



Mussel Spat Catching Farm

West Coast Waikato

Report prepared for North Western Mussels Ltd

October 2024

Document History

Versions

Version	Revision Date	Summary	Reviewed by
0.1	31/05/2024	Draft for client review	Cussioli/Berthot
0.2	18/06/2024	Draft addressing comments	Cussioli/Berthot
0.3	24/06/2024	Draft for internal review	Cussioli/Berthot/Beamsley
0.4	29/06/2024	Draft for internal review	Cussioli
0.5	08/07/2024	Draft for client review	Cussioli/Berthot/Beamsley
0.6	10/07/2024	Draft for client review	Cussioli
0.7	10/07/2024	Draft for client review	Cussioli/Brett
0.8	12/082024	Draft for client review	Cussioli/Berthot

Distribution

Version	Date	Distribution
1.0	22/10/2024	North Western Mussels Ltd

Document ID: P0589 - 01

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Executive Summary

North Western Mussels Limited (NWML) is planning to apply for a resource consent to undertake green lipped mussel (*Perna canaliculus*) spat collection and nursery activities off the west coast of Waikato, New Zealand. NWML have asked MetOcean Solutions (MOS) to assess the potential effects of the spat collection and nursery activities on the wave and hydrodynamics around the spat catching sites, nearshore and at surf breaks of national and regional significance in the environs (Figure 1).

In general the impacts of the proposed spat collecting lines on wave conditions immediately offshore the Nationally and Regionally significant surf breaks are considered to be no more than minor. Methodologies and findings are summarised below.

The industry standard Delft3D-WAVE model was used to simulate scenarios with and without the proposed spat collection structures (backbone lines) for the most frequent wave conditions (wave height, period and direction) in the region (e.g. Figure 2). Since some nationally and regionally significant surf breaks are located in the area, we also simulated conditions that are conducive for producing high quality surfing wave conditions at the nationally and regionally significant surf breaks within the region. Results are presented as maps illustrating the differences in the wave height between the simulations with and without the backbone lines, i.e., how the structures could potentially affect wave heights within the region and in the lee of the structures.

To account for the potential wave height attenuation due to the presence of the spat collecting structures, each longlines within the proposed spat collecting areas were defined as individual 'obstacles' within the numerical model. Based on the work of Plew (2005) and knowing the Energy Transmission Ratio (ETR) for the size of the proposed structures and density of the dropper lines, the associated transmission coefficients for each longline was able to be determined iteratively. These were:

- a. transmission coefficient of 0.988 (98.8%) per line for a total transmission of 64% (the equivalent of a dropper density of 0.08 droppers.m⁻²), and
- b. transmission coefficient of 0.991 (99.1%) per line for a total transmission of 71% (the equivalent of a dropper density of 0.06 droppers.m⁻²).

The results for the most conservative of the coefficients (a) 0.988 (i.e., less transmission = more attenuation in wave height) are presented in Figure 3 to Figure 5. Results show that for waves from southwest ($H_s = 2$ m, $T_p = 12$ s), in the lee of the farms, wave height could potentially be reduced by 15% (Site A, B and C) and 8.5% for Site D. At the shoreline directly inshore of the Sites there is a potential change of order 6% (Site A), 9-10% (Site B-



C) and 4% (Site D) can be expected. The largest changes in wave direction occurred for waves from the west. In the lee of the farms, wave direction could potentially change 1.7 degrees for Site A and 1.5 degrees for site D, with lower values at the shoreline. As adopted by Mead (2013), changes less than 2 degrees were considered 'very small' and are not illustrated in the associated figures.

An assessment of potential effects of the farm on the hydrodynamics based on the literature and hindcast current data was undertaken. In general, the effects of the farm are localised and minor. The farm is aligned with the main current directions (based on the hindcast) which minimises attenuation. In addition, giving the length of longlines and local depth, there could potentially be more than 60% gap in the water column (accounting for the gap between the sea surface and submerged backbone lines, and the gap between the dropper lines and the seabed), minimising flow restriction and turbulence. The sites are located in regions of relatively slow current velocities, and as such it is likely that potential effects of the spat lines on hydrodynamics can be expected to be localised and minor.

We conducted additional simulations with backbone lines spaced every 100 m (half the number of backbone lines in each site). Maintaining a consistent transmission coefficient per line, we observed that the reduction in wave height was approximately halved compared to scenarios with 50-meter spacing. Consequently, this adjustment resulted in reducing spatial extent of affected wave heights.

Depending on the wave incident direction relative to the orientation of the spat lines (represented as obstacles in the numerical model) cumulative attenuation can occur.

Based on the simulated dropper densities and transmission coefficients, the effect of the proposed spat lines on wave heights at the Raglan nationally and regionally significant surf breaks is expected to be minor, with less than 1% changes expected. For the surf breaks to the north of Raglan (Te Akau), wave height change near the shoreline could potentially be of the order 3-4% for waves propagating from the northwest. For the surf breaks to the south of Raglan (Ruapuke Beach), wave height change near the shoreline could potentially be of the order 2-4% for waves propagating from both the northwest and west (noting that these directions are not conducive for producing quality surf conditions). Wave direction change near the shoreline could potentially be 0.3 degrees or less.

We assumed the same transmission coefficient for all scenarios regardless of the wave period. Results for scenarios with peak wave period greater than 10 s are likely conservative, since longer period waves tend to be less attenuated than short period waves.



The effects of the spat catching farm on the wave and current attenuation, foreshore, and surf breaks of national and regional significance are summarised in Table 1 (for 64% transmission). In general, the impacts of the proposed spat collecting lines are considered to be no more than minor. Wave direction modifications by the proposed spat lines are expected to be very small and are not expected to impact the quality of the surfable waves.

Coastal processes are generally not expected to be significantly affected by the reduction in wave height. A high-level analysis on longshore transport has been conducted using an empirical formula (Kamphuis, 2000) and considering the changes in the nearshore related to a reduction in wave height from 2% to 10% and change in wave direction by ± 1.2 degrees (Table 1). The analysis indicates a reduction in longshore transport due to these changes. For the most frequent waves (southwest, with 82% occurrence in the offshore area, Table 2-1), this suggests a potential reduction of about 2-20% in longshore transport to the north and the attenuation may slightly reduce the potential storm erosion. For the rest of the time (approximately 19%), waves typically approach from the West or Northwest. This pattern suggests a reduction in southward sediment transport. The percentage change represents very small and localized changes along the beach and is site-dependent, e.g., the highest changes in significant wave height (10%) occur only at sites B-C within a narrow, discrete region for the conditions simulated (Figure 3-3 top right).



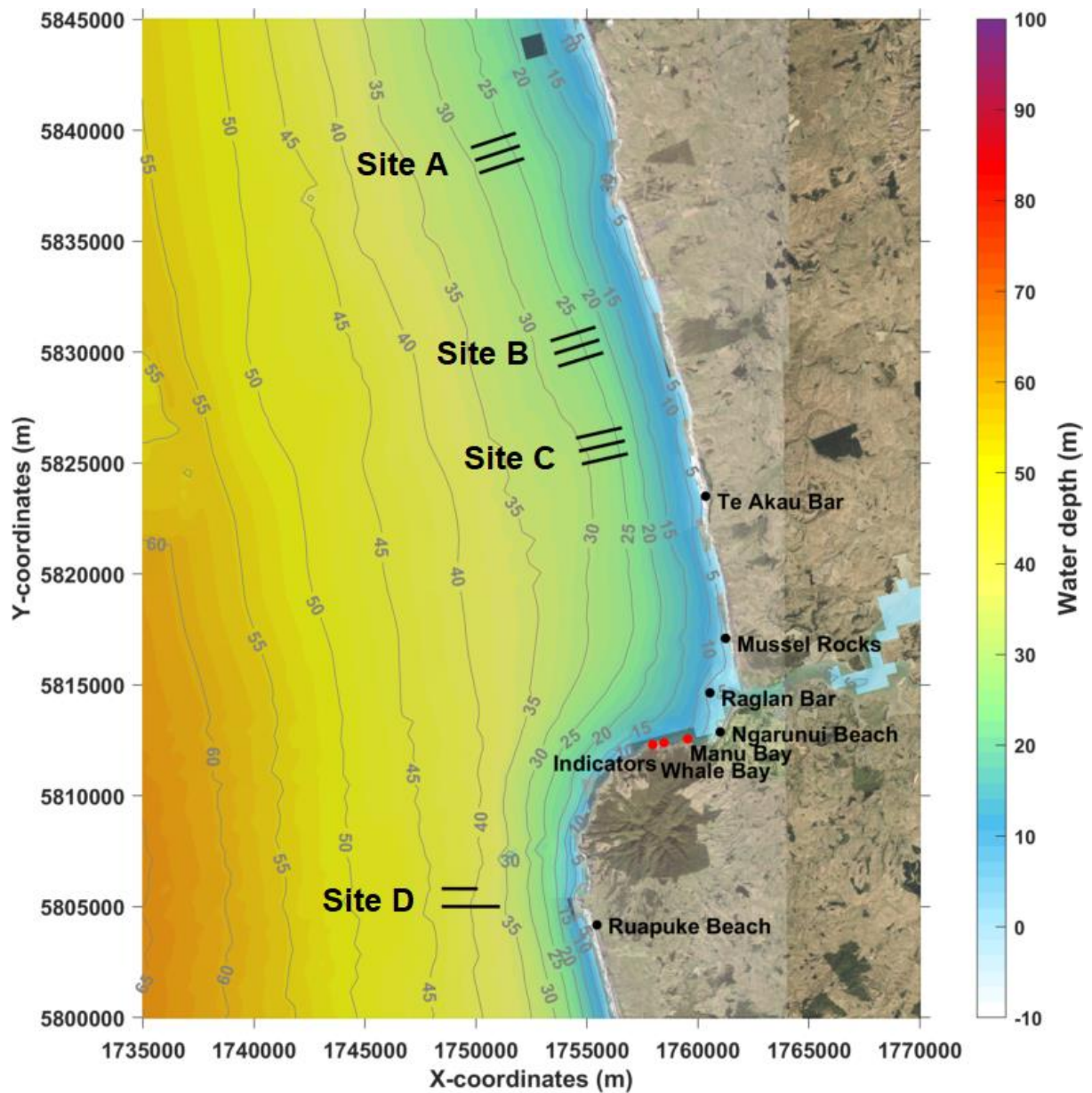


Figure 1 Map of surf breaks of national and regional significance (red and black points, respectively) and proposed mussel spat nursery sites (black lines).

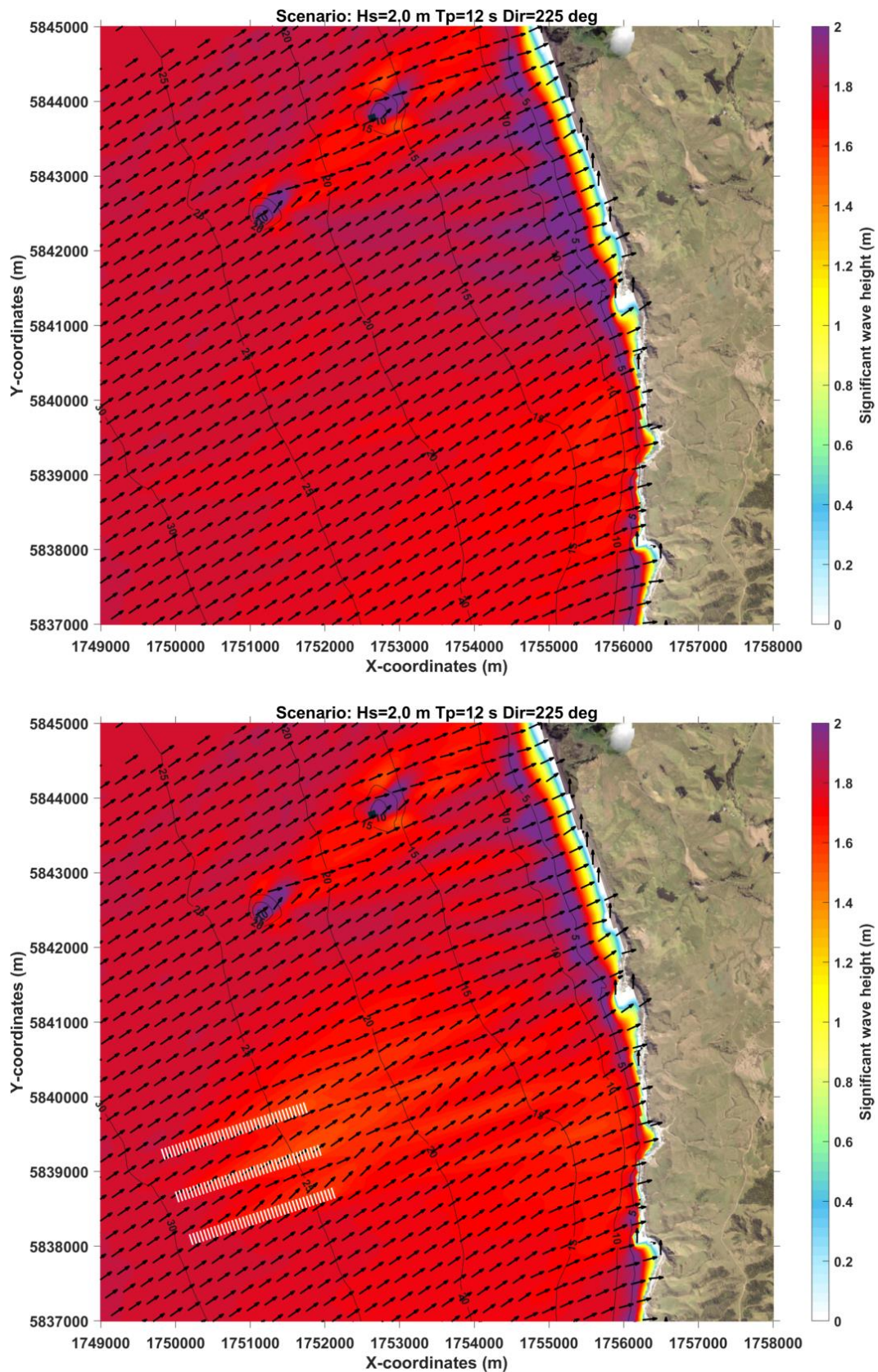


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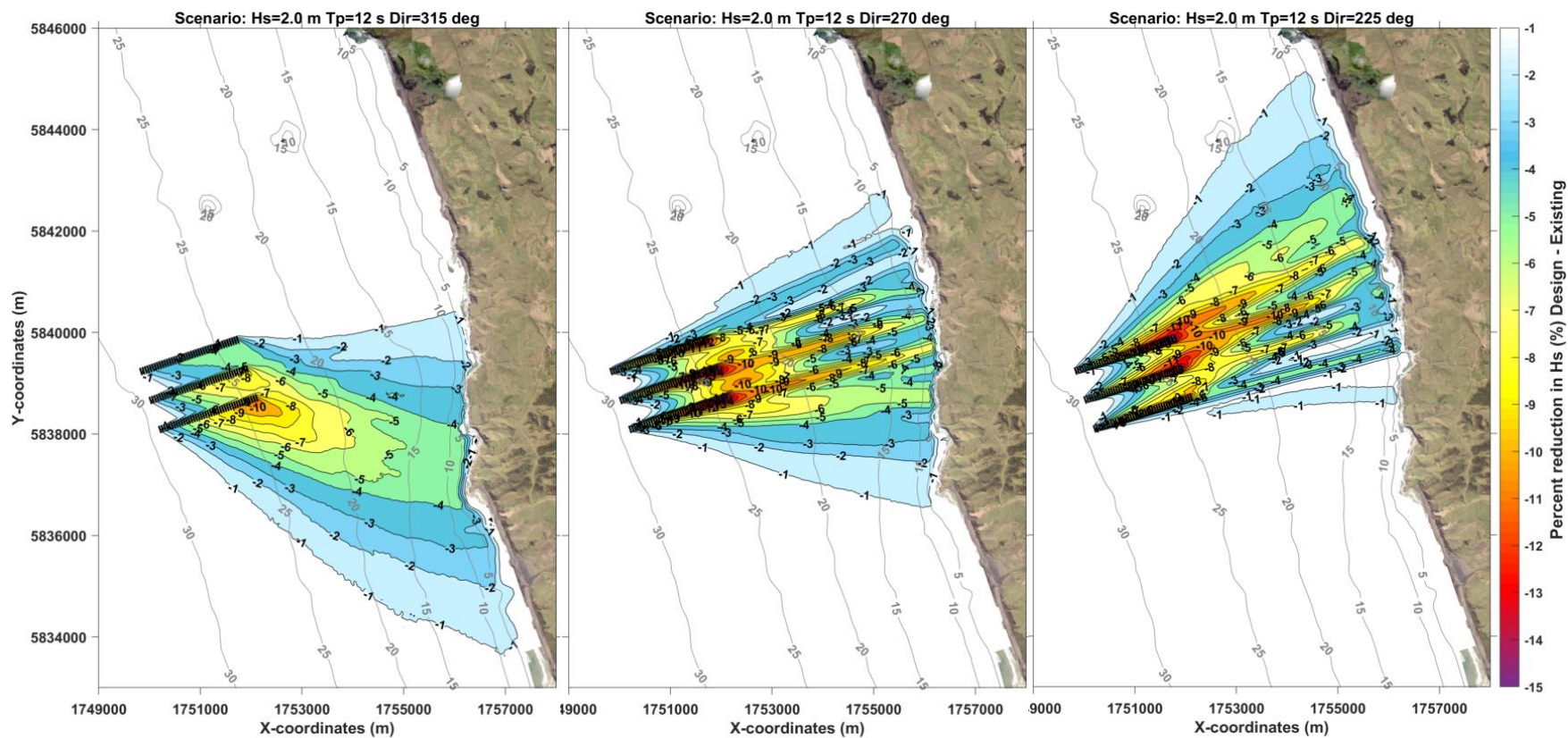


