the Irish Sea.

Around White Rock Beach the outputs from the flow model were used to evaluate the potential impacts on current speeds and swimmer safety. Further, the sediment transport model results were analysed to assess the effects on sediment supply to Whiterock Beach and any potential influence on the surf break, particularly the presence or absence of a sand bar. The wave model outputs were used to determine any changes in the location of wave breaking.

2.6.2 Conclusions

Analysis of the representative wave condition results indicates a net sediment transport direction from south to north along the frontage. The highest potential for sediment movement occurs within approximately 100 metres of the coastline. However, the presence of exposed bedrock in certain areas limits the availability of mobile sediment, restricting transport across the rocky bed areas.

Results using the Type 2B Results (Morphological Feedback Included, Cross-Shore Transport off) show:

2025 Projections:

- Change in beach position based on volume changes to rock outcrop.
  - A general trend of erosion is observed between profiles P4 and P7 around the Martello Tower, with rates ranging from -0.2 to -1.1 m/yr.
  - Between profiles P4 and P1, there is a tendency for accretion, except at P2, where erosion is predicted at -0.7 m/yr.

2075 Projections:

- Similar to 2025, change in beach position based on volume changes to rock outcrop.
  - Erosion continues between profiles P4 and P7, with rates again ranging from -0.2 to -1.1 m/yr.
  - Accretion is expected between profiles P4 and P1, with predicted rates between +0.1 and +0.8 m/yr.

Overall, the 2075 results under future climate conditions are broadly consistent with the 2025 projections.

At White Rock Beach under conditions of pure tides, the revetment impact on current speed and flow circulation is negligible. When offshore waves originate from the northeast (NE), the nearshore currents predominantly flow southward. The impact on current speed is generally small, except in the area adjacent to the revetment, where changes of up to 0.10 m/s are observed. When offshore waves originate from the east-northeast (ENE), the nearshore currents continue to flow mainly southward. The impact on current speed remains small, although the location of the clockwise eddy in front of White Rock Bay shifts slightly. When offshore waves originate from the south (S), the nearshore currents predominantly flow northward. The impact on current speed is generally small, but the location of the maximum current speed within the clockwise eddy in front of White Rock Bay shifts approximately 20 meters northward. Similar shifts in the location of the clockwise eddy are also observed in the Baseline case. These shifts are attributed to minor variability in wave conditions, such as changes in mean wave direction (MWD) of plus or minus 10 degrees. Therefore, the change in the eddy's location is not considered significant.

Model results indicate a reduction in the sediment feed into White Rock Beach. This reduction is primarily attributed to the footprint of the proposed revetment, which obstructs part of the northward sediment drift that typically supplies the bay. A clockwise eddy located in front of the bay facilitates the offshore movement of beach sediment. This eddy is observed under wave conditions ranging from east-northeast (ENE) to south (S). However, its exact position along the coast can vary depending on the incident wave conditions. Given the reduced sediment input into the bay and no corresponding change in the seaward sediment drift, it is likely that White Rock Beach will experience erosion in the short to medium term.

No sand bar is evident in the vicinity of White Rock Bay, specifically within 400 meters offshore from the shoreline. The impact of the proposed revetment on wave decay within the surf zone is negligible, with changes less than 0.10 m observed across all simulated wave scenarios.

2.6.3 Limitations

The sediment transport model operates under the assumption that sediment is readily available. It does not impose any constraints on sediment availability, except in the areas identified as rocky to the south of White Rock Beach.

3. References

Jacobs, 2023. Wave and Sediment Transport Modelling (Phase 1) for East Coast Railway Infrastructure Protection Projects, Report 7694-ZZ-P2-ENG-CM-JAC-0001, Issued March 2023.

Jacobs, 2024. Phase 2 Coastal Area Modelling Boundary Conditions Report for East Coast Railway Infrastructure Protection Projects, Issued January 2024.

Jacobs, 2025. Phase 3 Coastal Processes Report for East Coast Railway Infrastructure Protection Projects, Report 7694-CCA2_3-P3-REP-CV-JAC-0001, Issued August 2025.

Ove Arup, 2020. East Coast Erosion Study, Assessment of Existing Coastal Processes and Coastline Evolution, July 2020

Appendix A. LITDRIFT

The two-dimensional sediment transport model, MIKE 21 ST, is primarily designed to simulate sand transport, with a grain size limit of up to 2mm. However, to evaluate sediment transport involving coarser materials such as shingle, the LITDRIFT model—capable of handling both sand and shingle fractions—was employed. Specifically, the LITDRIFT model was used to determine an appropriate scaling factor that could translate sediment transport results obtained for 2mm sand to those applicable for larger shingle sizes, namely the 15mm seen in CCA2-3 sediment samples.

Eight coastal profiles were analysed (Figure A - 1) using nearshore wave climate data spanning from January 1988 to December 1997. Sediment transport simulations were conducted for two representative grain sizes—2mm and 15mm—corresponding to D50 values, with bed roughness in the LITDRIFT model set as 20 times the D50 for each case. The model did not account for the presence of rocky seabeds, assuming uniform sediment conditions across all profiles. Results consistently indicate a net northward sediment transport direction across the entire study area.

Table A - 1 shows the results of the two different sediment sample sizes. Differences in transport rates between the two sediment sizes yield an average scaling factor of 0.16. This means that sediment transport results initially calculated for 2mm grain size using the CAM model can be adjusted to represent 15mm shingle by applying this factor.

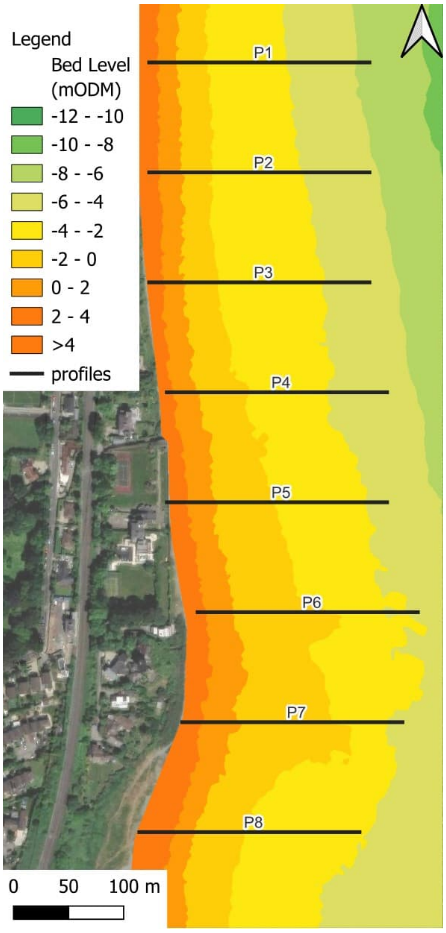

Figure A - 1. LITDRIFT profiles used for varying sediment size

Table A - 1. LITDRIFT yearly transport rates for varying sediment sizes

Profile	Net transport D50 2mm (m^3/yr) (graded sand)	Net transport D50 15mm (m^3/yr) (graded sand)	Scale factor 15mm
1	-17330	-2732	0.16
2	-19350	-2886	0.15
3	-19410	-2995	0.15
4	-20700	-3057	0.15
5	-21460	-3629	0.17
6	-21650	-3982	0.18
7	-21810	-3693	0.17
8	-20770	-2598	0.13