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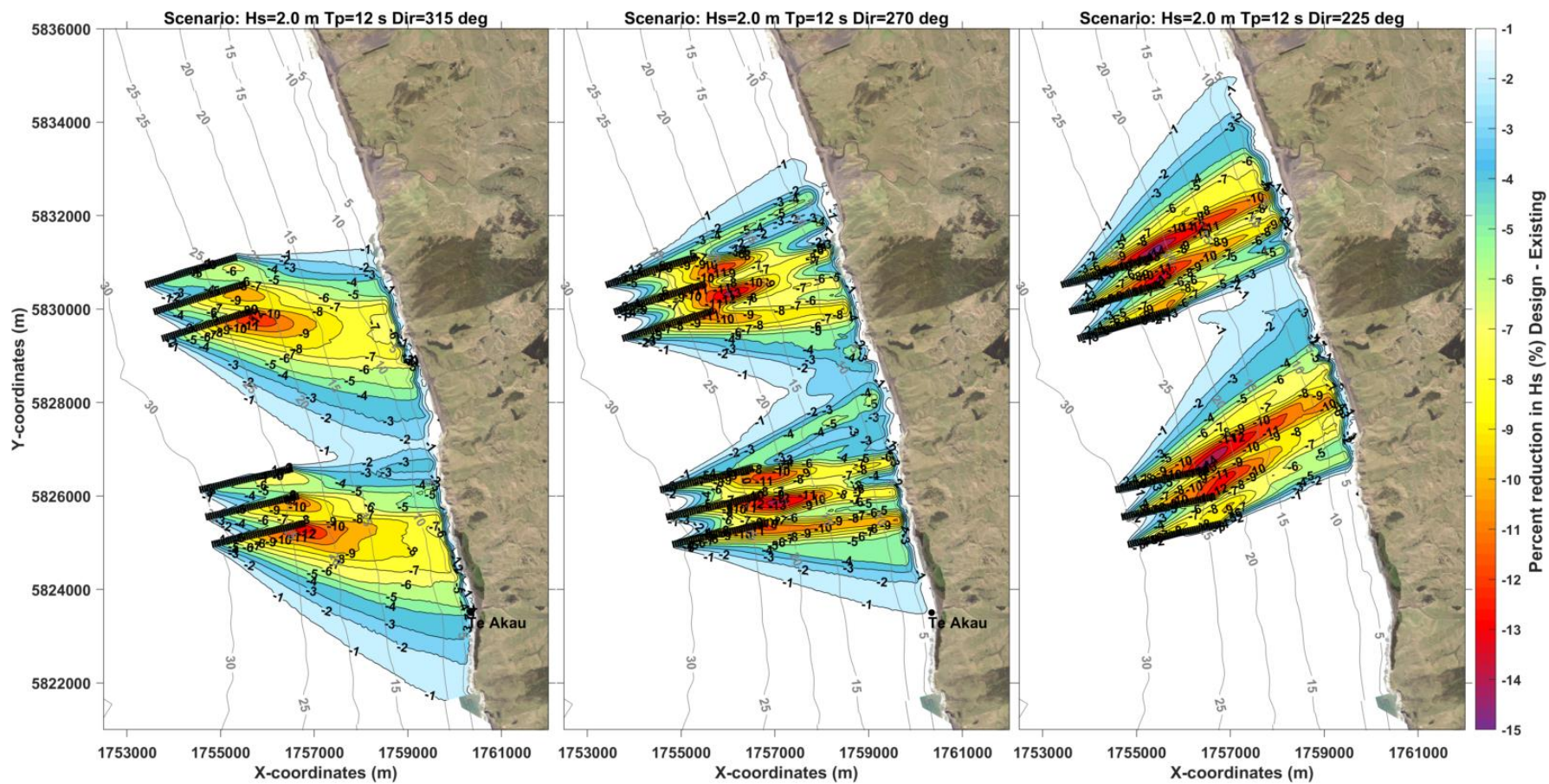


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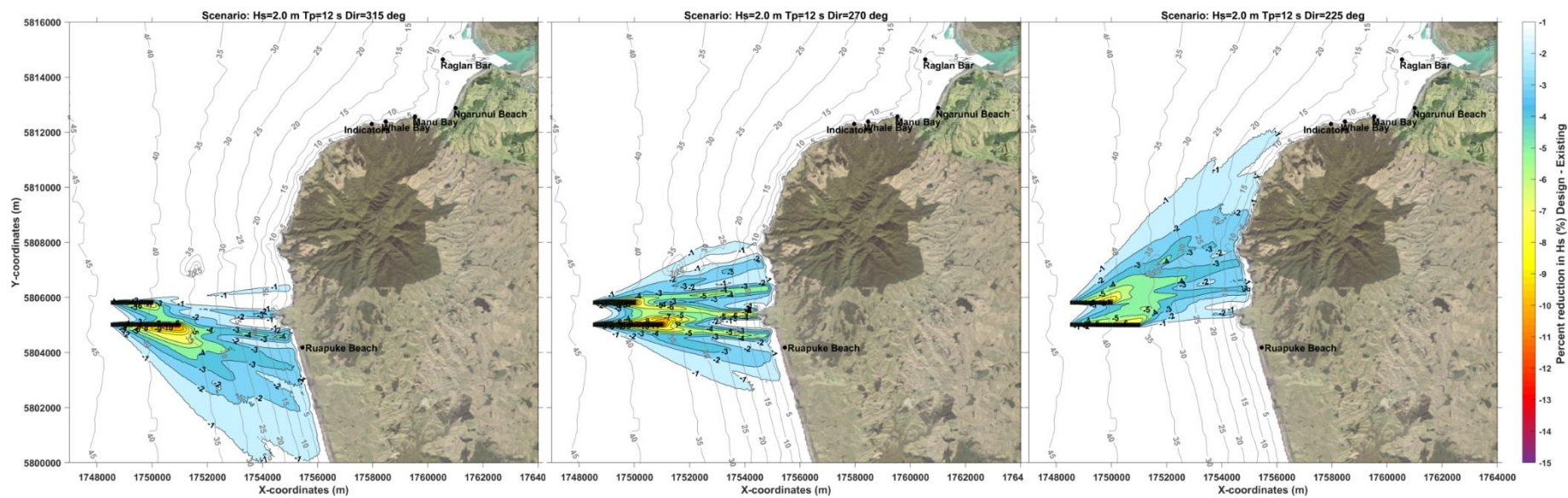


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Table 1 Summary of effects.

Physical elements	Qualitative and/or quantitative assessment	Effects statement
Wave attenuation	8.5-15% potential reduction in wave height in the lee of the farm depending on Site and incident wave direction. Change in wave direction less than 1.7 degrees.	Localised and minor Very small
Current attenuation	Farm is aligned with flow to minimise attenuation. More than 60% gap in water column giving local depth and length of longlines, i.e. not restricting flow. Sites present slow currents in a high wave energy area. Potentially more localised effect on the flow over a smaller area compared to areas with faster currents.	Localised and minor
Effect on foreshore	4-10% potential reduction in wave height on the nearshore directly in front of the sites. Percent reduction depending on Site and incident wave direction. Change in wave direction less than 1.2 degrees. 2-20% potential reduction in longshore transport along the beach, site dependent.	Minor Very small Very small and localized
Effect on surf breaks of national significance	1% change contour do not extend to the surf breaks of national significance. No change in wave direction near the surf breaks.	Less than minor
Effect on surf breaks of regional significance	Potential 3-4% change near Te Akau for northwest waves and 2-4% change near Ruapuke for northwest and west waves. Northwest waves have low occurrence. Change in wave direction less than 0.3 degrees.	Minor Very small



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1.Introduction

1.1 Scope of report

North Western Mussels Limited (NWML) is planning to apply for a Resource Consent to undertake green lipped mussel (*Perna canaliculus*) spat collection and nursery activities off the West Coast of Waikato. NWML have asked MetOcean Solutions (MOS) to assess the potential effects of the spat collection and nursery activities on waves and hydrodynamics (with a particular focus on the potential wave attenuation) around the spat catching sites, nearshore, and at surf breaks of national and regional significance in the region (Figure 1-1).

A previous study was carried out by MetOcean Solutions (MetOcean Solutions, 2022) based on a literature review and hindcast data. For this study, we used the industry standard Delft3D-WAVE model to simulate potential effects of the four proposed mussel spat nursery sites (Figure 1-2).



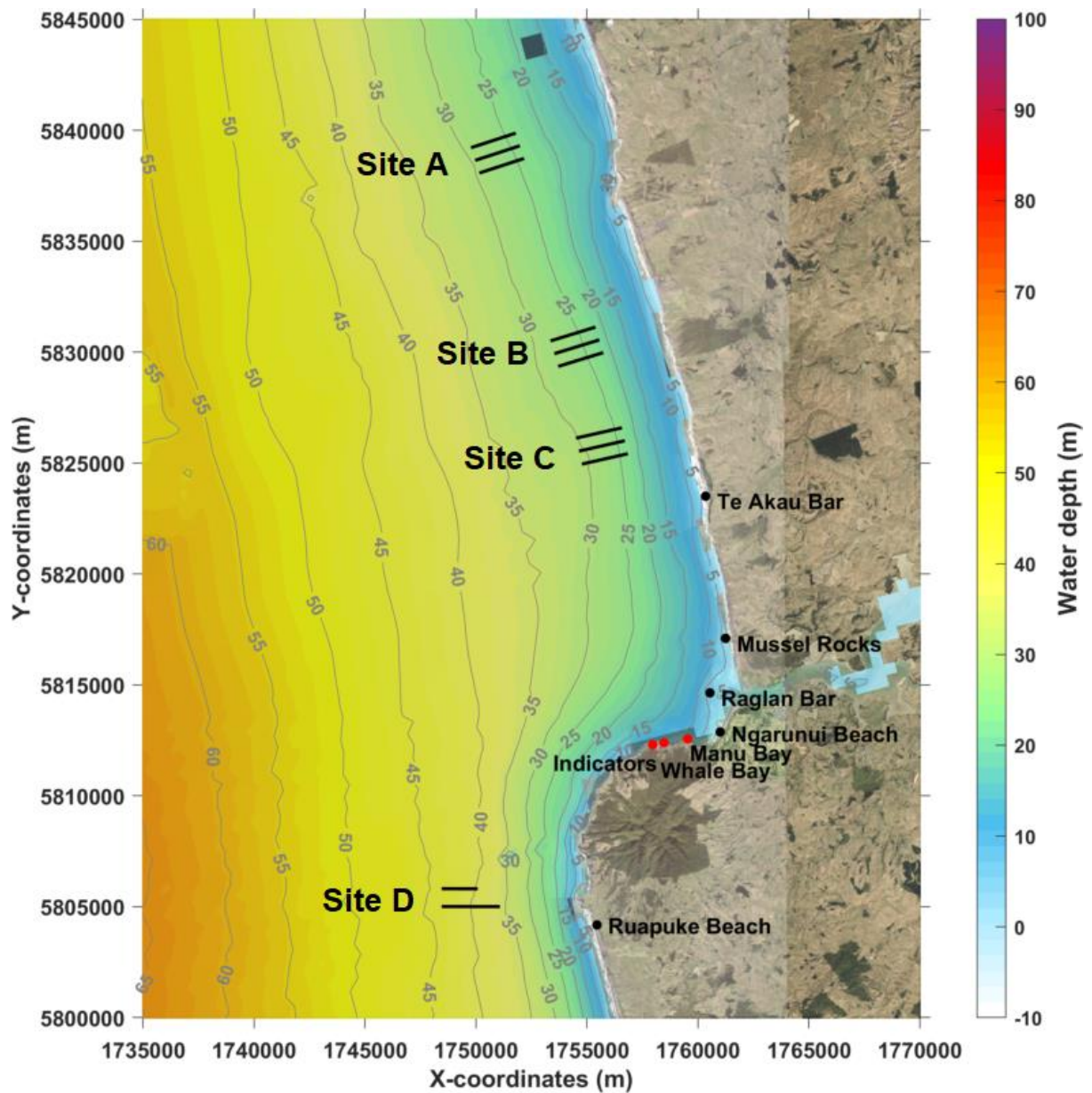


Figure 1-1 Map of surf breaks of national and regional significance (red and black points, respectively) and proposed mussel spat nursery sites (black lines).



Figure 1-2 Locations of the four proposed mussel nursery sites (sites A, B, C and D) and rows on the Waikato west coast.

1.2 Outline of activities

The aim of the west coast nursery is to serve as a donor site of spat to commercial mussel farms in the Hauraki Gulf. Four sites (Site A, B, C and D) have been proposed by the applicant for mussel spat nursery. The sites are between 3 to 4 km from the shoreline and in water depths ranging between 20 to 45 m. The northern and southern most sites (Site A and D respectively) are approximately 32 km apart (see Figure 1-2).

Site A, B and C are proposed to consist of three rows, and Site D is proposed to consist of two rows. The rows at Site A, B and C are expected to measure 300 m x 2000 m (see example Site A in Figure 1-3), whereas, the upper and lower rows at Site D are expected to measure 400 m x 1500 m and 400 m x 2500 m, respectively (Figure 1-4). The total proposed coverage area is of the order 700 hectares (Site A, B, and C = 180 ha each and Site D = 160 ha). The layout of Site D has been modified from the previous study to be outside the main reserves and surf break swell corridors in the area (Figure 1-5).

It is proposed that there will be 41 x 300 m longlines per row for Sites A, B and C, and for Site D, 31 x 400 m (upper row) and 51 x 400 (lower row) longlines (see Figure 1-3 and Figure 1-4). The backbones are expected to be 130-150 m long at a distance of 50 m apart (blue line in Figure 1-3 and Figure 1-4). Each row will consist of single or paired lines which will be anchored by screw anchors 6 to 12 m deep in the seafloor (Figure 1-6), and about 75 m of warp between the anchor point and the longline will be used at either end of the longline. The warp will be longer at the deeper site D.

On the 150 m backbone the catching rope (dropper lines) will go down 8 m and up 8 m once every 0.5 m, so this amounts to 4 droppers or 32 m of catching rope every 1 m of backbone. Considering that this setup will be repeated over 150 m of backbone and for 41 lines covering the 2000 m row (or 31 and 51 lines covering 1500 m and 2500 m for Site D), the droppers line density (or number of droppers per square metre) will be approximately 0.04 dropper.m⁻² for each row of Sites A, B and C (over 160 ha) and 0.03 dropper.m⁻² for each row of Site D (over 180 ha). Should paired lines be used the dropper density would increase to 0.08 dropper.m⁻² for the area where double lines are used (Site A, B, C) and to 0.06 dropper.m⁻² (Site D).

The backbone will be suspended 3 m below the sea surface by 20 floats/buoys of 300 litres each. The spacing of the floats will vary with time and weight on the line but is typically expected to start at 10 m apart and increase to 2m with time and weight.



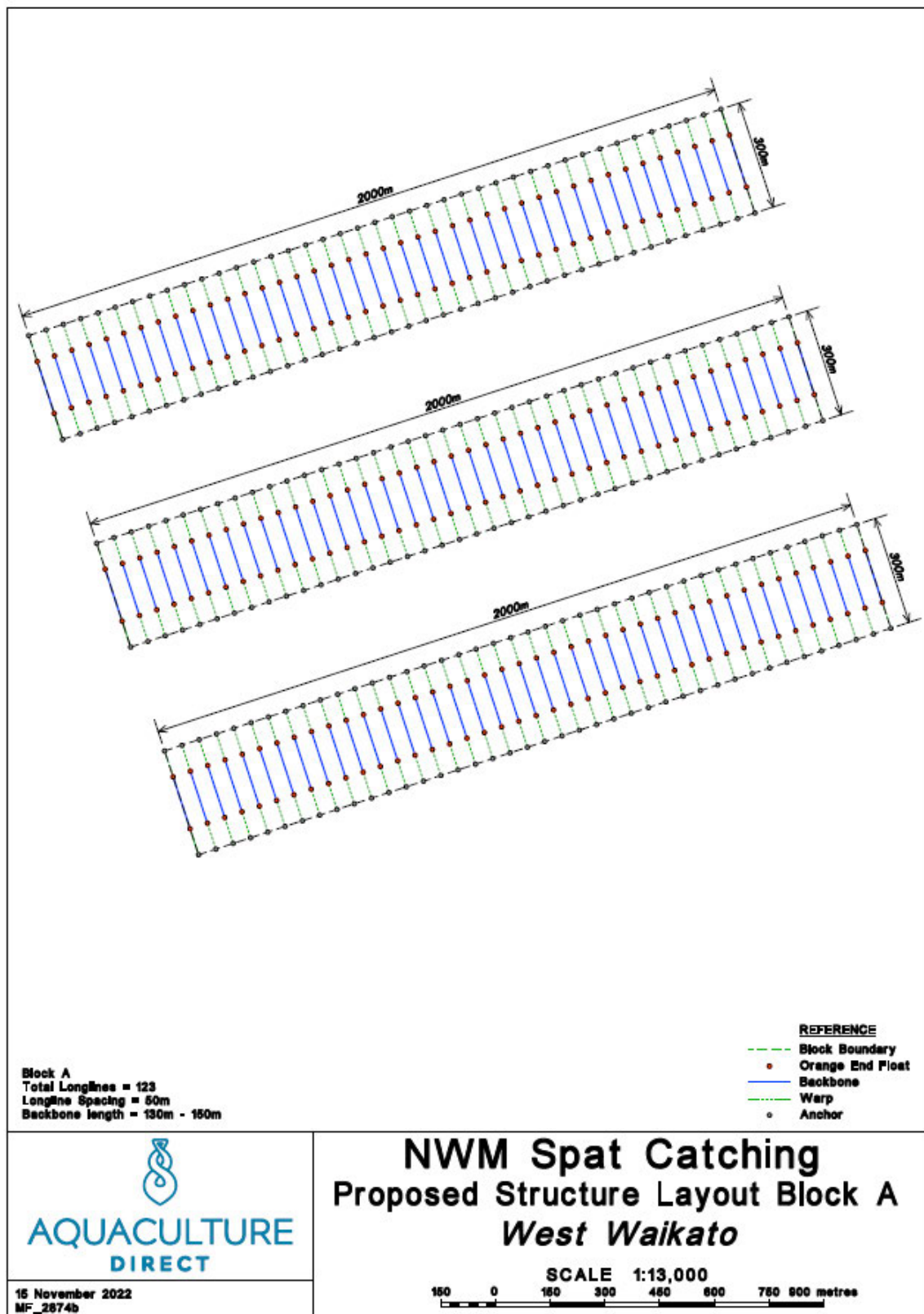


Figure 1-3 Proposed structure layout Site A. Sites B and C present same layout as Site A.

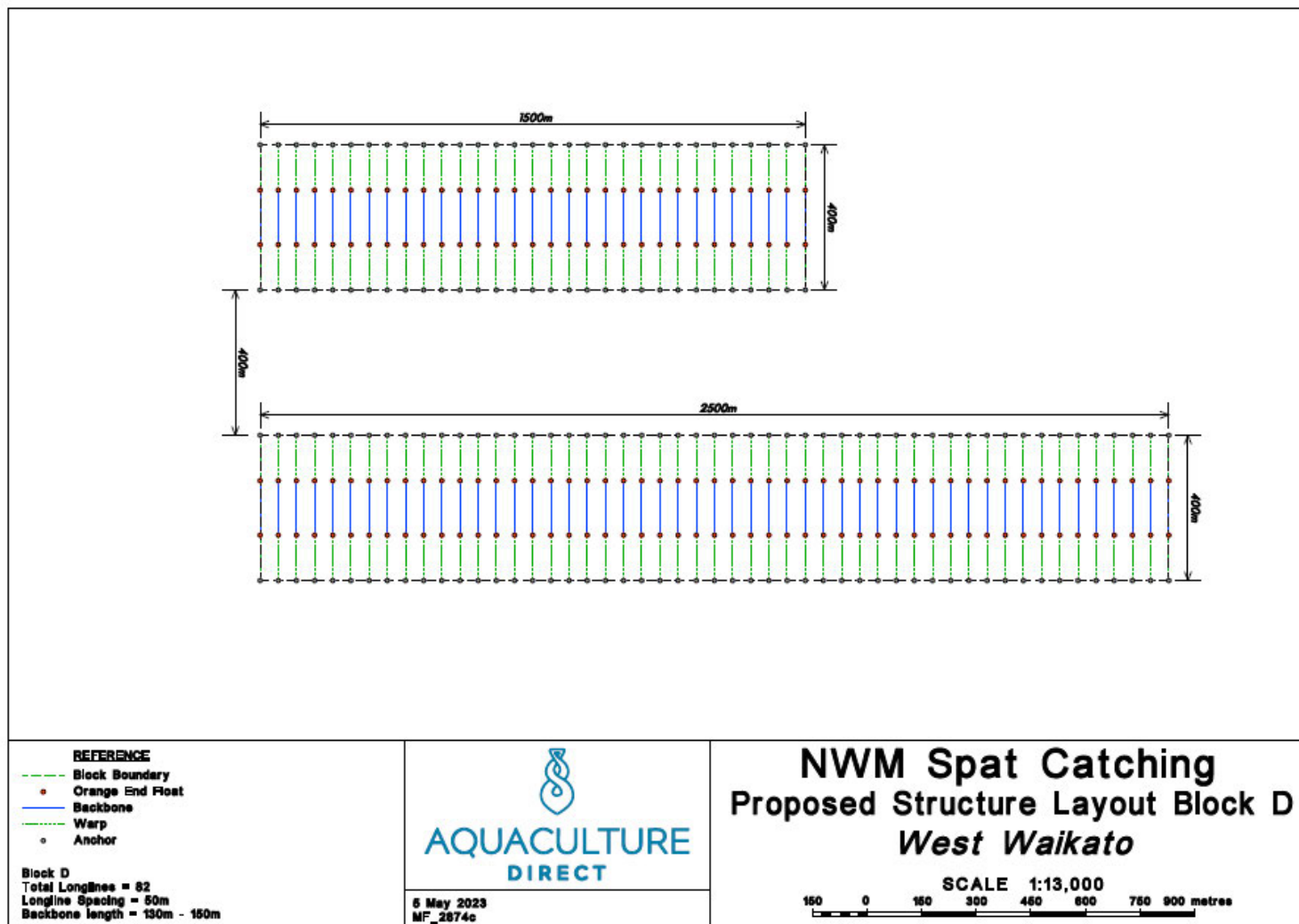


Figure 1-4 Proposed structure layout Site D.

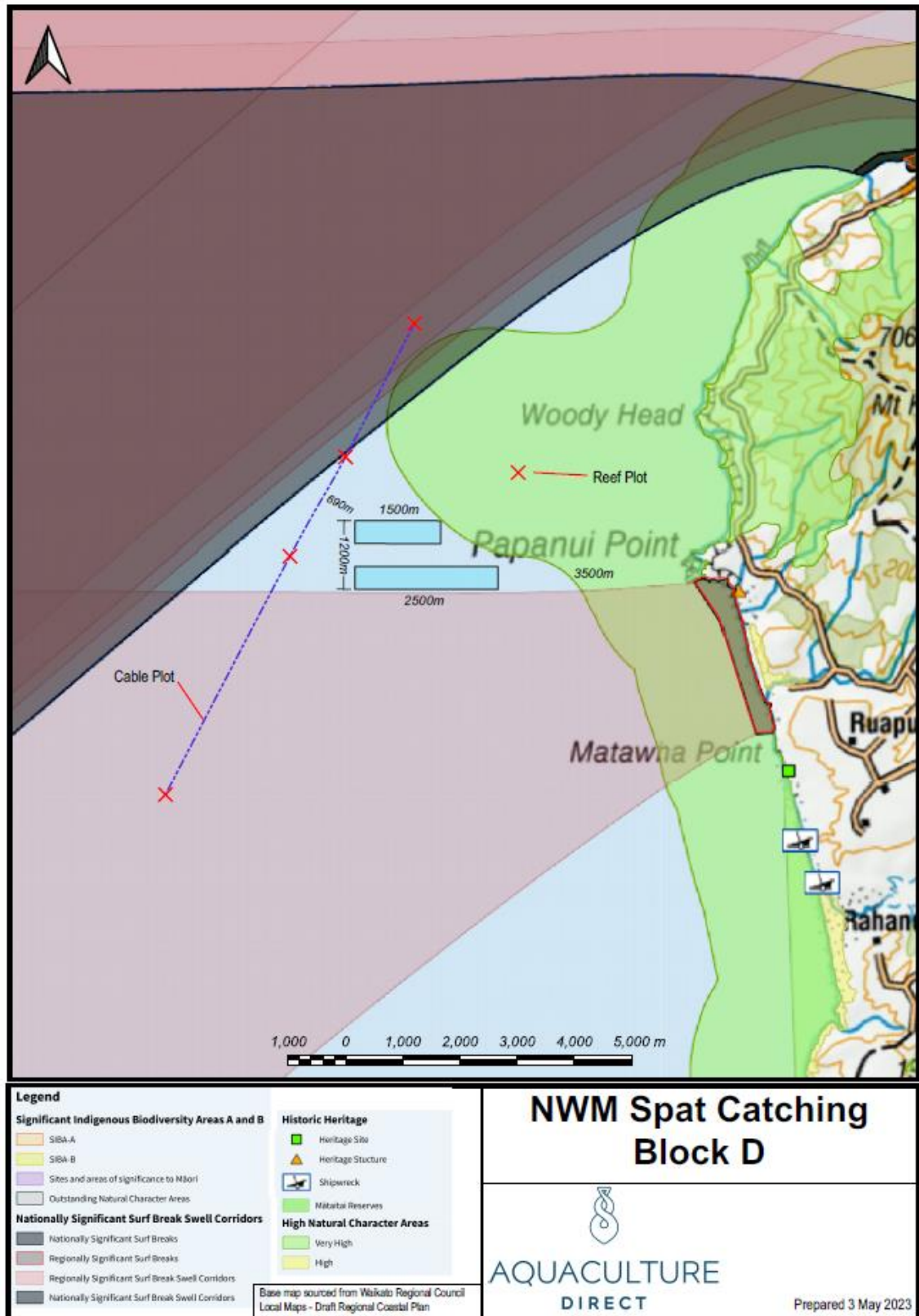
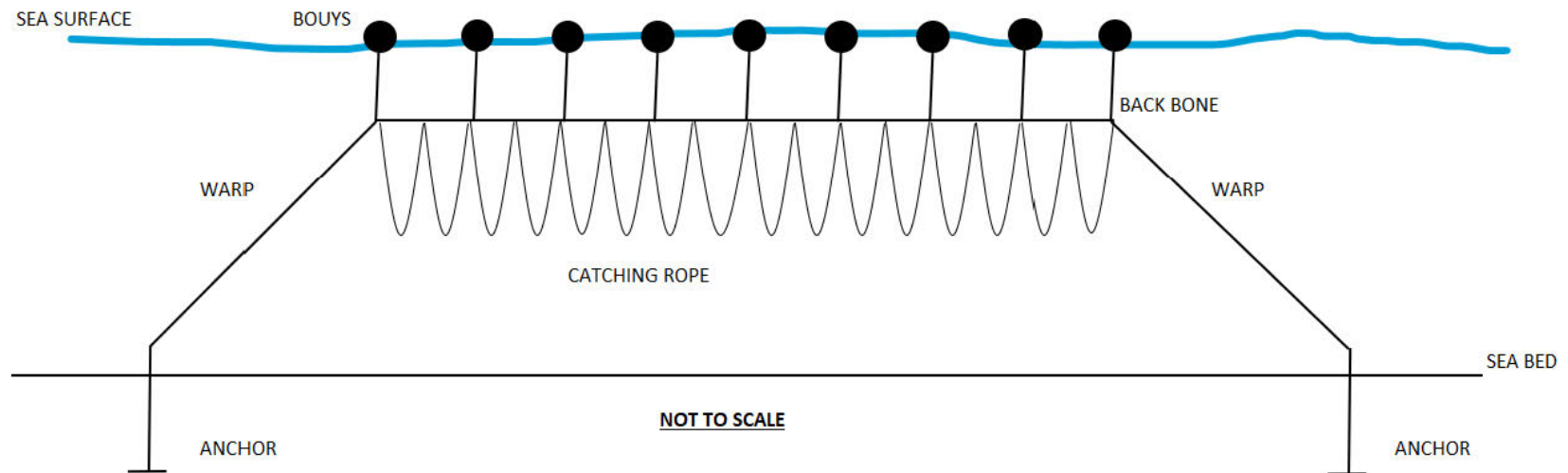


Figure 1-5 Location of Site D in relation to significant biodiversity, historical and natural character areas and surf break swell corridors.

Waikato West Coast Mussel Spat Catching and Nursery Long Line Structure



- Anchors: To be drilled into the seabed 6m - 12m depending on site substrate
- Warps: To be 32mm to 44mm diameter rope with 30ton plus breaking strain
- Buoys: Spaced 2m to 10m apart
- Backbone: 150m in length and 32mm diameter
- Catching rope: 8m down in length. 60mm-80mm diameter weighted fribulated self tensioning catching rope

Figure 1-6 Diagram illustrating an example of mussel spat catching and nursery long line structure.

2.Methods

The methodology of this study consists of establishing a wave model using the latest bathymetry, robust boundary forcing conditions, and representation of the nursery structures as accurate as possible considering model limitations.

We then run simulations of representative scenarios, both with and without the spat structures, to assess their potential effects. The selected scenarios include the most frequent wave conditions as well as the optimal wave conditions for the surf breaks in the area.

2.1 Bathymetry

Bathymetry data was amalgamated in a GIS environment from a variety of sources including LiDAR data in the shallow intertidal regions, local single-beam surveys in the shallow harbour/estuary entrances, electronic navigation chart data and digitised fare sheets (Figure 2-2 and Figure 2-3).

Data was sourced in a variety of datums and projections, all converted to NZTM2000 and Mean Sea Level (MSL), which is required within the modelling space.

Based on an analysis by NIWA for the Kawhia tide gauge (Figure 2-1) between 2008 and 2014, Mean Seal Level (MSL) is 0.13 m above MVD (Moturiki vertical datum). Chart Datum (CD) to MSL offsets varied between 1.83 m and 2.369 m depending on the fare sheet.

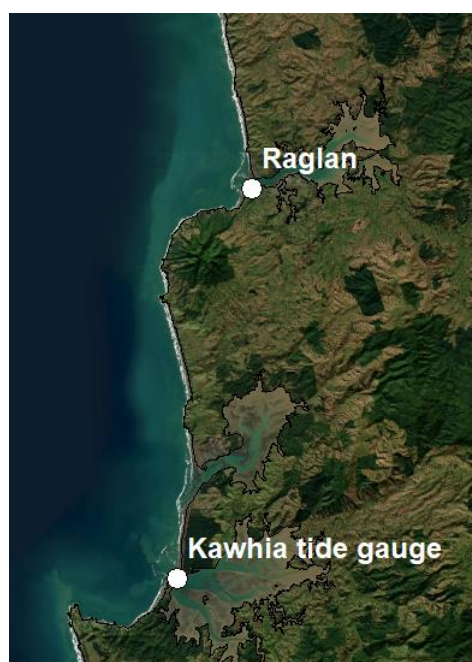


Figure 2-1 Location of Kawhia tide gauge.

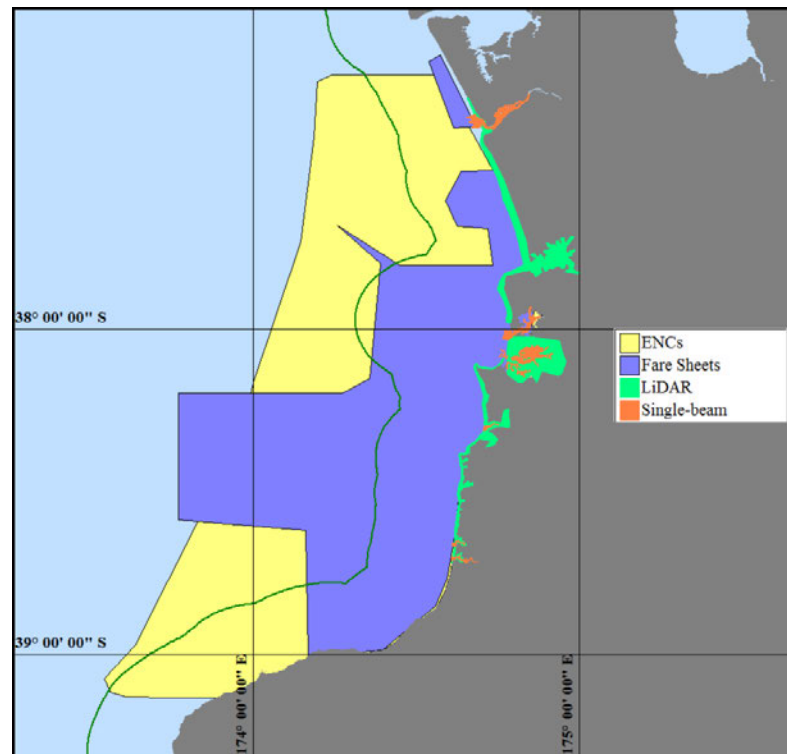


Figure 2-2 Sources and location of raw bathymetry data. The 12 nautical mile territorial sea limit is indicated as a green line.

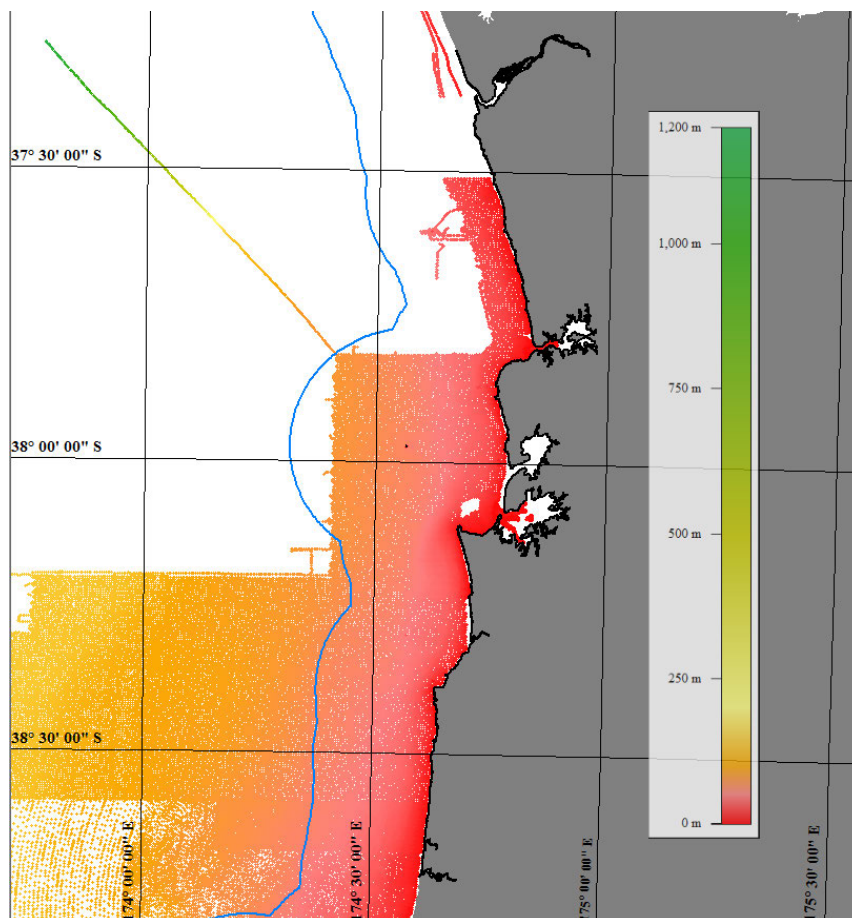


Figure 2-3 Fare sheets data coverage.

2.2 Wave conditions

Wave climate at the four mussel spat collection sites are assessed by statistical analysis and presented in the MetOcean Solutions (2022) report. In this report, we analysed the wave hindcast dataset extracted at the offshore boundary of our model domain (see Section 2.4.2 for more details on the model domain) at 37.939° S and 174.500° S (1731778.3; 5.799909.4 - NZTM2000) to provide the most frequent wave conditions for the boundary forcing. The hindcast datasets used is the MetOcean Solution's New Zealand Wave North Island (SWAN). Details of the model are provided in Appendix A.

The predominant wave direction is from southwest (total probability = 82.23%) mostly associated with significant wave heights (H_s) ranging between 1.5 m to 2.0 m (probability = 22.00%, Table 2-1). A joint probability analysis of significant wave height (H_s) and wave peak period (T_p) indicates that the most frequent period interval ranges from 12 to 14 seconds with significant wave heights of 1.5 m to 2.0 m (probability = 11.26%, Table 2-2). Peak wave periods ranging from 12-14 are the most frequent for southwest waves (probability = 35.60%, Table 2-3).

Table 2-1 Joint probability (%) of significant wave height (H_s) and mean direction of spectral peak (Dpm) at the offshore boundary of the parent grid.

H_s (m)	N	NE	E	SE	S	SW	W	NW
0 - 0.5	0	0.01	0	0	0	0.04	0.02	0.02
0.5 - 1	0.01	0.01	0	0	0	1.79	0.14	0.03
1 - 1.5	0.01	0.04	0.01	0.02	0.01	12.88	0.91	0.20
1.5 - 2	0.02	0.11	0.06	0.03	0.02	22.00	2.10	0.59
2 - 2.5	0.01	0.07	0.03	0.01	0.01	18.93	2.75	0.79
2.5 - 3	0.01	0.03	0.02	0	0.01	12.30	2.55	0.63
3 - 3.5	0	0	0	0	0	7.05	2.04	0.38
3.5 - 4	0	0	0	0	0	3.67	1.39	0.21
4 - 4.5	0	0	0	0	0	1.83	0.89	0.11
4.5 - 5	0	0	0	0	0	0.97	0.59	0.04
5 - 5.5	0	0	0	0	0	0.44	0.34	0.02
5.5 - 6	0	0	0	0	0	0.19	0.20	0.01
6 - 6.5	0	0	0	0	0	0.09	0.11	0
6.5 - 7	0	0	0	0	0	0.03	0.05	0
7 - 7.5	0	0	0	0	0	0.01	0.02	0
7.5 - 8	0	0	0	0	0	0.01	0.01	0



Table 2-2 Joint probability (%) of significant wave height (H_s) and relative peak period (T_p) at the offshore boundary of the parent grid.

H_s (m)	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12	12 - 14	14 - 16	16 - 18	18 - 20	20 - 22
0 - 0.5	0.06	0.03	0	0	0	0	0	0	0	0
0.5 - 1	0.02	0.04	0.02	0.04	0.61	0.84	0.24	0.12	0.04	0
1 - 1.5	0	0.11	0.19	0.36	3.04	6.78	2.31	0.99	0.28	0.03
1.5 - 2	0	0.23	0.50	1.17	3.73	11.26	5.49	1.99	0.52	0.05
2 - 2.5	0	0.10	0.64	1.61	2.90	8.62	6.14	2.12	0.42	0.04
2.5 - 3	0	0.02	0.46	1.48	2.19	4.98	4.53	1.63	0.24	0.02
3 - 3.5	0	0	0.15	1.21	1.33	2.72	2.83	1.11	0.12	0
3.5 - 4	0	0	0.01	0.78	0.74	1.37	1.48	0.81	0.08	0
4 - 4.5	0	0	0	0.40	0.46	0.70	0.80	0.43	0.04	0
4.5 - 5	0	0	0	0.12	0.40	0.38	0.44	0.26	0.01	0
5 - 5.5	0	0	0	0.02	0.26	0.21	0.21	0.1	0.01	0
5.5 - 6	0	0	0	0	0.14	0.11	0.12	0.04	0	0
6 - 6.5	0	0	0	0	0.07	0.06	0.05	0.03	0	0
6.5 - 7	0	0	0	0	0.02	0.03	0.03	0.01	0	0
7 - 7.5	0	0	0	0	0	0.02	0.01	0	0	0
7.5 - 8	0	0	0	0	0	0.01	0	0	0	0

Table 2-3 Joint probability (%) of relative peak period (T_p) and mean direction of spectral peak (D_{pm}) at the offshore boundary of the parent grid.