Appendix B. CAM model additional result

B.1 Yearly Morphological Results

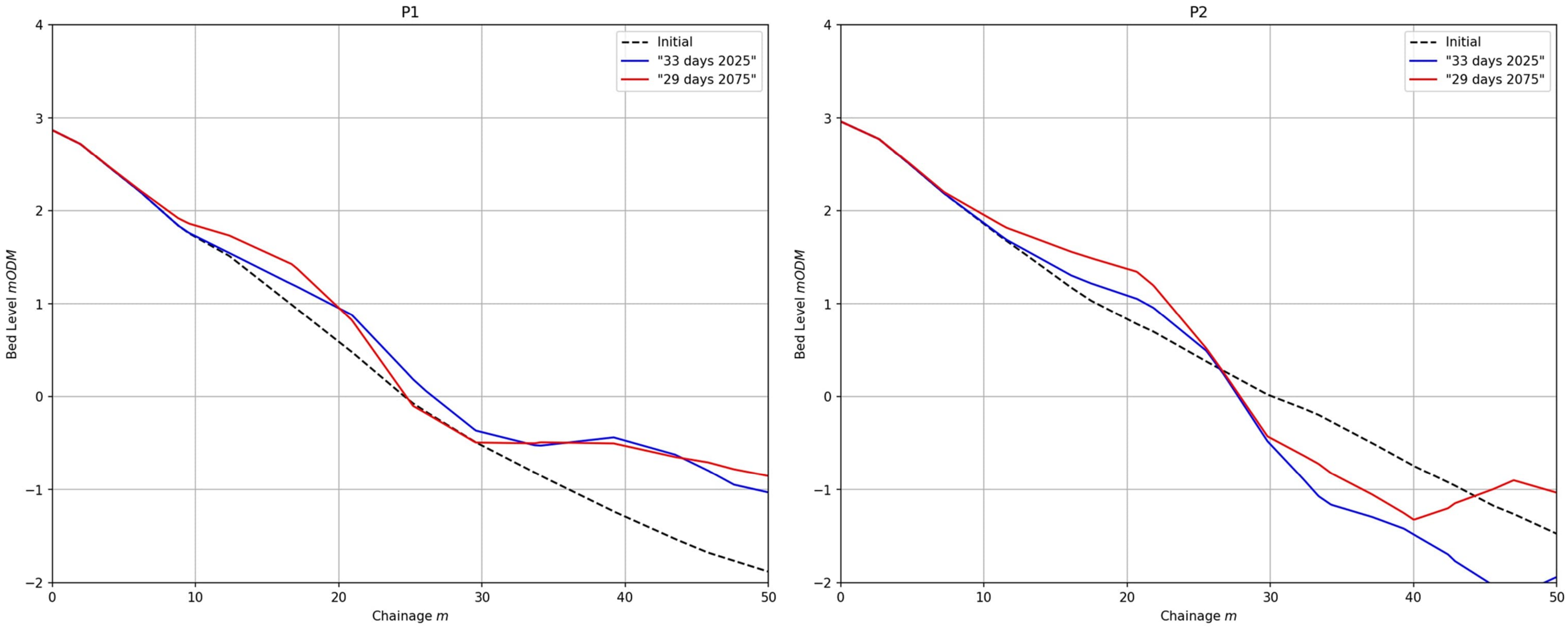

Figure B - 1. Yearly bed level changes for both present day and climate change after one equivalent year (33 days present day and 29 days 2075) - profiles P1 and P2. Results using 2mm grainsize

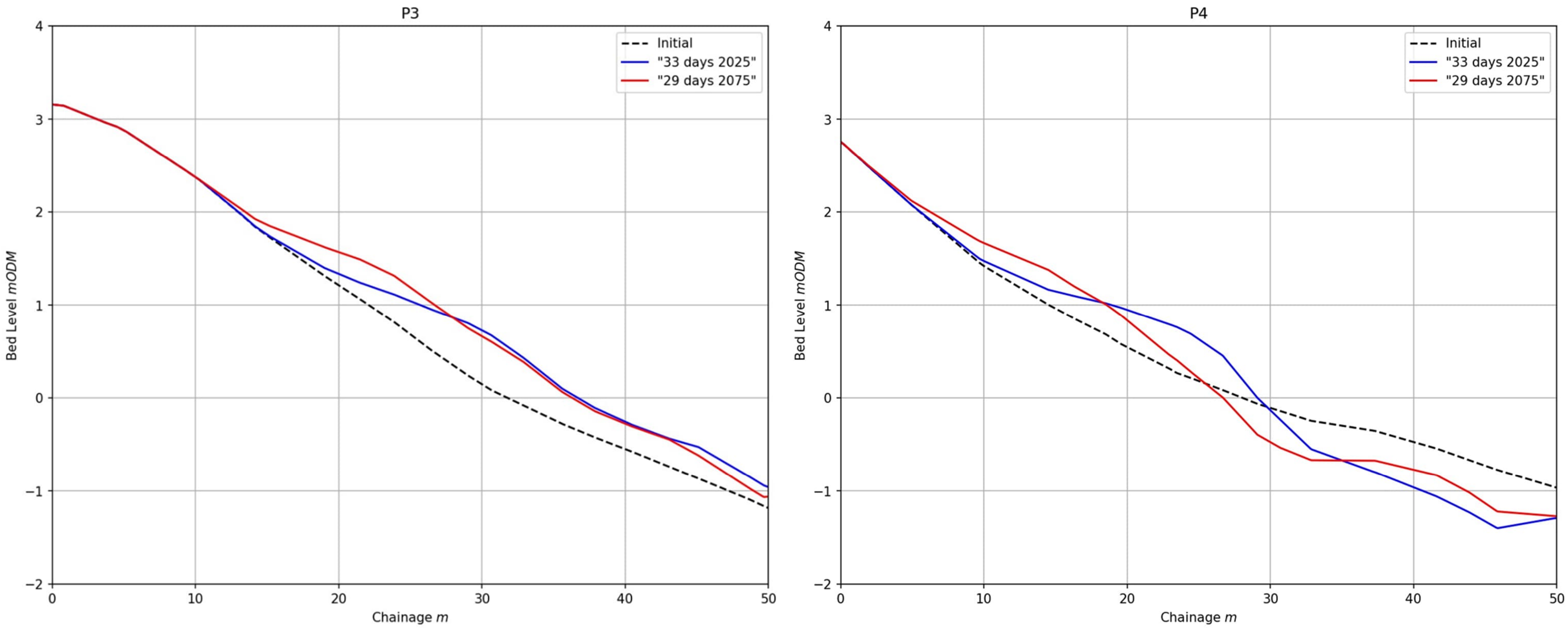

Figure B - 2. Yearly bed level changes for both present day and climate change after one equivalent year (33 days present day and 29 days 2075) - profiles P3 and P4. Results using 2mm grainsize

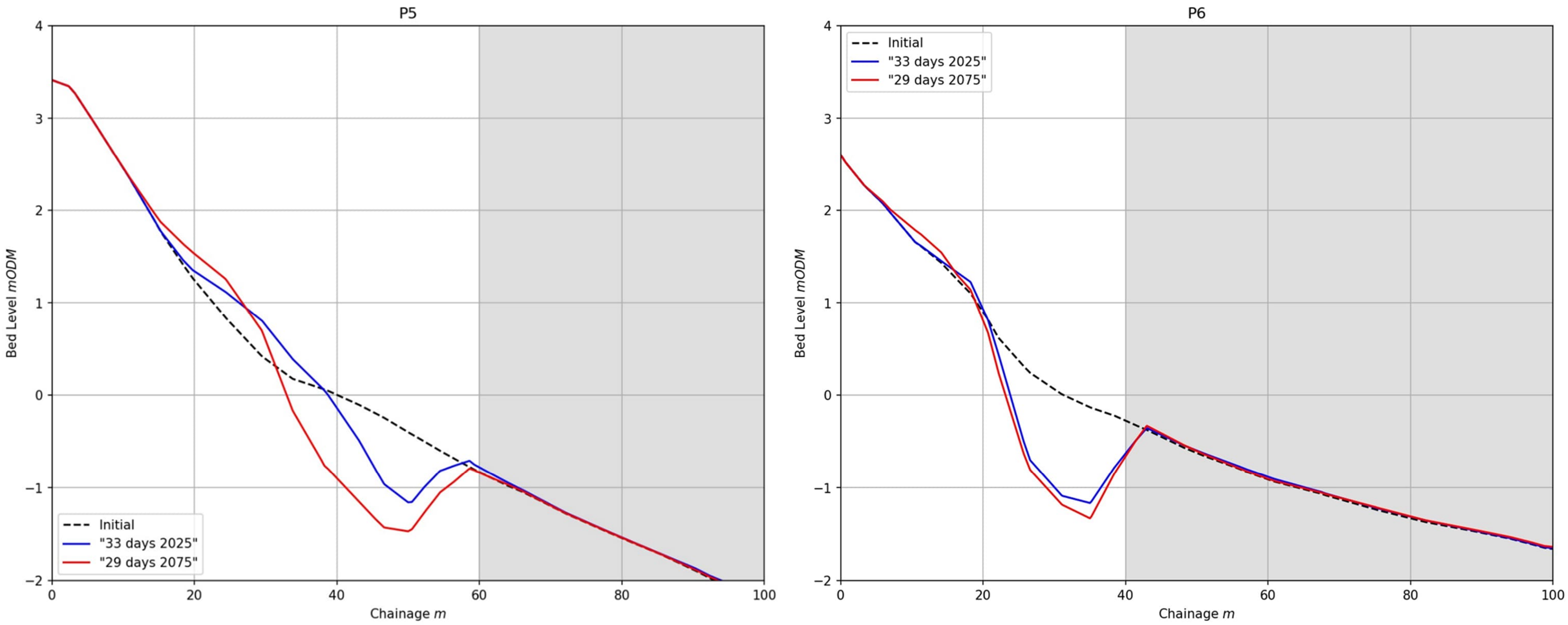

Figure B - 3. Yearly bed level changes for both present day and climate change after one equivalent year (33 days present day and 29 days 2075) - profiles P5 and P6. Results using 2mm grainsize

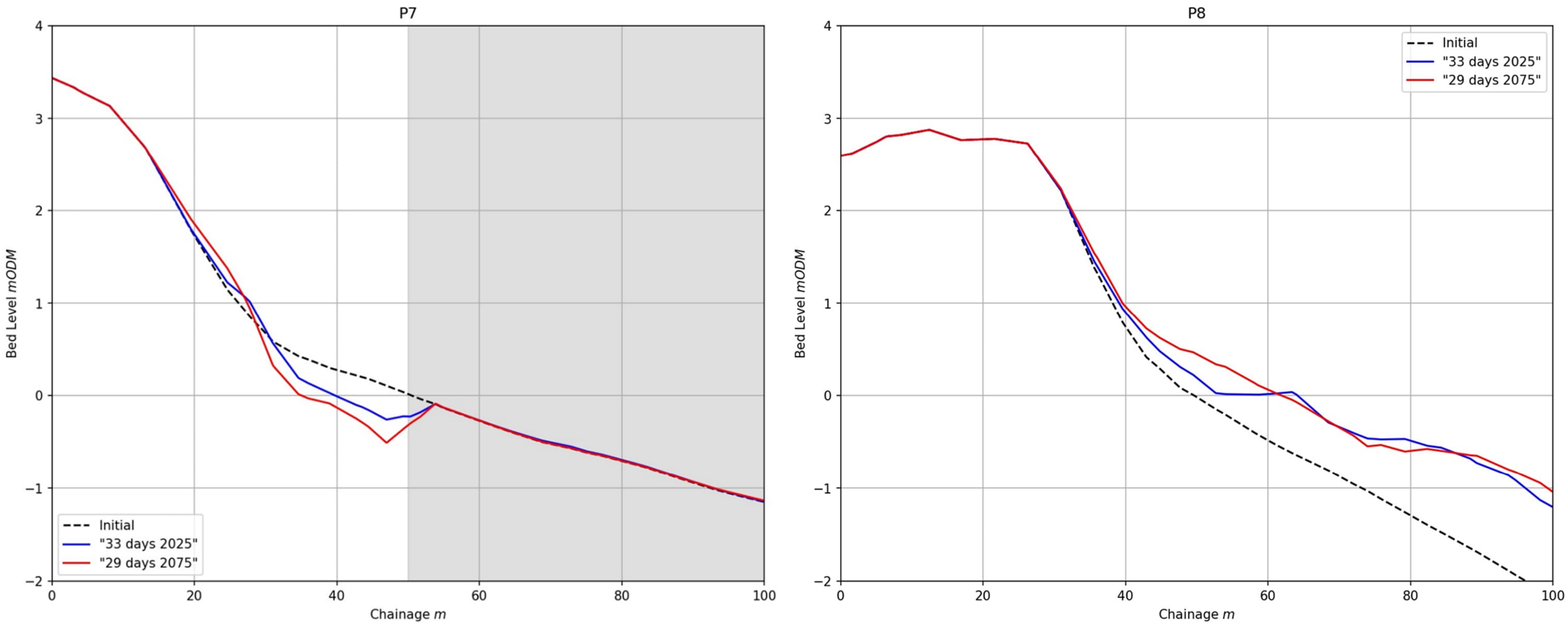

Figure B - 4. Yearly bed level changes for both present day and climate change after one equivalent year (33 days present day and 29 days 2075) - profiles P7 and P8. Results using 2mm grainsize