T_p (s)	N	NE	E	SE	S	SW	W	NW
2 - 4	0.01	0.01	0	0	0	0.03	0.02	0
4 - 6	0.03	0.24	0.10	0.01	0.01	0.08	0.02	0.05
6 - 8	0.03	0.02	0.01	0.01	0.01	0.58	0.71	0.59
8 - 10	0	0	0	0.03	0.01	2.20	3.39	1.57
10 - 12	0	0	0	0.01	0.01	11.25	3.88	0.73
12 - 14	0	0	0	0	0	35.60	2.40	0.10
14 - 16	0	0	0	0	0	23.86	0.82	0.01
16 - 18	0	0	0	0	0	8.00	1.64	0
18 - 20	0	0	0	0	0	0.64	1.13	0
20 - 22	0	0	0	0	0	0	0.14	0

2.3 Surfing conditions

Policy 16, 'Surf breaks of national significance', of the New Zealand Coastal Policy Statement (NZCPS, 2010) requires that decision makers 'protect the surf breaks of national significance', by 'ensuring that activities in the coastal environment do not adversely affect the surf breaks'. Surf breaks of national significance are listed in Schedule 1 of the NZCPS 2010.



The NZCPS 2010 Guidance note on Policy 16 states that surf breaks are an important recreational resource contributing with economic and social benefits to New Zealand. Developments in the coastal marine area have the potential to adversely affect the integrity of surf breaks, by compromising the natural features and processes that create the wave. Such activities can include discharges that affect water quality, changes in seabed morphology by dredging, flattening, or creating mounds of sediments at seabed, limiting access to the surfable areas, and structures that impact on surf breaks and wave quality.

There are three surf breaks of national significance in West Waikato defined in the Schedule 1 of the NZCPS (2010), all of them are in Raglan. These are Manu Bay, Whale Bay and Indicators (Figure 1-1).

Another five surf breaks of regional significance, as defined by Atkin and Mead (2016), are located along the coastline inshore of the proposed sites: Te Akau, Mussel Rocks, Raglan Bar, Ngarunui Beach and Ruapuke Beach (Figure 1-1).

The most favourable swell direction for all the surf breaks considered in this study is southwest (Atkin and Mead, 2016). A discussion with oceanographers and local surfers provided optimal conditions for the two types of surf sites considered here, point breaks and beach breaks. In general, longer wave period (>16 s) will provide optimal conditions at the points while shorter periods (10-12 s) will provide the best surfing condition at the beach. In terms of wave height, 1-2 m waves will include surfers of most levels. As the wave height increases (e.g. 3-4 m), the target group will narrow to more advanced surfers.

A summary of the optimal surfing conditions for point and beach breaks in the area around Raglan is described in Table 2-4.

Table 2-4 Optimal surfing conditions at beach and point breaks around Raglan.

H_s (m)	T_p (s)	Dpm (deg)	Break
0.5	10	225	beach + point
1	10	225	beach + point
1	16	225	point
1.5	16	225	point



2.4 Wave modelling

2.4.1 Model description

The modelling system Delft3D (Deltares, 2018) was used in this study. Delft3D has been specifically developed to simulate the dynamics of complex coastal regions controlled by a wide range of physical and morphological processes. Delft3D has been successfully applied worldwide to a wide range of coastal studies, including, within the New Zealand context, Port Otago (Weppe et al., 2015), Tauranga Harbour (Ramli et al., 2015) and Rees River (Williams et al., 2016).

Delft3D - WAVE

The third-generation SWAN model (Simulating WAVes Nearshore) is used in the Delft3D-WAVE module (Booij et al., 1999; Ris et al., 1999). SWAN computes the evolution of random, short-crested waves in coastal regions with deep, intermediate and shallow water depths. Wave forces computed by the wave module on the basis of the radiation shear stress gradients can be used as a driving force to compute the wave-induced currents and set-up in the flow/hydrodynamic module.

2.4.2 Model domain

The model ran using a nesting approach, i.e., boundary conditions are prescribed for the low-resolution, higher-coverage parent grid and information is transferred to the high-resolution smaller 'Site' grids. The full domain includes 4 grids:

- Parent grid (90 x 156 cells, resolution = 500 m)
- Site A grid (168 x 253 cells, resolution = 50 m)
- Site B and C grid (160 x 280 cells, resolution = 50 m)
- Site D grid (304 x 327 cells, resolution = 50 m)

The parent grid extends approximately 78 km (NW-SE) along the coast and reaches approximately 34 km offshore (E-W) in its widest portion (Figure 2-4)

The backbone lines were setup in the model as obstacles. In Delft3D-WAVE, an obstacle represents a structure like a breakwater, with the option of reducing its blockage to the flow and wave propagation by prescribing a transmission coefficient, i.e., making it more 'porous', letting some of the wave energy pass through the obstacle. A transmission coefficient was prescribed for each backbone line, based on the wave transmission expected for the dropper density and the length of the row. Details on the transmission coefficient are presented in Section 2.4.4.



The model grids were aligned to the structures as much as possible and three cells were included in each backbone line. Two options of lines were simulated, (1) lines spaced 50 m apart following the proposed design and (2) lines spaced every 100 m for a model sensitivity run. This was to test the difference in wave attenuation for the different layouts.

Bathymetry data was interpolated onto the model grid, with the vertical datum set to Mean Sea Level (Figure 2-4 and Figure 2-5).

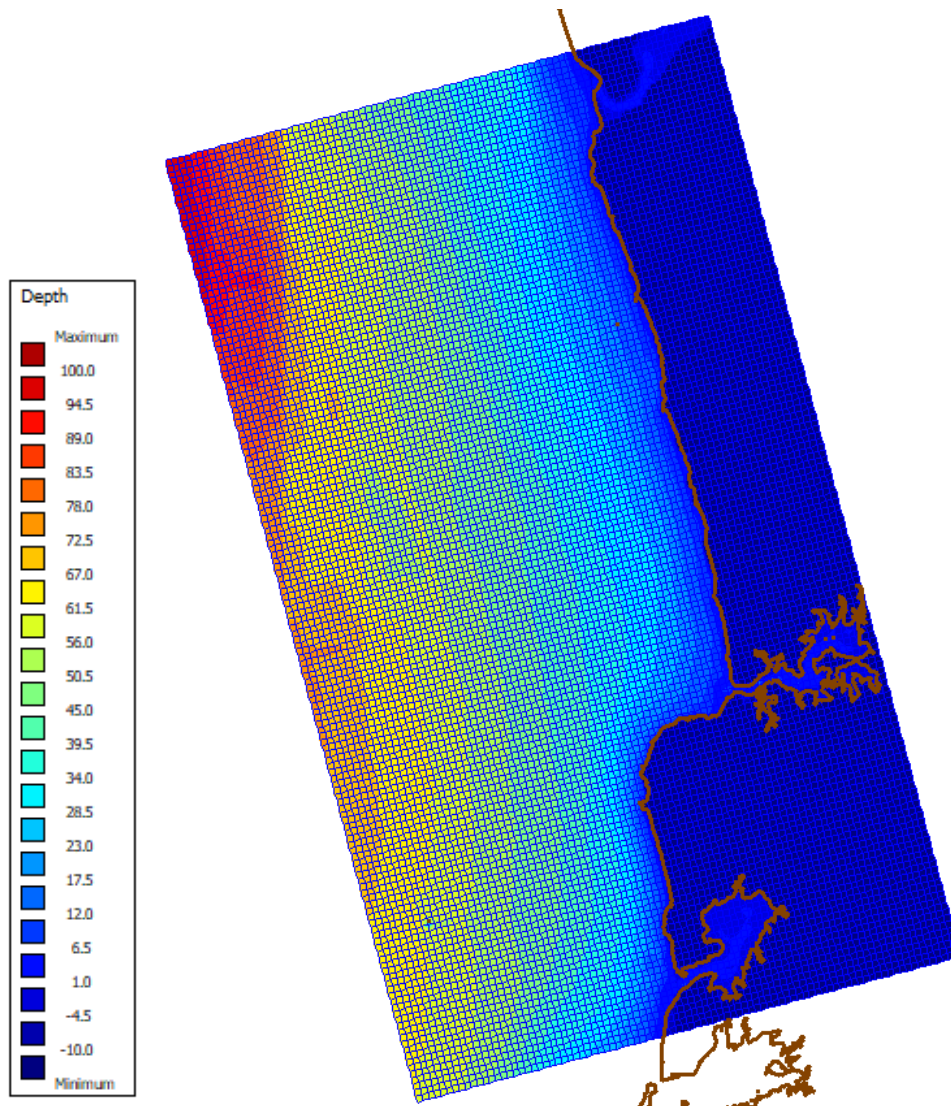


Figure 2-4 Parent grid and bathymetry.

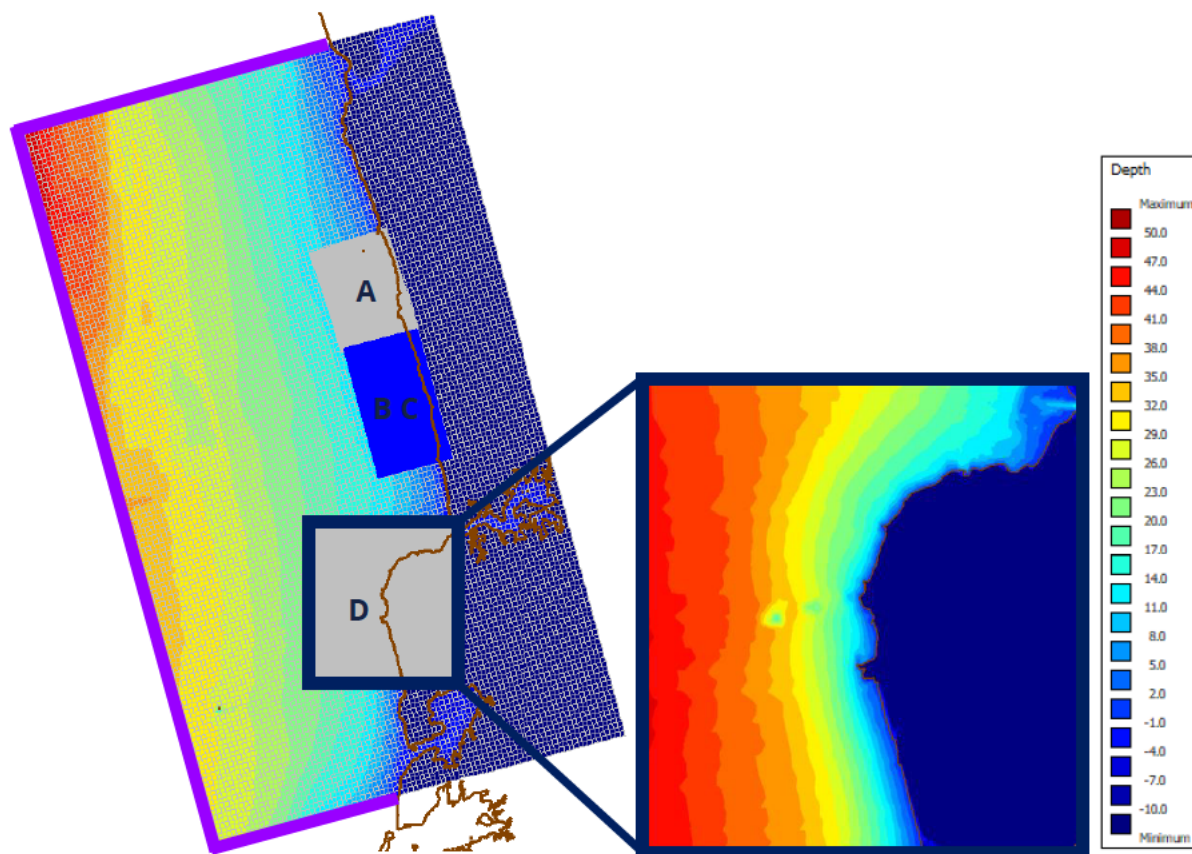


Figure 2-5 Grids covering Sites A to D nested onto parent grid (left) and bathymetry detail for Grid D (right). Purple lines around the parent grid represent the open boundaries where wave conditions were imposed.

2.4.3 Model calibration

The model calibration was performed by comparing the modelled results to wave data measured by a Spotter wave buoy deployed directly offshore Manu Bay surf break. The Spotter buoy was deployed at the approximate location of 37.816° S and 174.811° E from 25 February 2020 to 08 March 2020 (Figure 2-6).

The calibration run was forced by timeseries of wave hindcast parameters (H_s , T_p and D_{pm}) extracted from the MetOcean Solutions wave hindcast for the duration of the buoy deployment, and applied along the north, west, and south open boundaries (purple lines around the parent grid in Figure 2-5). Description of the hindcast model is presented in Appendix A:.

The model calibration suggested that the bottom friction formulation of Hasselmann et al. (1973) (JONSWAP), using a coefficient equal to $0.038 \text{ m}^2/\text{s}^3$ for swell conditions was the most appropriate configuration. Wave breaking was simulated using a constant critical wave height to water depth ratio of 0.73 with a proportionality coefficient for the rate of dissipation of 1. The simulations did not include wind.

Comparisons between modelled and measured wave parameters are presented in Figure 2-7 and Figure 2-8. The modelled results show a good agreement with the measured data, with a slight underestimation of wave height peaks and overestimation of wave period in relation to the measured data (Figure 2-7). Waves are mainly from west-northwest with the model representing satisfactorily the main direction of wave propagation (Figure 2-8).

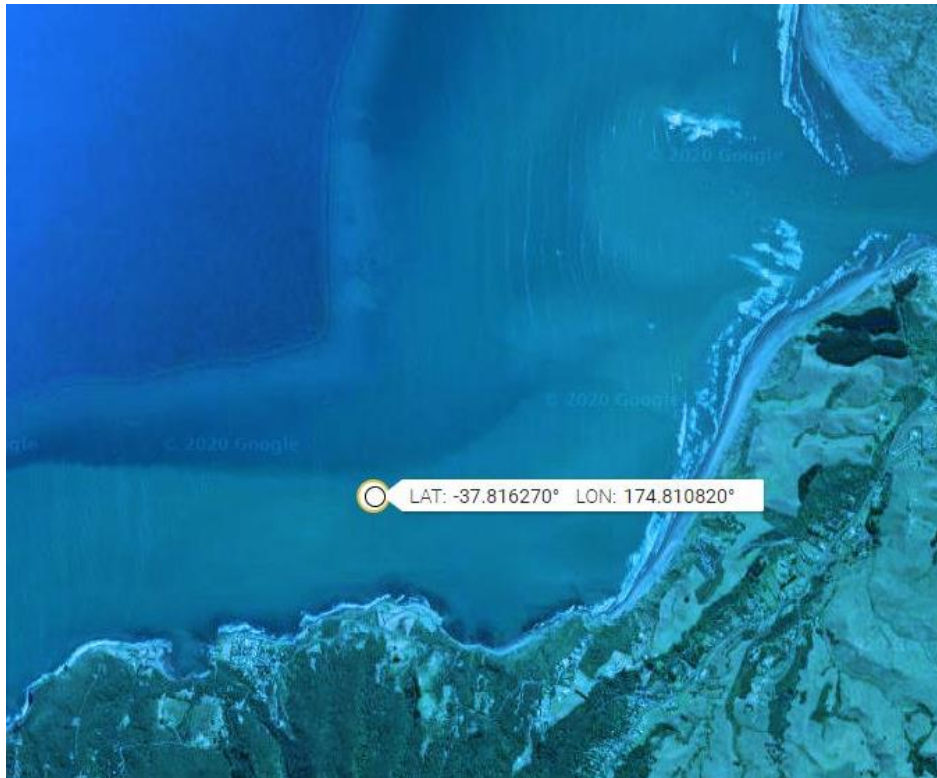


Figure 2-6 Location of spotter buoy deployment (top) and view of the buoy floaters (bottom).

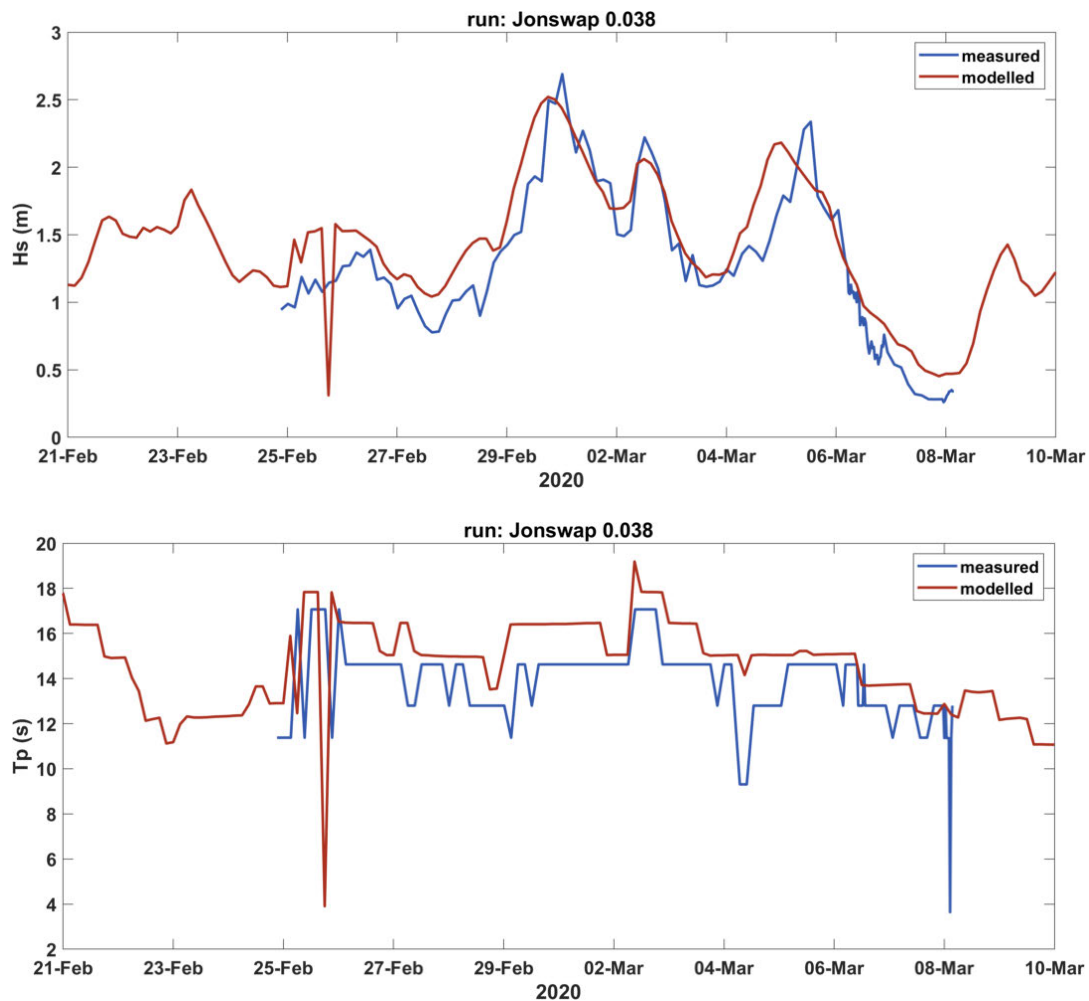


Figure 2-7 Comparison between measured and modelled significant wave height (H_s , top) and peak period (T_p bottom) for Feb/Mar 2020 at the spotter buoy location (-37.816, 174.811).

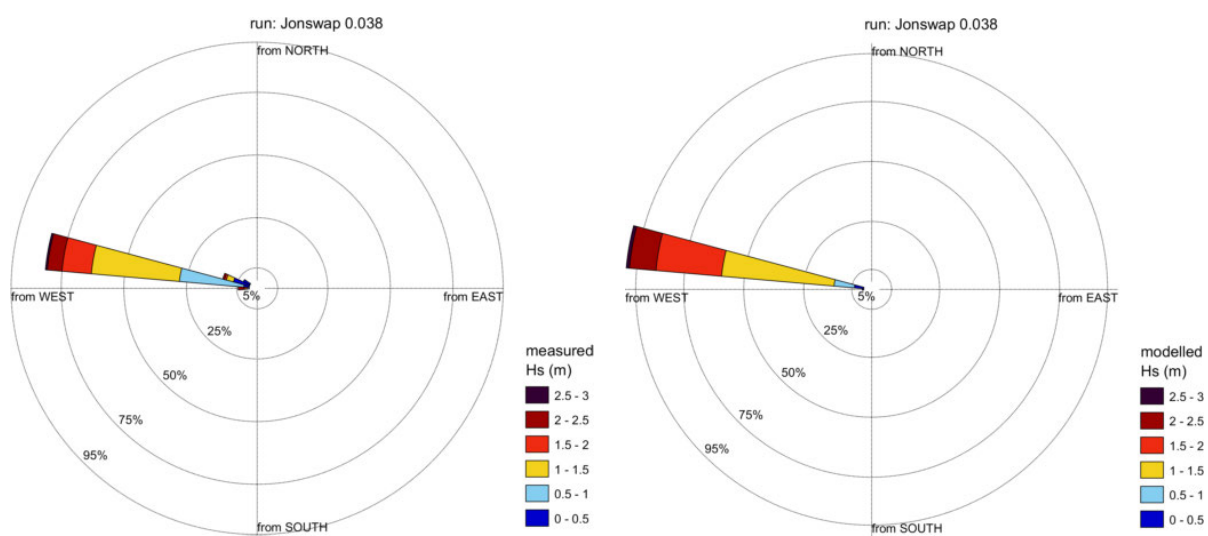


Figure 2-8 Wave roses for measured (left) and modelled (right) waves for Feb/Mar 2020 at the spotter buoy location (-37.816, 174.811).

2.4.4 Transmission coefficient

The attenuation of waves passing through the mussel spat catching structure was represented in the model as a series of obstacles that represented the number of spat longlines expected in each of the Sites. The proposed mussel spat structures are expected to consist of longlines spaced 50-metres apart, with

1. 3 rows of 41 longlines for Sites A, B and C, and
2. 3 rows of between 31-51 longlines for Site D.

The spatial extent of these areas is of the order 160-180 ha, with an estimated dropper density of

1. 0.04 and 0.08 m² for a single and double dropper density for Sites A, B and C respectively, and
2. 0.03-0.06 m² for a single and double dropper density for Site D respectively.

Knowing the dropper density and the approximate perpendicular length of the proposed spat collecting area to the incident wave direction (2000 m) we are able to use the relationship of Plew (2005) as illustrated in Figure 2-9 to determine the relative transmission coefficient (or percentage attenuation) of each of the numerically defined longlines (treated as obstacles) within the wave model.

We achieved this by simulating a series of idealised numerical flume cases; each with a set number of obstacles that represented the expected number of spat longlines and adjusted the level of transparency of the obstacles until the combined total Energy Transmission Ratio (ETR) matched that expected based on Plew (2005), see Figure 2-9. Simulations were run with an idealised wave condition of $H_s = 1$ m, $T_p = 14$ s propagating perpendicular to the orientation of the spat lines with a JONSWAP directional spreading coefficient of 4, with the ETR determined at the midpoint of the structure (see Figure 2-10).

Simulations suggested that,

- a. A transmission coefficient of 0.988 (98.8%) per line was required to provide a total transmission of 64% - the equivalent of a dropper density of 0.08 droppers.m⁻² according to Plew (2005) in Figure 2-9 and
- b. A transmission coefficient of 0.991 (99.1%) per line was required to provide a total transmission of 71% - the equivalent of a dropper density of 0.06 droppers.m⁻² according to Plew (2005) in Figure 2-9.



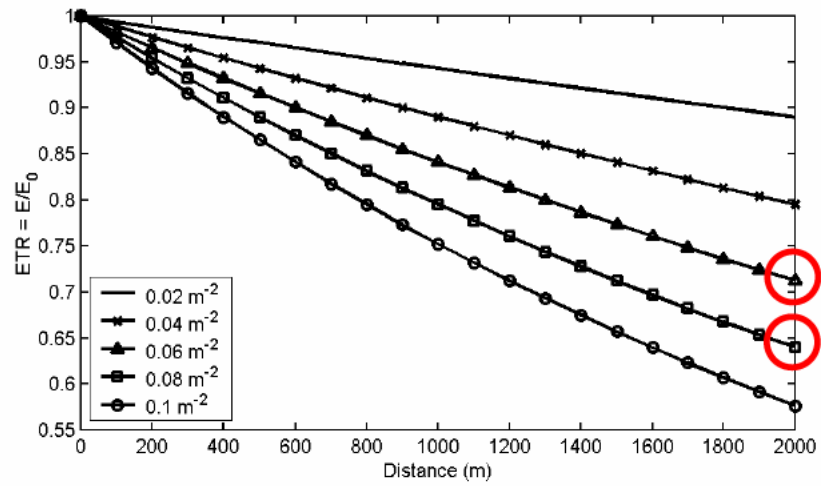


Figure 2-9 Energy Transmission Ratio (ETR) as a function of distance and dropper density (from Plew, 2005).

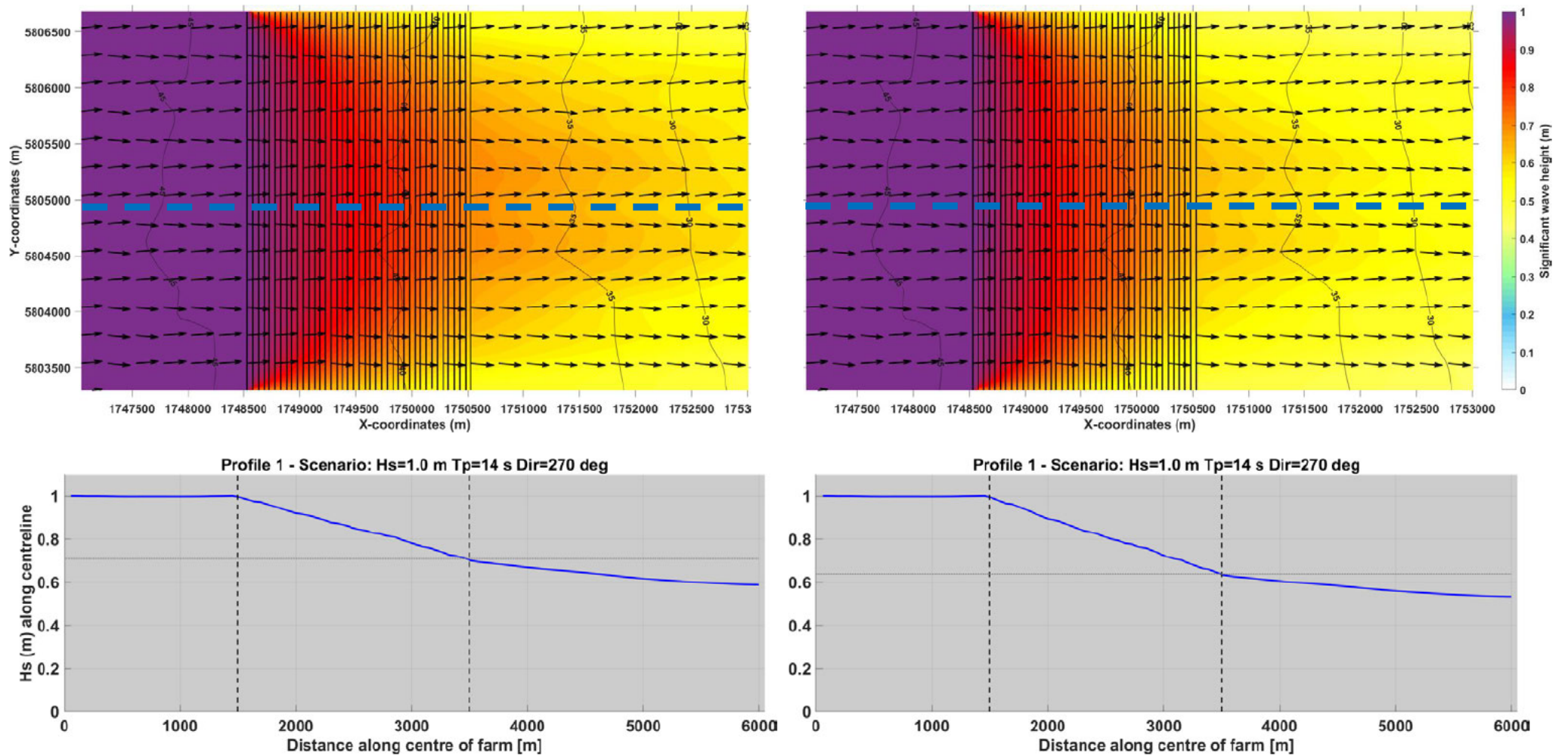


Figure 2-10 Significant wave height and direction (top) and profiles of significant wave height along the centreline of the map (bottom). Dashed black lines show the limits of the area covered by the line obstacles. Dotted grey line indicates the approximate transmission coefficient in the lee of the farm (left: 0.72 and right: 0.64).

2.4.5 Scenarios

The modelling approach involved simulating representative wave conditions, both with and without the structures, to assess their potential effects on wave conditions leeward of the sites, nearshore and at the Nationally and regionally significant surf breaks in the region.

The scenarios simulated in this study are listed in Table 2-5. The selected events include some of the most frequent wave conditions (as presented in Section 2.2) as well as the optimal surfing conditions (as described in Section 2.3). Scenarios were run for the two transmission coefficients presented in Section 2.4.4, i.e., for higher transmission of 0.991 and lower transmission of 0.988.

A sensitivity test was run with an alternative structure configuration with backbone lines 100 m apart (original layout included backbone lines at a distance of 50 m apart).

The model was run in stationary mode using wave parameters (H_s , T_p and Dpm) applied at the north, south, and west (offshore) open boundaries of the parent grid (Figure 2-5). Wave conditions were uniform, i.e. are constant along a side or segment of the boundary and defined as parametric spectral input. The JONSWAP spectral shape was used with a peak enhancement factor of 3.3.

Table 2-5 Modelled scenarios including most frequent wave conditions and optimal surfing conditions. All scenarios were run with and without structures. Structures with backbone lines every 50 m (└50), structures with backbone lines every 100 m (└100)

Scenarios	H_s	T_p	Dpm	Description
Run_01_50	2	12	315	NW waves, 50-m apart
Run_02_50	2	12	270	W waves, 50-m apart
Run_03_50	2	12	225	SW waves, 50-m apart
Run_01_100	2	12	315	NW waves, 100-m apart
Run_02_100	2	12	270	W waves, 100-m apart
Run_03_100	2	12	225	SW waves, 100-m apart
Run_04	0.5	10	225	SW, 50-m apart, Surf: beach + points
Run_05	1	10	225	SW, 50-m apart, Surf: beach + points
Run_06	1	16	225	SW, 50-m apart, Surf: points
Run_07	1.5	16	225	SW, 50-m apart, Surf: points



3. Results

3.1 Potential effects on incident wave climate

Wave height is attenuated as the waves propagate through the proposed spat lines (see example in Figure 3-1, middle). Compared to maps of significant wave height for the existing scenarios (no structures, e.g., Figure 3-1, top), the spat catching structures generally have the potential to reduce wave height in the lee of the sites (e.g., Figure 3-1, bottom). Potential changes in wave direction are mostly localised to the area immediately adjacent to the structures and in the lee of the sites.

To assess the potential effect of the spat catching structure on the wave height, we compared the simulations with and without the structures and calculated the percent change in wave height and the difference in wave direction.

The results in this section are for the **most conservative of the coefficients** (a) 0.988 (i.e., the case with a transmission coefficient of 0.64 or 64% transmission, reflective of greater wave height attenuation). A comparison between results for coefficients (a) 0.988 (64% transmission) and (b) 0.991 (71% transmission) is presented in Section 3.4.2.

Contour maps present the percent change in wave height (Figure 3-2, Figure 3-3 and Figure 3-4, top panels) and difference maps show the change in wave direction (Figure 3-2, Figure 3-3 and Figure 3-4, bottom panels) for Runs 01 to 03 ($H_s = 2\text{m}$, $T_p = 12$, wave direction from northwest, west and southwest).

We limited the presentation of the change in wave height to illustrate areas greater 1%, as areas with less than 1% changes in H_s have previously been noted as having 'no more than minor' effects, on surfing conditions (*South Taranaki Bight Iron Sand Extraction Project. Tran-Tasman Resources Ltd Marine Consent Decision* (2014)). Following the work of Mead,(2013), changes in wave direction less than 2 degrees were considered 'very small', and as such are not depicted within the figures..

Results show that, immediately in the lee of the structures, northwest waves are attenuated by 10% at Site A, 12-13% at Sites B-C and 10% at site D in the immediate lee of the farm. Nearshore directly in front of the Sites, wave height could potentially be reduced by 4% (Site A), 6-7% (Sites B-C) and 4% (Site D). Change in direction could potentially be 1.2 degree for Site D in the immediate lee of the site, with the other sites (A, B, and C) presenting changes no more than 0.85 degrees for northwest waves (Figure 3-2, Figure 3-3 and Figure 3-4, left panels).



The attenuation in wave height for waves coming from the west could potentially be 15% (Site A), 13% (Site B-C) and 12% for Site D in the immediate lee of the farm. Towards the shore directly in front of the Sites, reduction could potentially be of 6% (Site A), 9% (Site B-C) and 4-6% (Site D). Waves coming from west could potentially be the most affected in terms of directional change in comparison to the other scenarios. Maximum changes range from 1.3 to 1.7 degrees for the four sites (Figure 3-2, Figure 3-3 and Figure 3-4, middle panels).

For a typical wave from southwest, wave height could potentially be reduced by 15% (Site A), 15% (Site B-C) and 8.5% (Site D) directly in the lee of the farm. At the shoreline and directly in front of the Sites, change could potentially be of 6% (Site A), 10% (Site B-C) and 3% (Site D). Changes in wave direction could potentially range from 0.71 degrees (Site D) to 1.4 degrees (Site A) for southwest waves (Figure 3-2, Figure 3-3 and Figure 3-4, right panels).

Depending on the wave incident direction relative to the orientation of the spat lines (represented as obstacles in the numerical model) cumulative attenuation can occur.



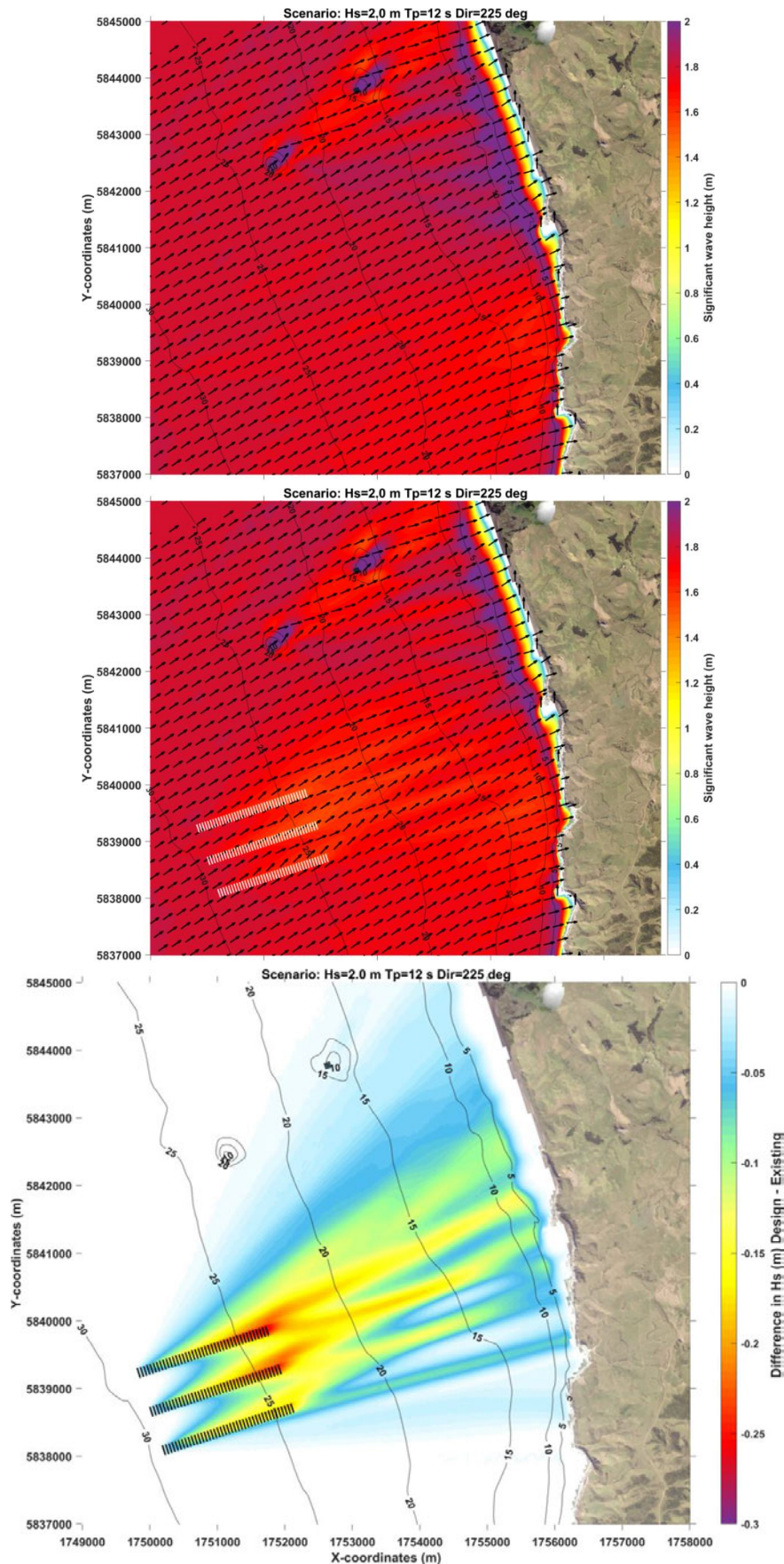


Figure 3-1 Examples of model output of significant wave height and direction (arrows) for Run_03_50 ($H_s = 2.0$ m, $T_p = 12$ s, $Dir = 225$ deg) for Site A. Top map is for the existing run (no structure) and middle map is for the run including the structures with the white lines representing the backbone lines at a distance of 50 m apart. Bottom map shows the difference in wave height between the two scenarios.