Appendix C. White Rock Current Speeds

C.1 Current speeds at -2hrs HW and HW

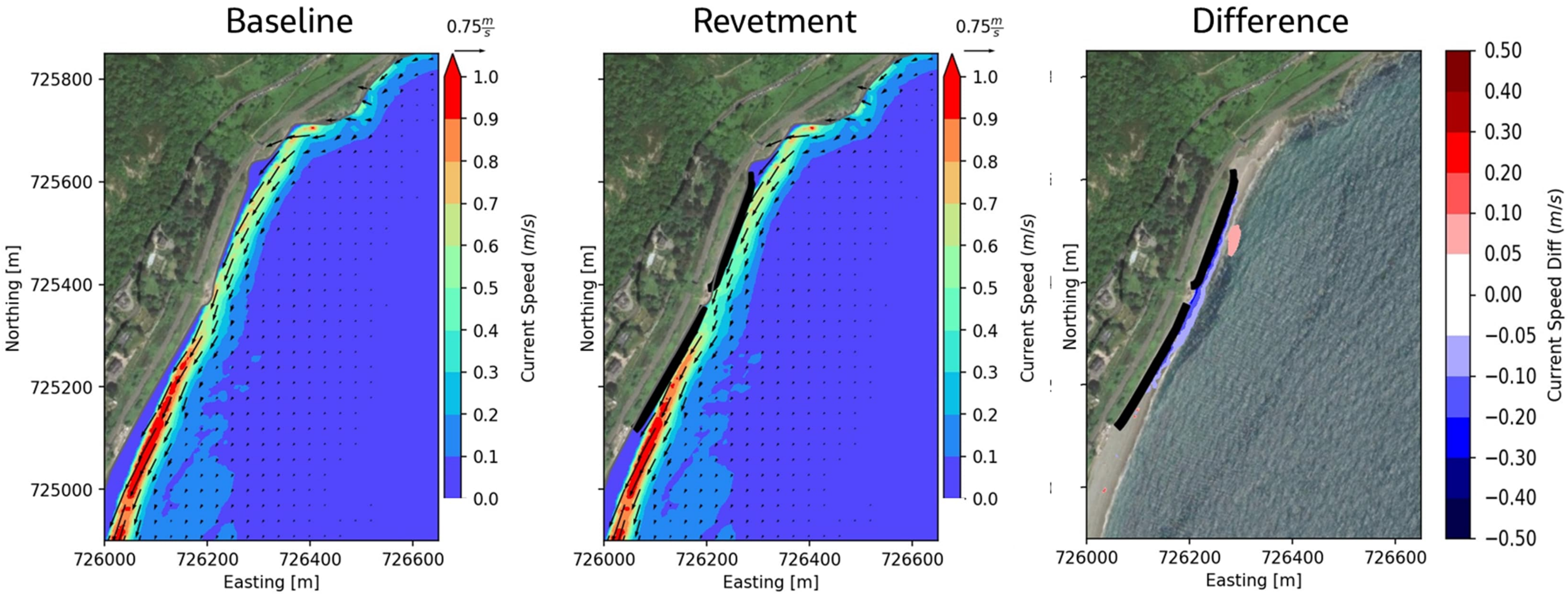

Figure C - 1. Waves from 45 deg current speeds at high water -2hrs, left=baseline, middle=revetment, right=difference (revetment-baseline)

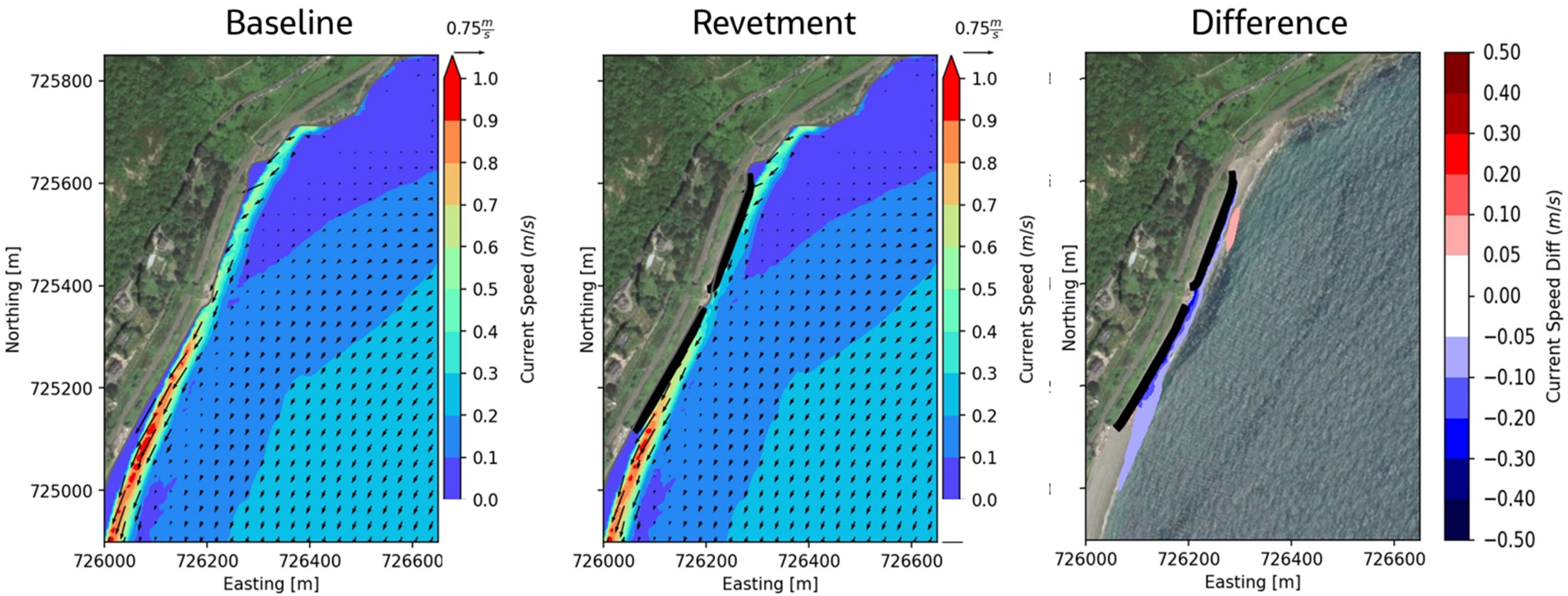

Figure C - 2. Waves from 45 deg current speeds at high water, left=baseline, middle=revetment, right=difference (revetment-baseline)