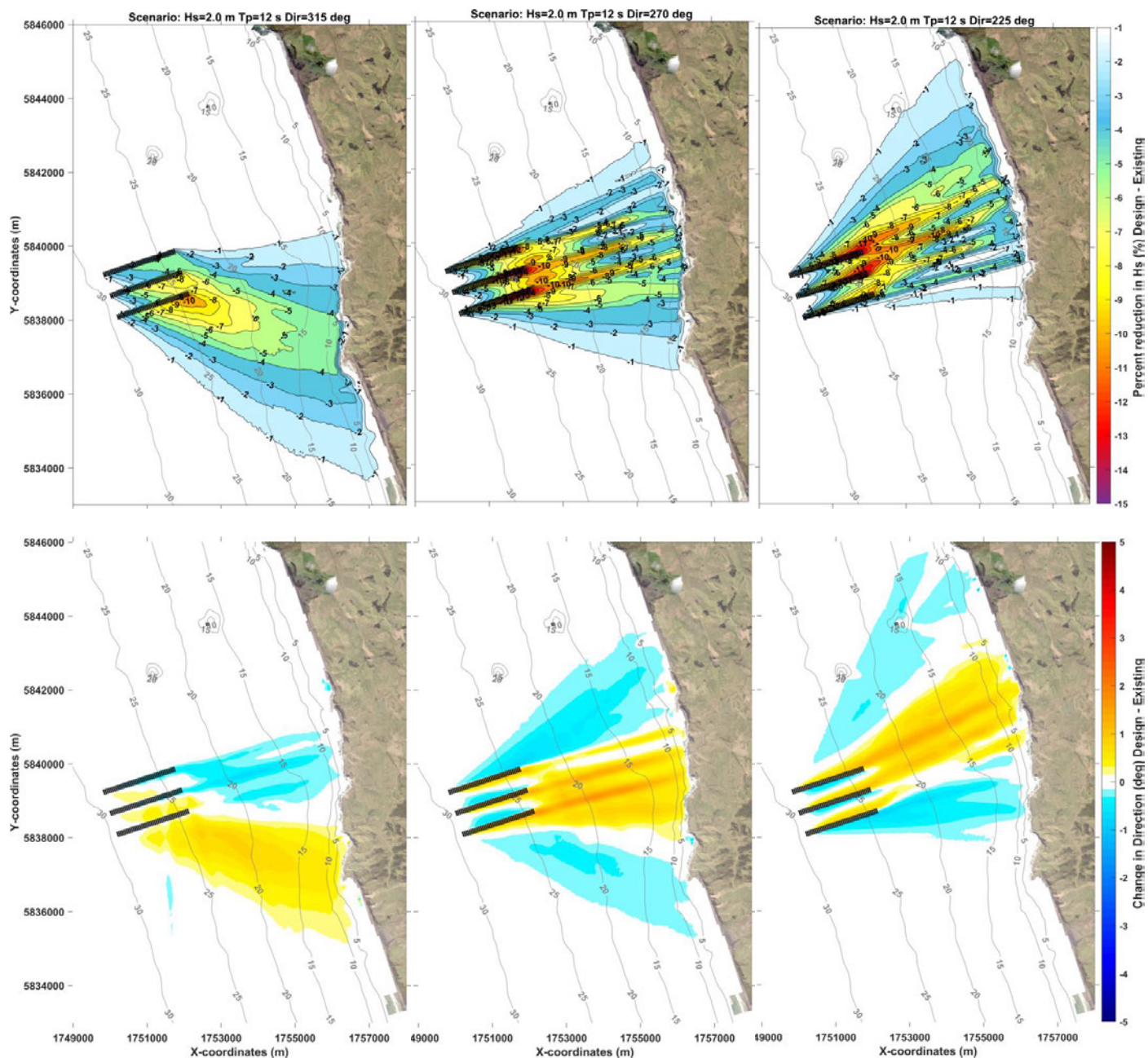


Figure 3-2 Percent reduction in H_s (top) and change in wave direction (bottom) between the existing (no structure) and the runs including the structures for Site A. Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 315 deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 270 deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 225 deg). Black lines represent the backbone lines at a distance of 50 m apart.

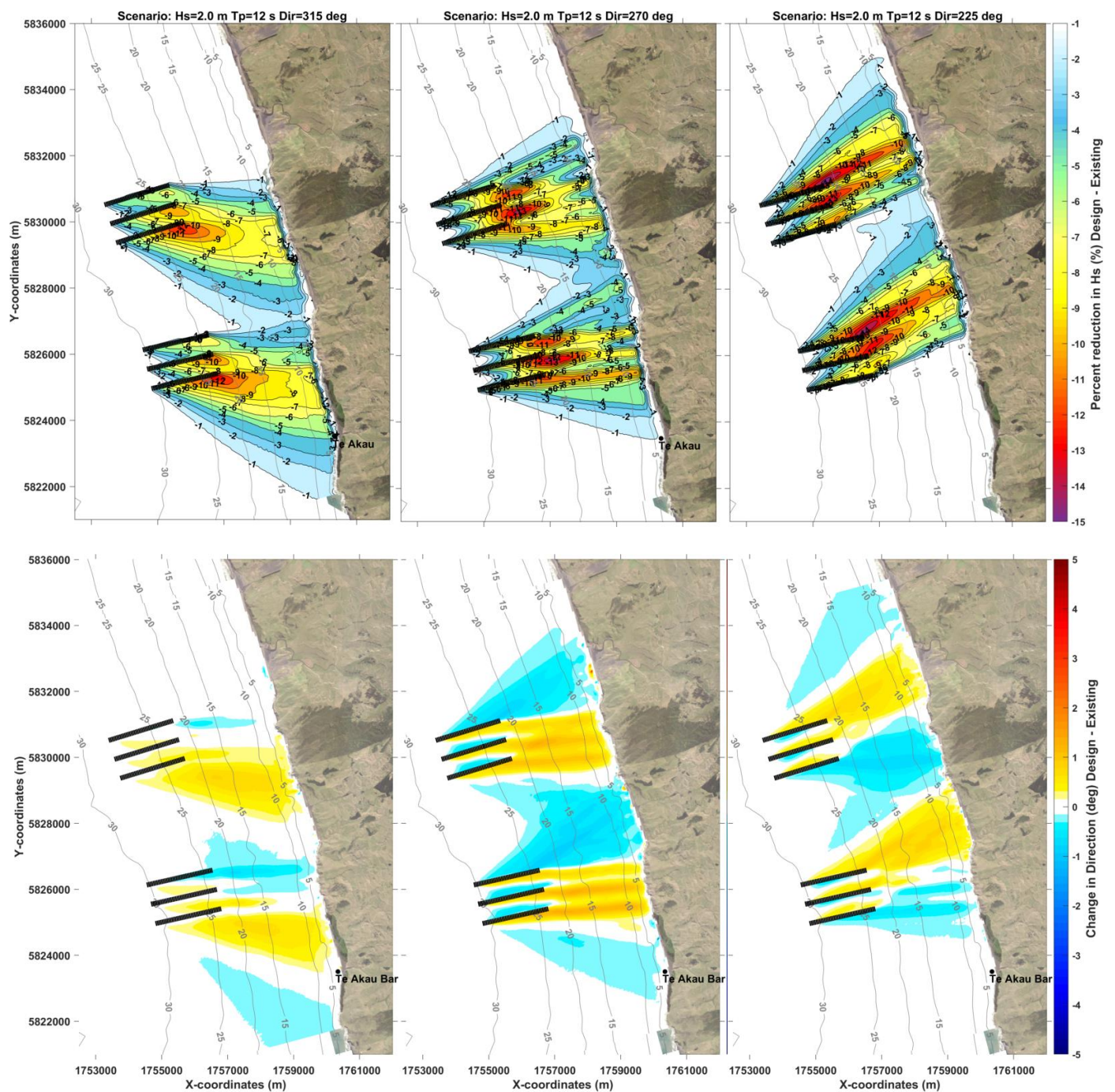


Figure 3-3 Percent reduction in H_s (top) and change in wave direction (bottom) between the existing (no structure) and the runs including the structures for Sites B and C. Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 315 deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 270 deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 225 deg). Black lines represent the backbone lines at a distance of 50 m apart.

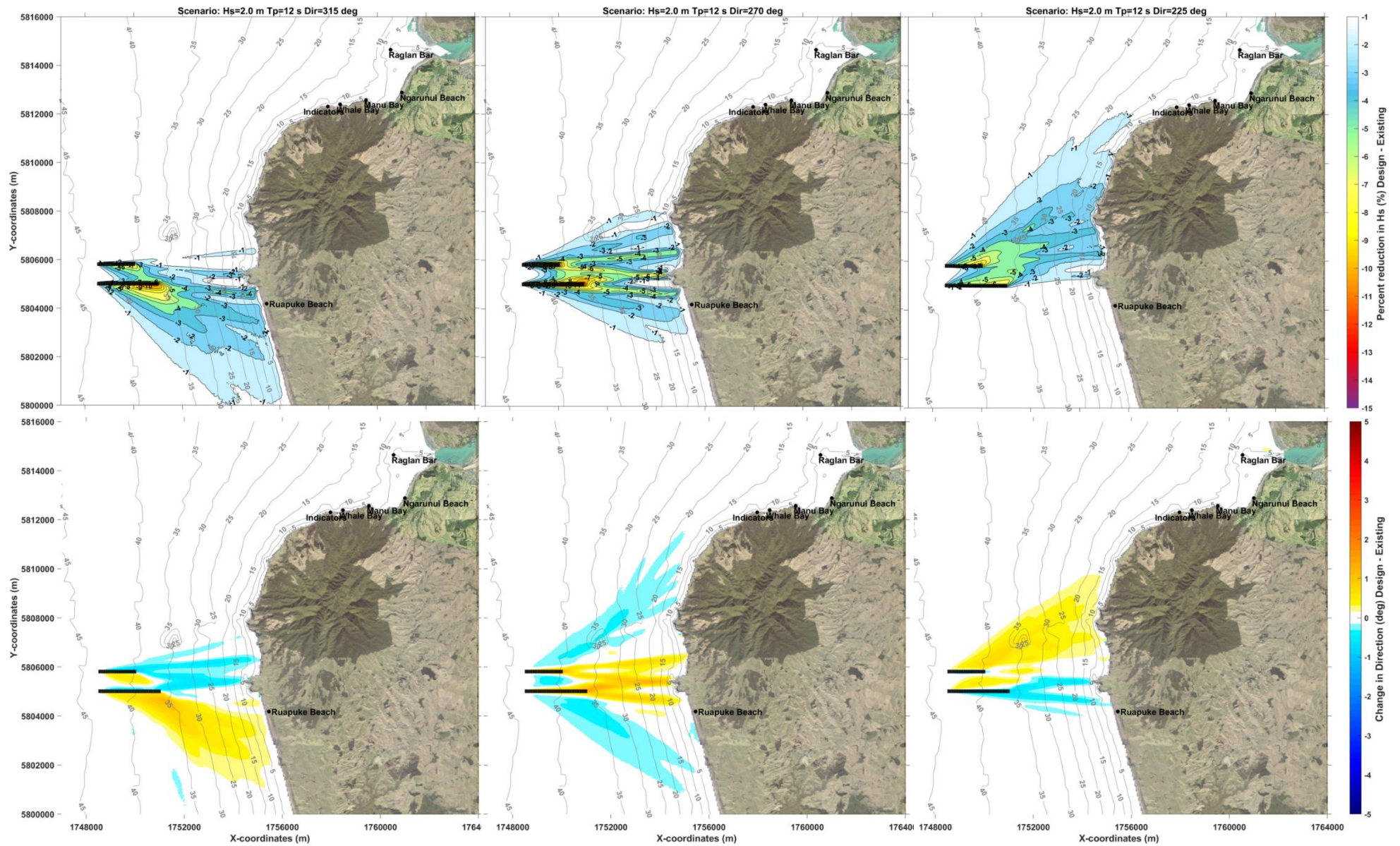


Figure 3-4 Percent reduction in H_s (top) and change in wave direction (bottom) between the existing (no structure) and the runs including the structures for Site D. Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 315 deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 270 deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 225 deg). Black lines represent the backbone lines at a distance of 50 m apart.

3.2 Potential effect of wave period on wave attenuation

Peak wave periods associated with the most frequent wave conditions offshore Raglan, range between 10 to 16 seconds (Section 2.2).

Results show that for longer period waves (e.g., $T_p = 16$ s), the contours showing the highest attenuation might extend further shorewards, but the overall impacted area is smaller for waves with longer periods (Figure 3-5).

Longer period waves are less attenuated than short period waves, maintaining their energy over longer distances, and being less affected when passing through the proposed spat lines.

In this study we assumed the same transmission coefficient for all scenarios regardless of the wave period. According to the finding of Plew (2005), longer period waves ($T_p > 10$ s) may be less affected by a mussel farms than waves with a shorter period ($T_p < 10$ s, i.e., higher frequencies > 0.1 Hz).

By adopting this approach, the results for scenarios with wave period longer than $T_p = 10$ s are likely conservative, since longer period waves tend to be less attenuated than short period waves.



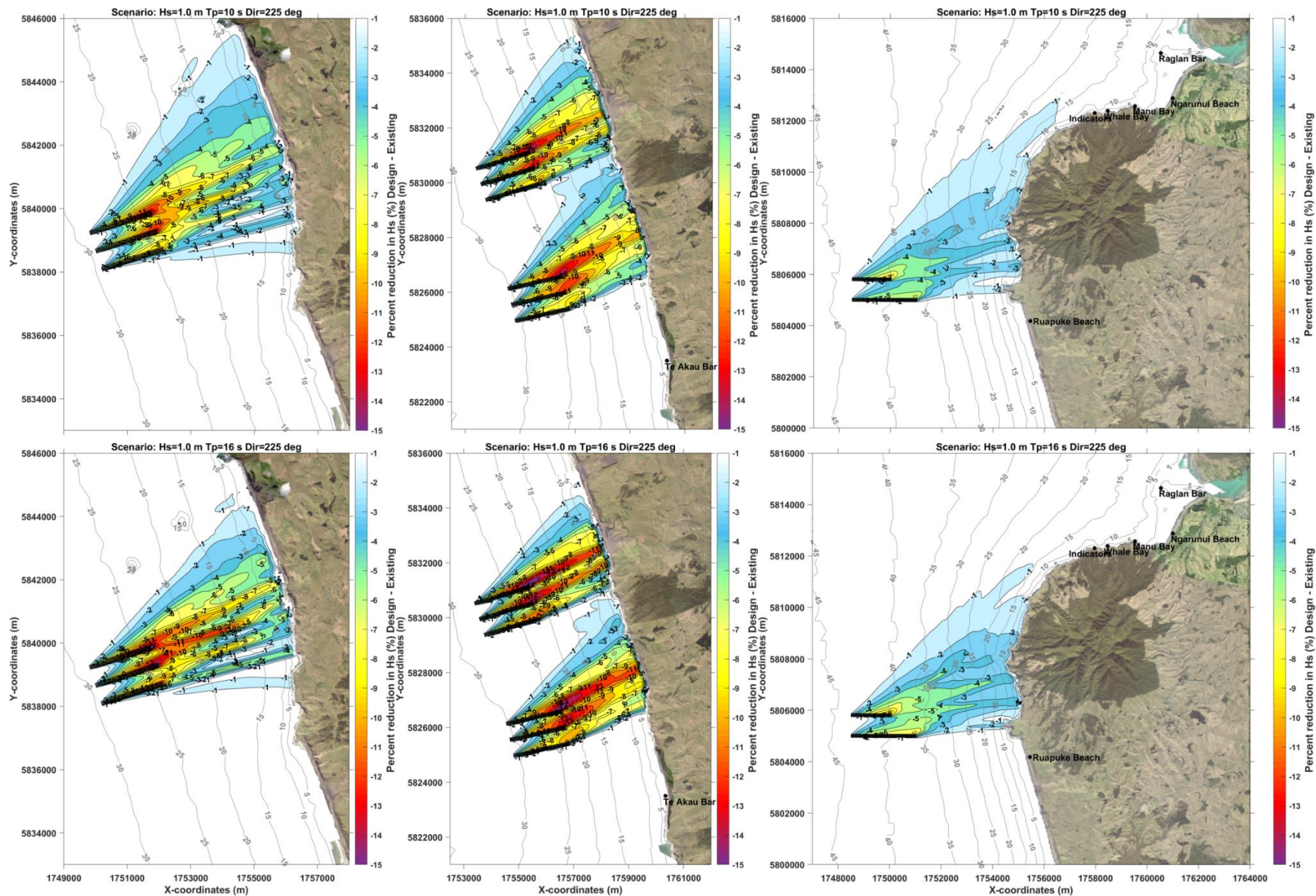


Figure 3-5 Percent reduction in H_s between the existing (no structure) and the runs including the structures for Site A (left), Site B-C (middle) and Site D (right). Top: Run_05_50 ($H_s = 1.0$ m, $T_p = 10$ s, $Dir = 225$ deg). Bottom: Run_06_50 ($H_s = 1.0$ m, $T_p = 16$ s, $Dir = 225$ deg). Black lines represent the backbone lines at a distance of 50 m apart.

3.3 Potential effects on surfing conditions

Site D is the closest site of the three surf breaks of national significance in Raglan (Manu Bay, Whale Bay and Indicators) and Ruapuke Beach, which is a surf break of regional significance. The distance of Site D top row to the nearest of the Point Breaks, Indicators, is approximately 10 km (Figure 1-1). Of the surf breaks of regional significance, Te Akau is the closest from a site (Site C), at about 4 km.

The optimum swell direction for all surf breaks is from the southwest. At Site D, the runs associated with the optimum surfing conditions (i.e., Run_06 to Run_09) showed that potential changes in wave height of approximately 7-9% are localised and limited to the lee of the sites, not extending more than approximately 500 m from the farm. The model shows gradual reduction in effects from the farm directly towards the coast around Papanui Point and Woody Head and towards Raglan.

The effect of the proposed spat lines on wave heights at the Raglan point breaks are considered to be minor (i.e. percentage difference of 1% or less) for the dropper density and transmission coefficients used in the simulations. For Run_06 ($H_s = 0.5$ m, $T_p = 10$ s, $Dir = 225$ deg) the 1% change contour is at least 2 km from the Nationally Significant surf break, Indicators (Figure 3-6, top left). Change in wave direction could potentially be in the order of 0.7 to 0.8 degree within 1-2 km directly in the lee of the farm for the surfing scenarios simulated. There is no change in wave direction near the surf breaks in Raglan (Figure 3-7).

For the surf breaks to the north of Raglan (Te Akau), wave height change near the shoreline could potentially be of the order 3-4% and wave direction change near the shoreline could potentially be of the order 0.2 degrees for waves propagating from the northwest. For the surf breaks to the south of Raglan (Ruapuke Beach), wave height change near the shoreline could potentially be of the order 2-4% and wave direction change near the shoreline could potentially be of the order 0.2-0.3 degrees for waves propagating from both the northwest and west (noting that these directions are not conducive for producing quality surf conditions).



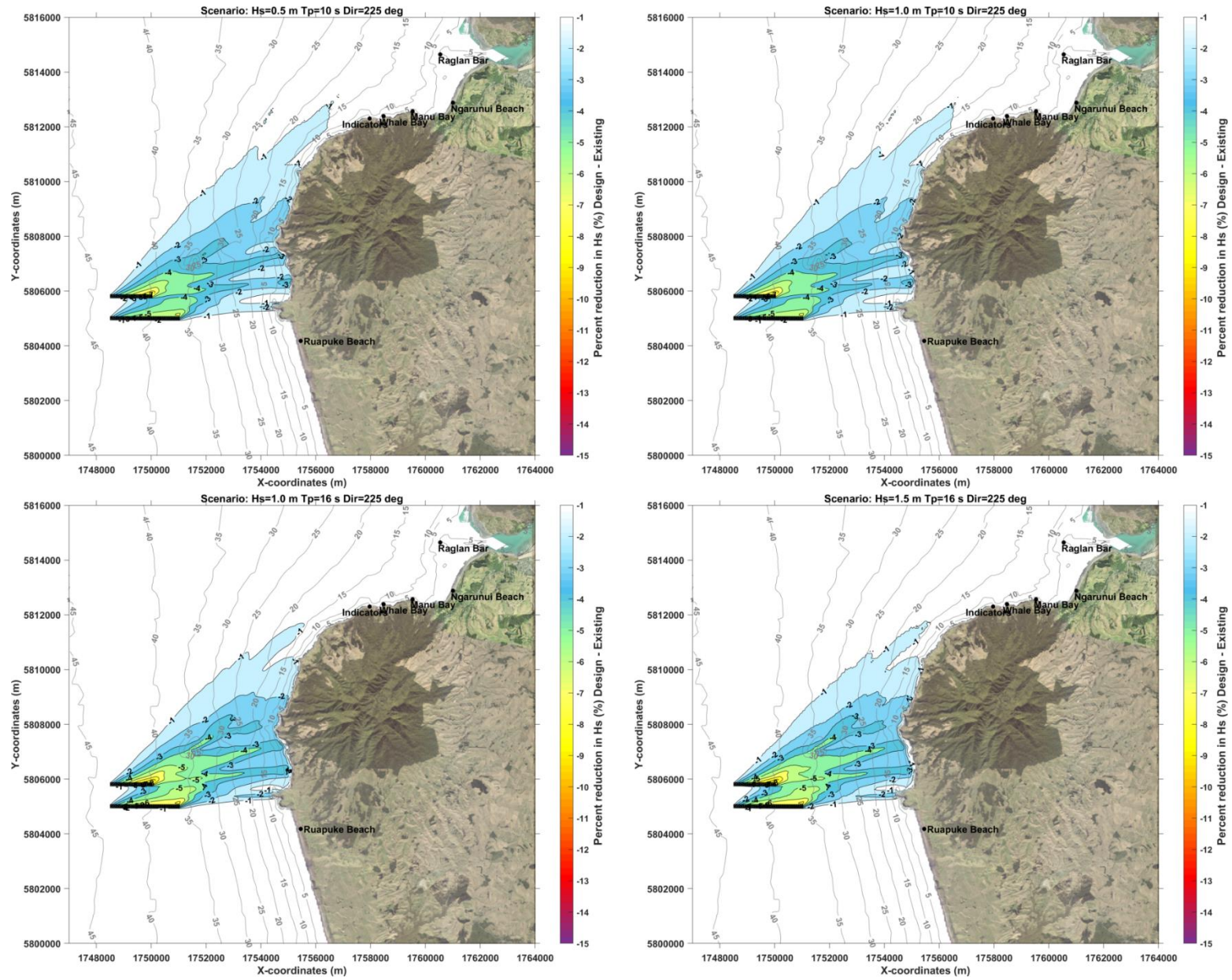


Figure 3-6 Percent reduction in H_s for Site D. Top left: Run_06_50 ($H_s = 0.5$ m, $T_p = 10$ s, $Dir = 225$ deg), top right: Run_07_50 ($H_s = 1.0$ m, $T_p = 10$ s, $Dir = 225$ deg), bottom left: Run_08_50 ($H_s = 1.0$ m, $T_p = 16$ s, $Dir = 225$ deg) and bottom right: Run_09_50 ($H_s = 1.5$ m, $T_p = 16$ s, $Dir = 225$ deg). Black lines represent the backbone lines at a distance of 50 m apart.

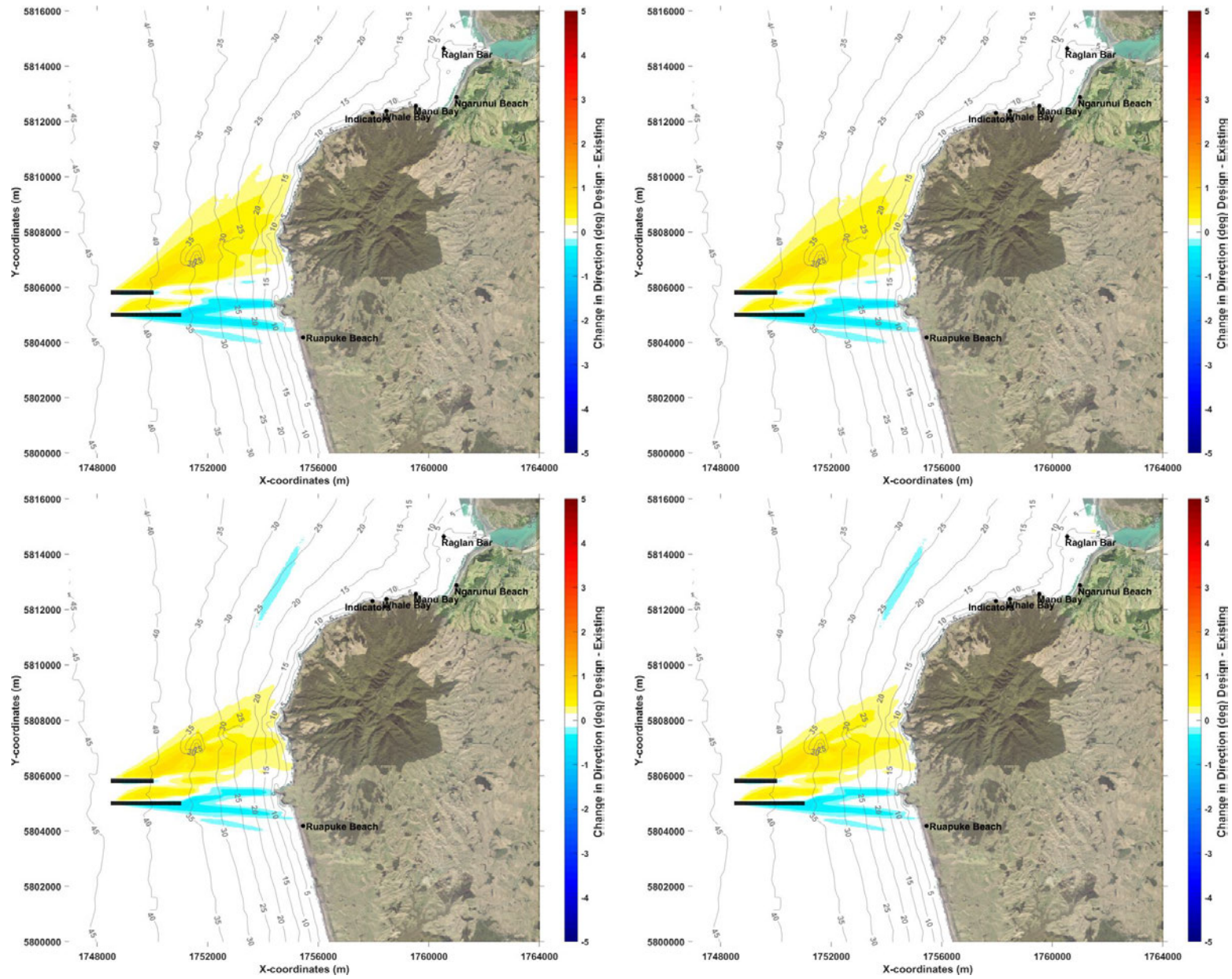


Figure 3-7 Difference in wave direction for Site D. Top left: Run_06_50 ($H_s = 0.5$ m, $T_p = 10$ s, $Dir = 225$ deg), top right: Run_07_50 ($H_s = 1.0$ m, $T_p = 10$ s, $Dir = 225$ deg), bottom left: Run_08_50 ($H_s = 1.0$ m, $T_p = 16$ s, $Dir = 225$ deg) and bottom right: Run_09_50 ($H_s = 1.5$ m, $T_p = 16$ s, $Dir = 225$ deg). Black lines represent the backbone lines at a distance of 50 m apart.

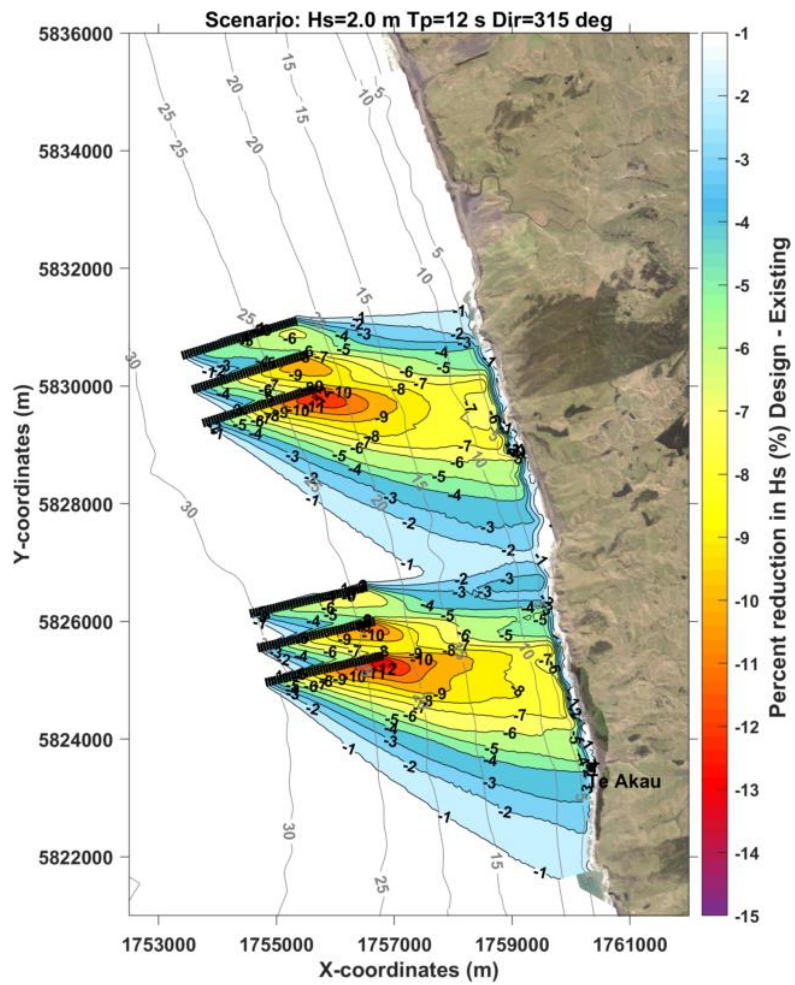


Figure 3-8 Percent reduction in H_s for Sites B and C for Run_01_50 ($H_s = 2.0$ m, $T_p = 12$ s, $Dir = 315$ deg. Black lines represent the backbone lines at a distance of 50 m apart. Te Akau at the south is one of the surf breaks of regional significance.

3.4 Sensitivity runs

3.4.1 Number of backbone lines

We conducted additional simulations with backbone lines spaced every 100 m (half the number of backbone lines in each site) to test the difference in wave attenuation for the different layouts (i.e. lines 50 m vs. 100 m apart).

Maintaining a consistent transmission coefficient per line (0.988), we observed that the reduction in wave height was approximately halved compared to scenarios with 50-meter spacing. Consequently, this adjustment resulted in reducing spatial extent of affected wave heights (Site A: Figure 3-9, Sites B-C: Figure 3-10 and Site D: Figure 3-11).



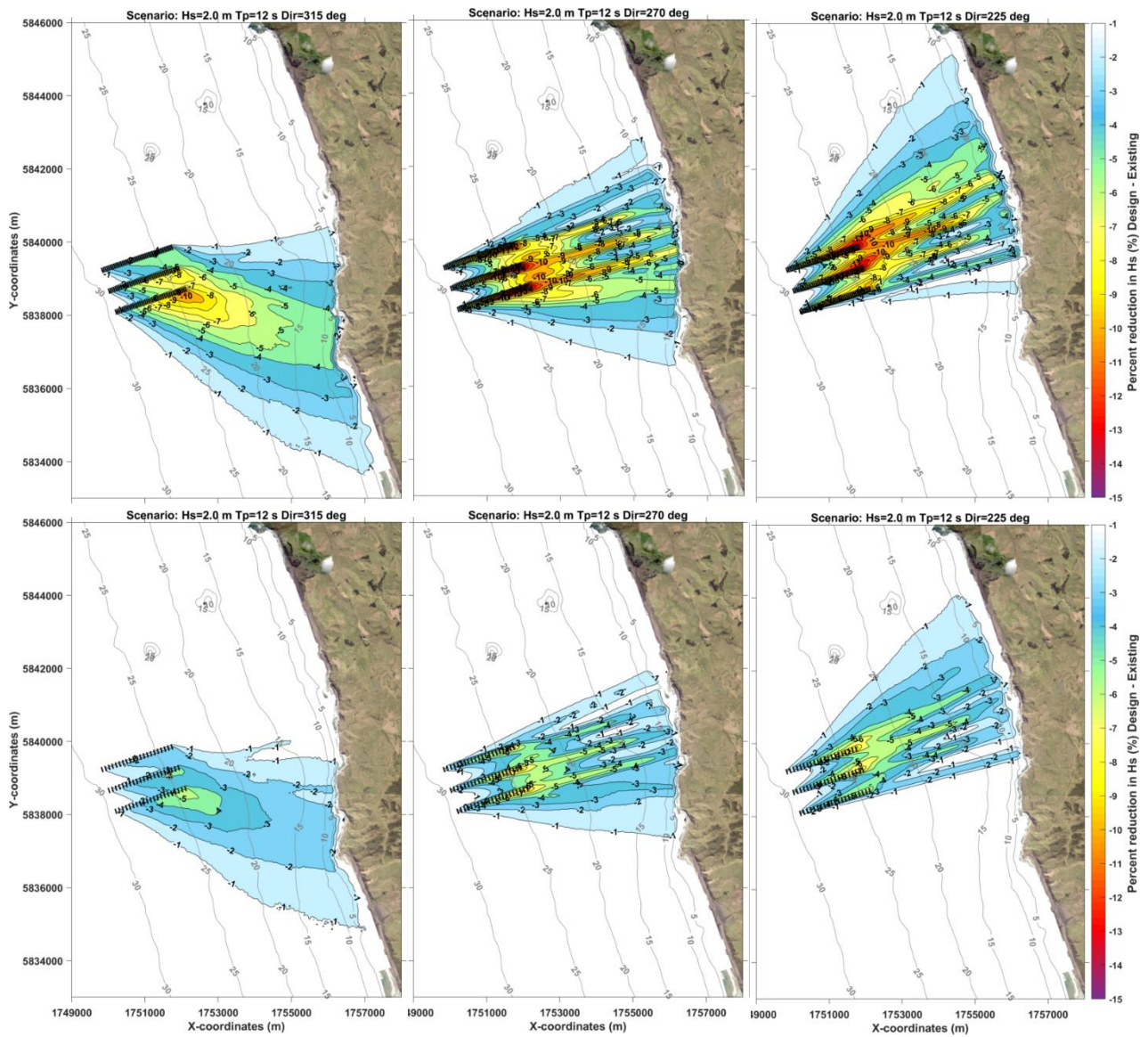


Figure 3-9 Percent reduction in H_s between the existing (no structure) and the runs including the structures for Site A. Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 315 deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 270 deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 225 deg). Black lines represent the backbone lines at a distance of 50 m apart (top) and 100 m apart (bottom).

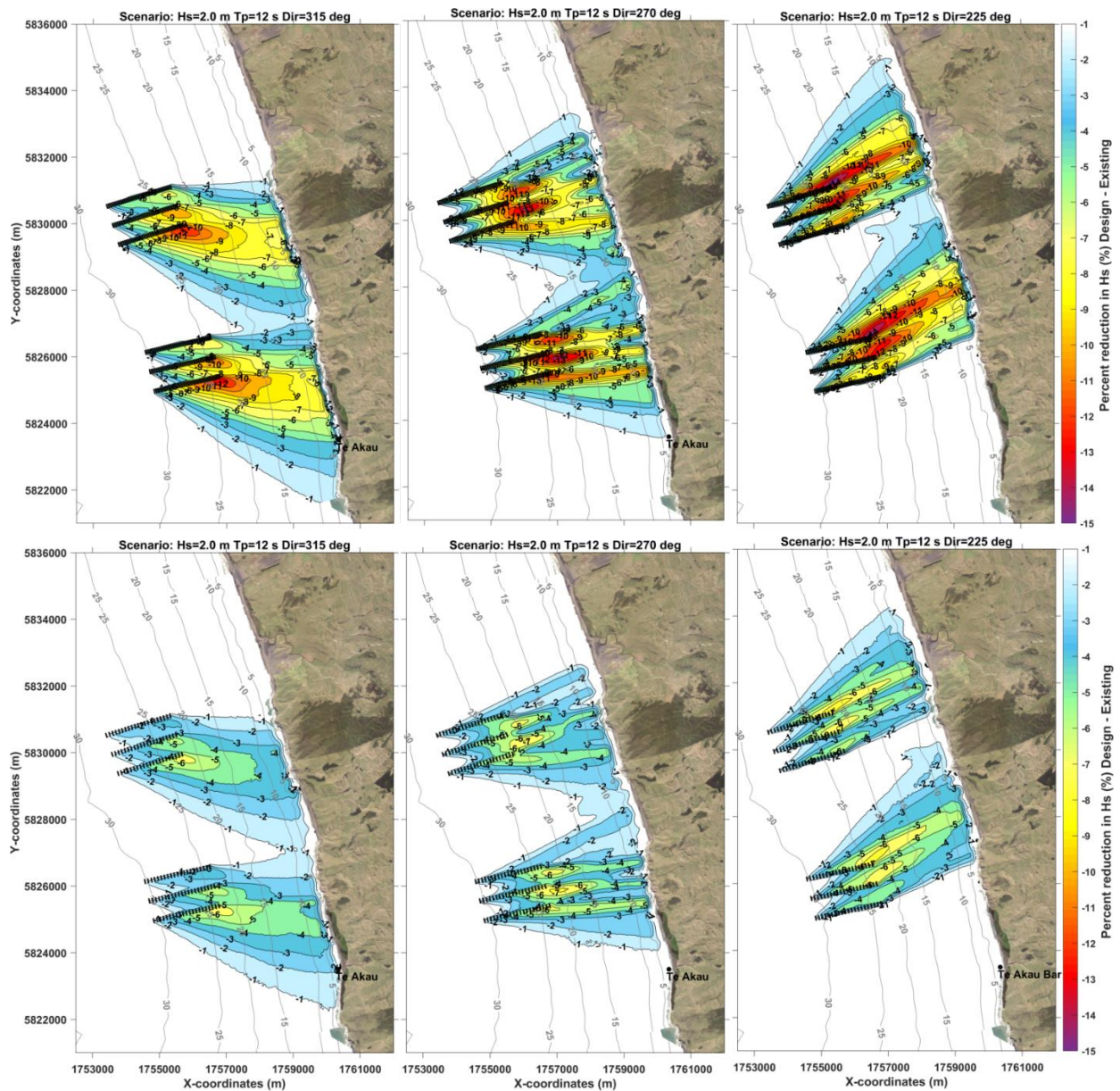


Figure 3-10 Percent reduction in H_s between the existing (no structure) and the runs including the structures for Sites B-C. Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 315$ deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 270$ deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 225$ deg). Black lines represent the backbone lines at a distance of 50 m apart (top) and 100 m apart (bottom).