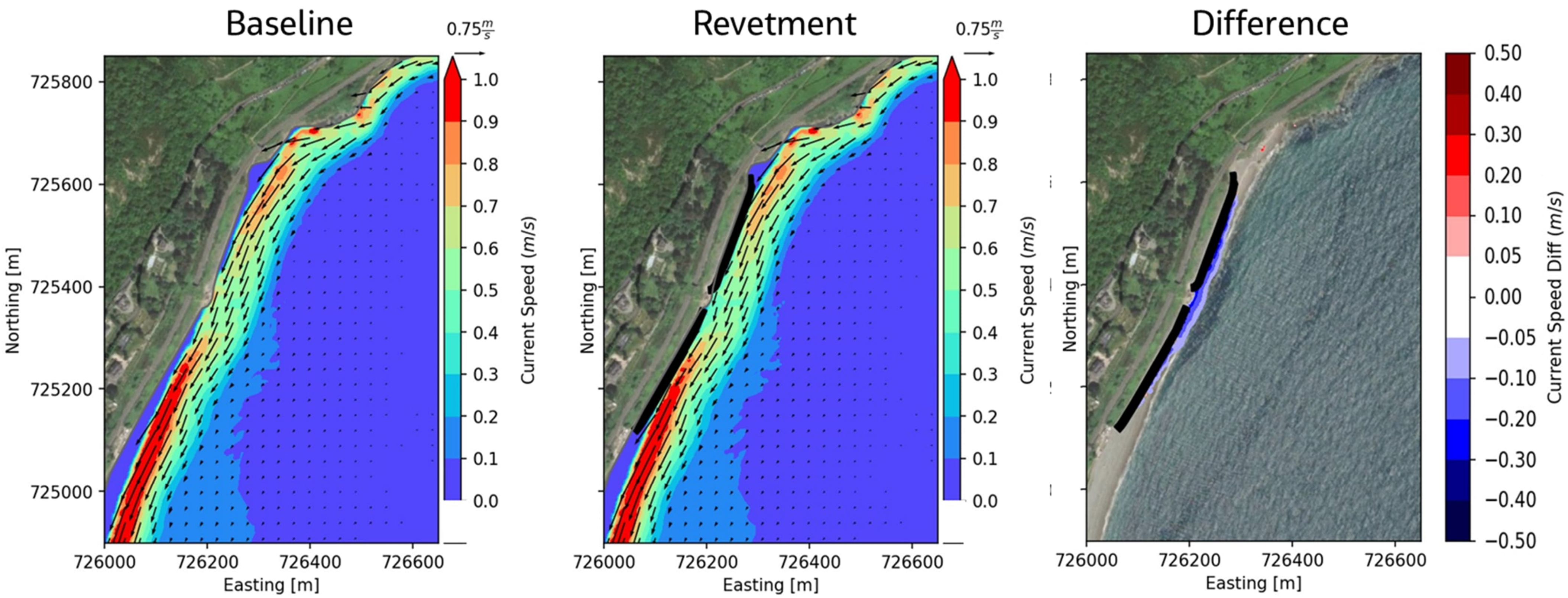

Figure C - 3. Waves from 75 deg current speeds at high water -2hrs, left=baseline, middle=revetment, right=difference (revetment-baseline)

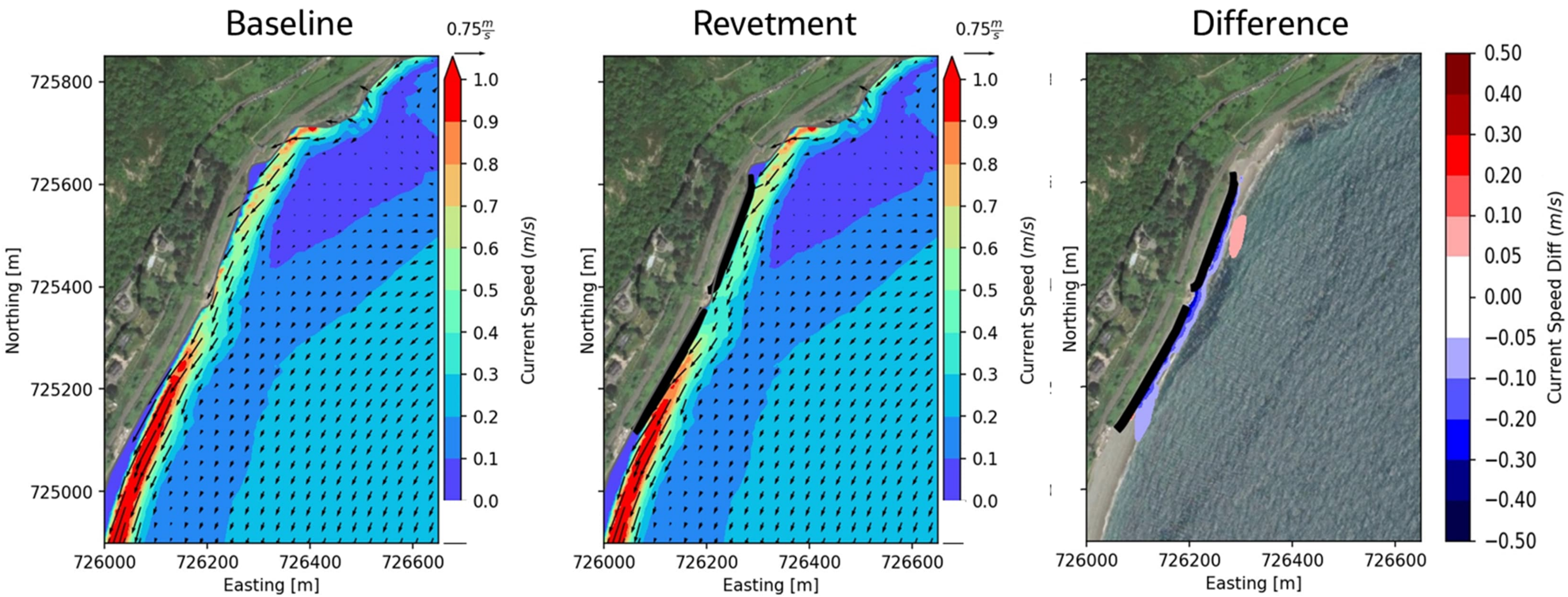

Figure C - 4. Waves from 75 deg current speeds at high water, left=baseline, middle=revetment, right=difference (revetment-baseline)

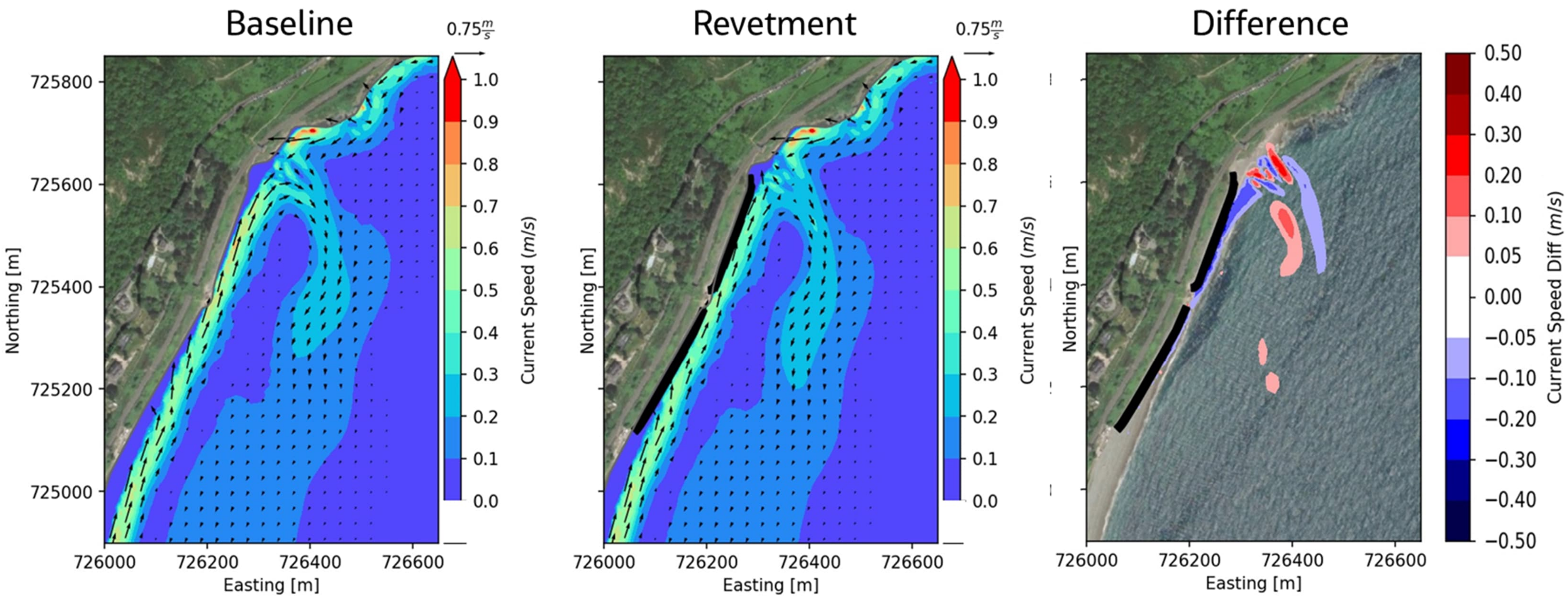

Figure C - 5. Waves from 185 deg current speeds at high water -2hrs, left=baseline, middle=revetment, right=difference (revetment-baseline)

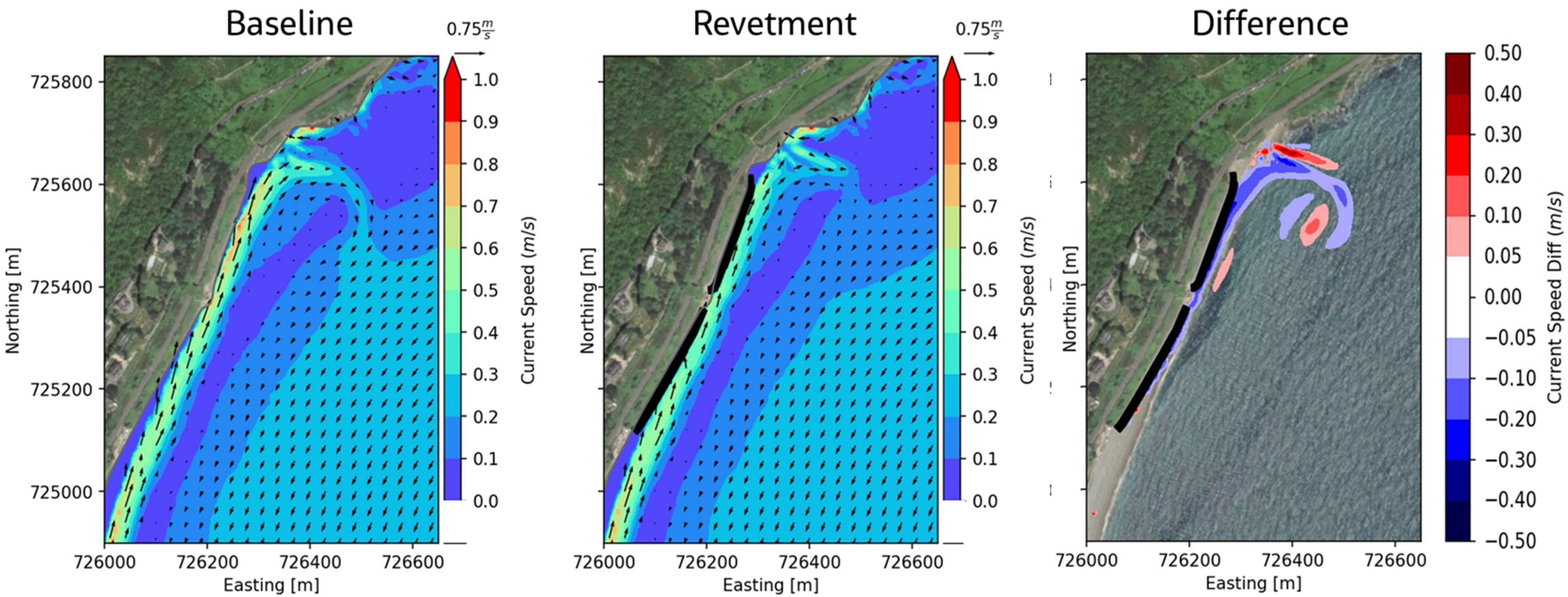

Figure C - 6. Waves from 185 deg current speeds at high water, left=baseline, middle=revetment, right=difference (revetment-baseline)

C.2 Impact on current speeds at HW Offshore waves from 185 +/- 10 deg

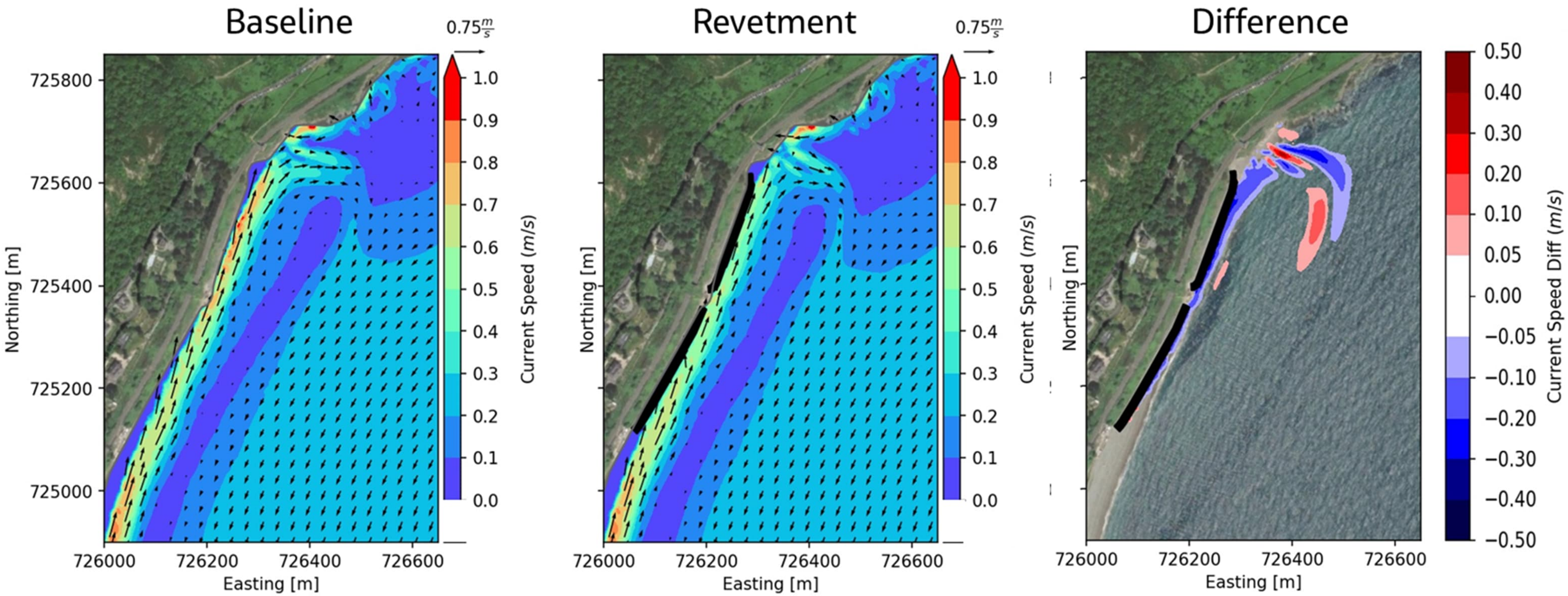

Figure C - 7. Waves from 175 deg current speeds at high water, left=baseline, middle=revetment, right=difference (revetment-baseline)

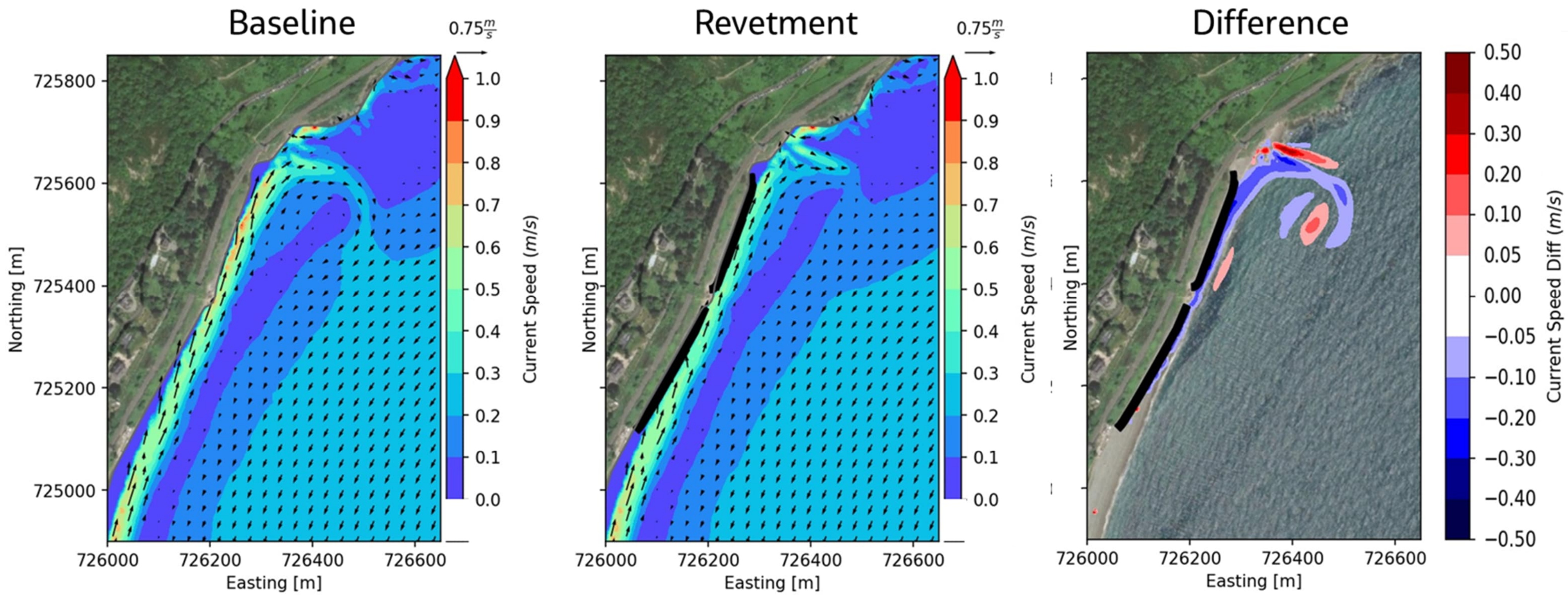

Figure C - 8. Waves from 185 deg current speeds at high water, left=baseline, middle=revetment, right=difference (revetment-baseline)

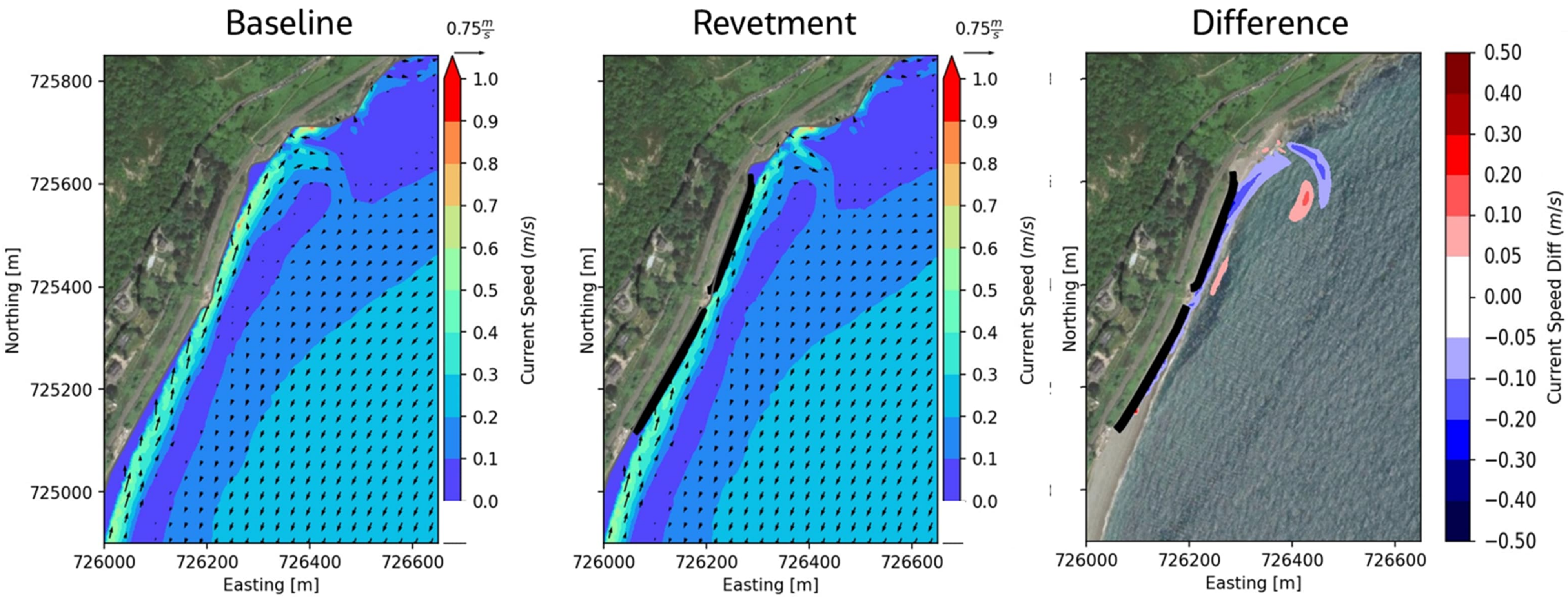

Figure C - 9. Waves from 195 deg current speeds at high water, left=baseline, middle=revetment, right=difference (revetment-baseline)

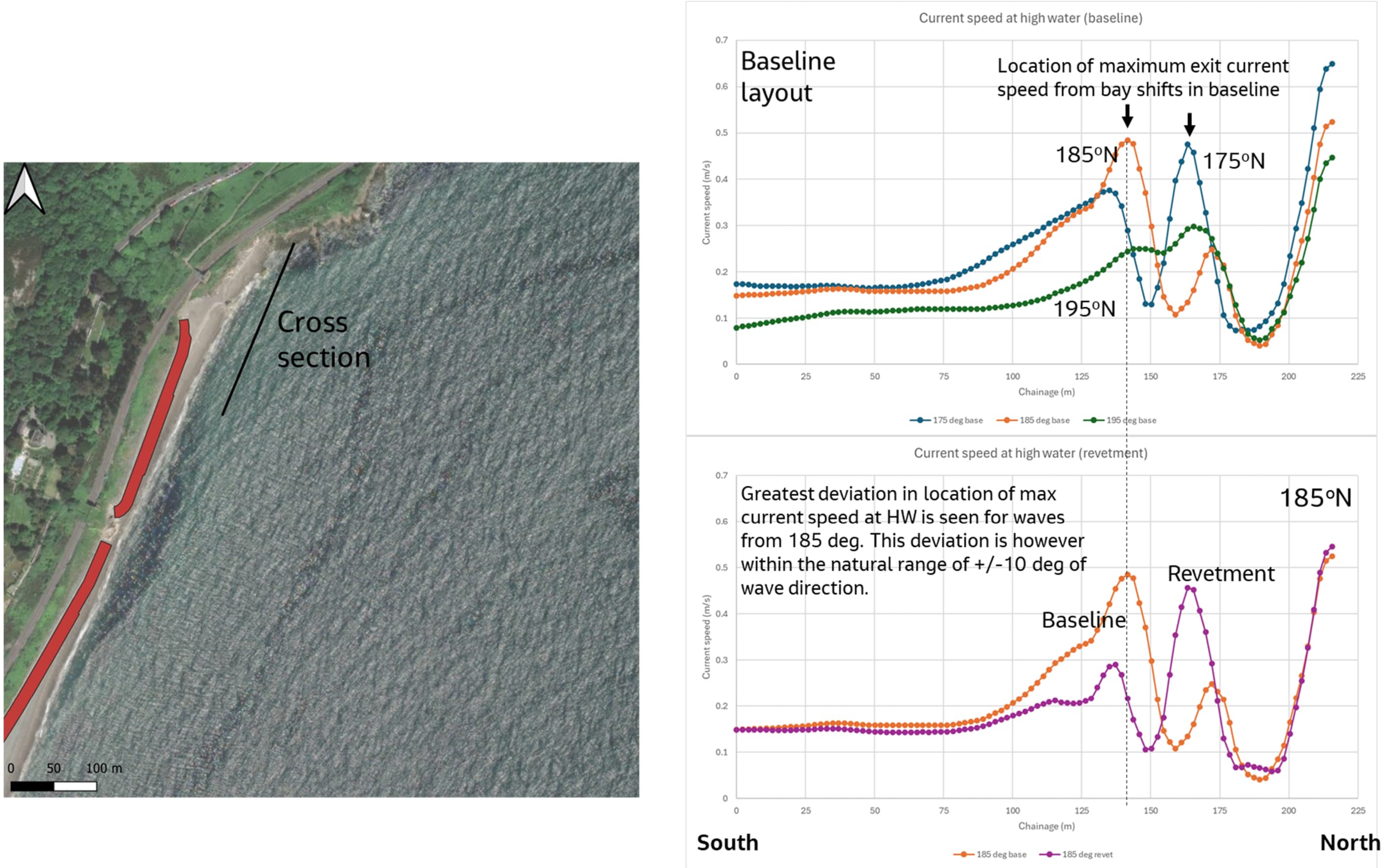

Figure C - 10. High water - Current x-section for waves from 175,185,195 deg