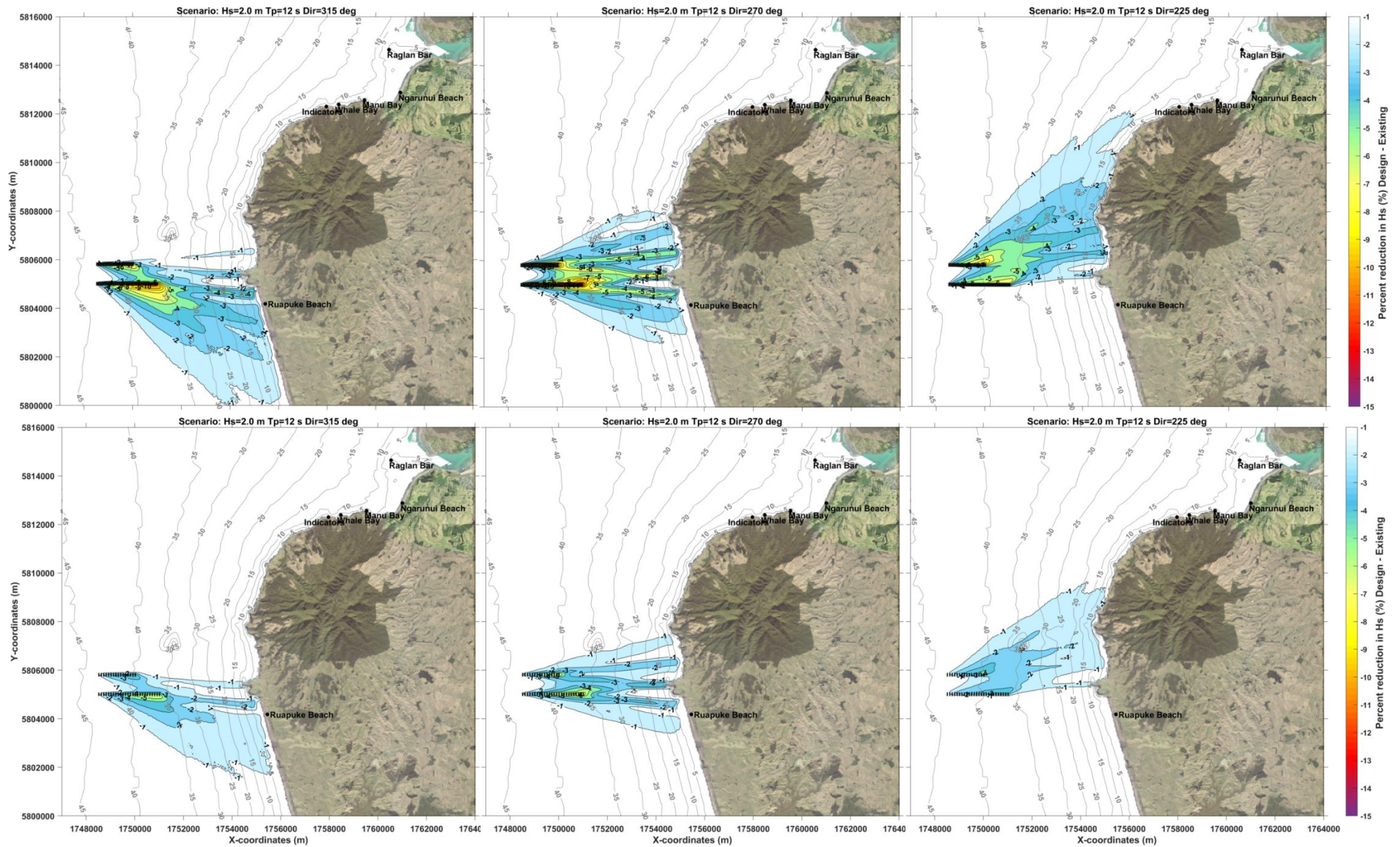


Figure 3-11 Percent reduction in H_s between the existing (no structure) and the runs including the structures for Site D. Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 315 deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 270 deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, Dir = 225 deg). Black lines represent the backbone lines at a distance of 50 m apart (top) and 100 m apart (bottom).

3.4.2 Transmission coefficients

Simulations were carried out using two different transmission coefficients, (a) 0.988 to represent a total transmission of 64% (the equivalent of a dropper density of 0.08 droppers/m²) and (b) 0.991 to represent a total transmission of 0.71 (the equivalent of a dropper density of 0.06 droppers/m²). Coefficient (a) represents the most conservative of the two, i.e., resulting in less transmission, therefore potentially more attenuation in wave height.

As anticipated, applying a higher transmission coefficient per line (0.991) led to reduced attenuation and smaller footprint of potential wave height changes compared to runs using a coefficient of 0.988 (Site A: Figure 3-12, Sites B-C: Figure 3-13 and Site D: Figure 3-14).



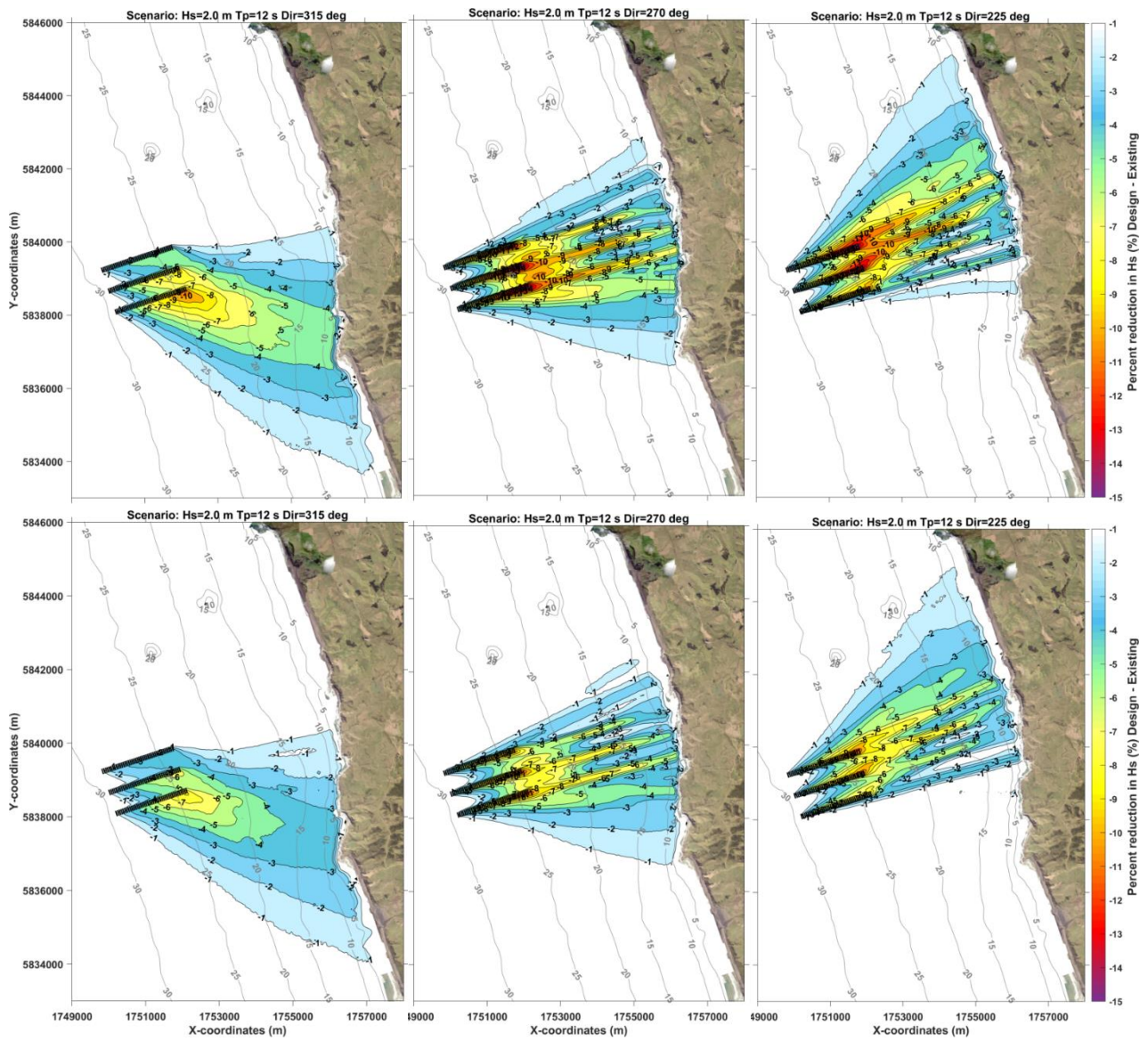


Figure 3-12 Percent reduction in H_s between the existing (no structure) and the runs including the structures for Site A. Transmission coefficient 0.988 (top) and 0.991 (bottom). Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 315$ deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 270$ deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 225$ deg). Black lines represent the backbone lines at a distance of 50 m apart.

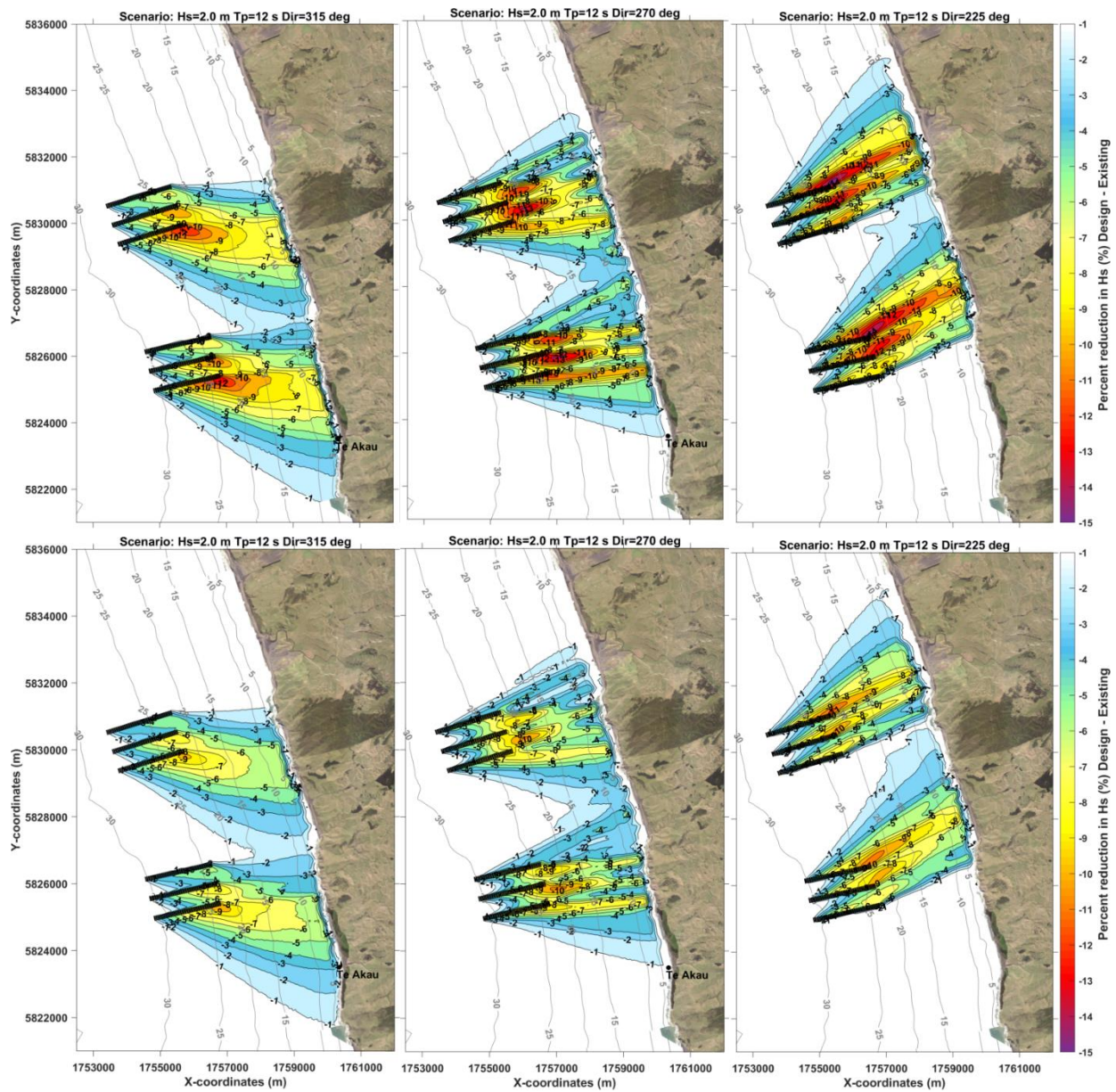


Figure 3-13 Percent reduction in H_s between the existing (no structure) and the runs including the structures for Sites B-C. Transmission coefficient 0.988 (top) and 0.991 (bottom). Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 315$ deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 270$ deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 225$ deg). Black lines represent the backbone lines at a distance of 50 m apart.

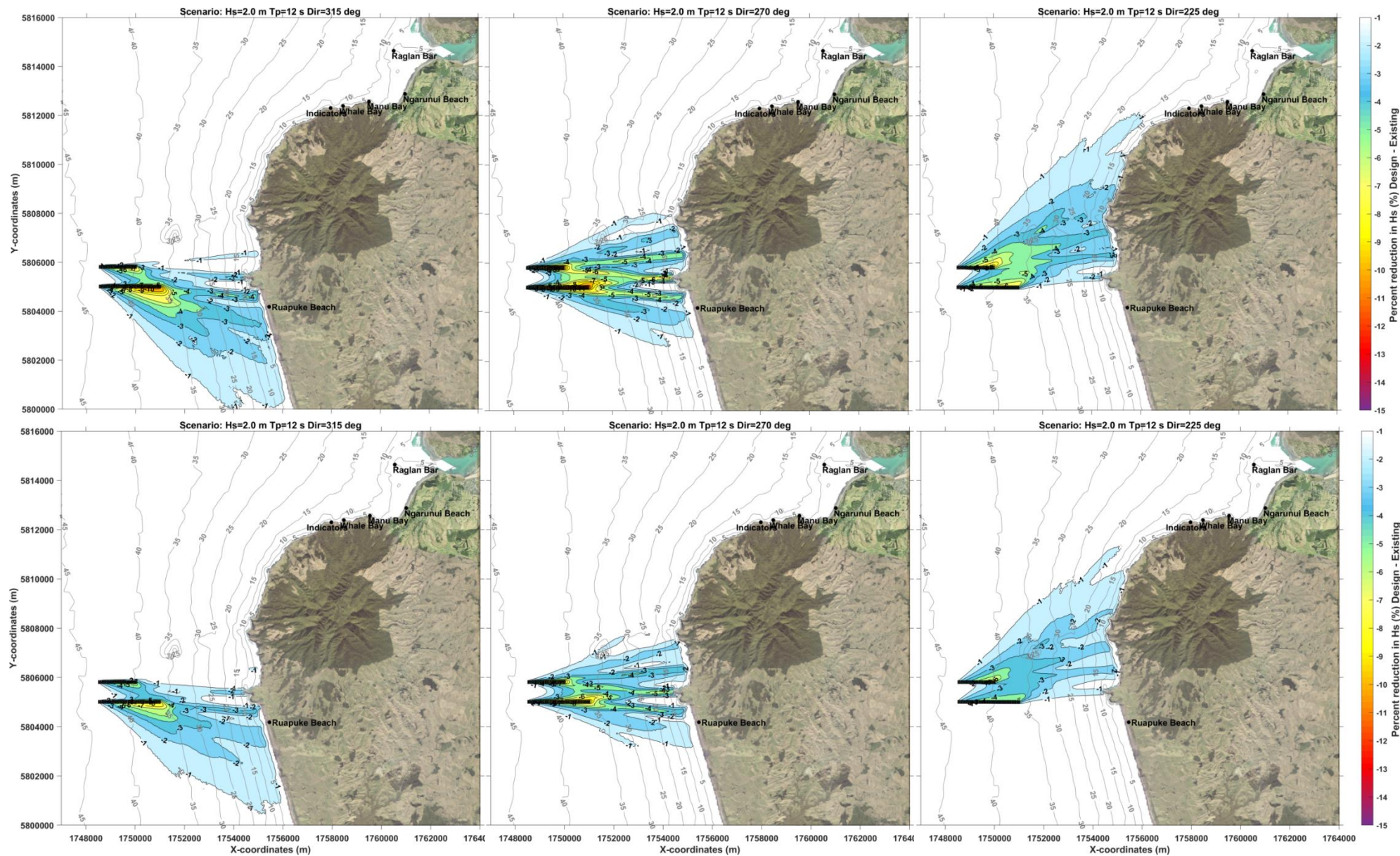


Figure 3-14 Percent reduction in H_s between the existing (no structure) and the runs including the structures for Sites D. Transmission coefficient 0.988 (top) and 0.991 (bottom). Run_01_50 (left, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 315$ deg), Run_02_50 (middle, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 270$ deg) and Run_03_50 (right, $H_s = 2.0$ m, $T_p = 12$ s, $Dir = 225$ deg). Black lines represent the backbone lines at a distance of 50 m apart.

3.5 Potential effects on hydrodynamics

The previous MetOcean report (MetOcean Solutions, 2022) discusses the potential effects of the farm on current attenuation, based on the literature and hydrodynamic hindcast for the region. The main aspects taken into consideration in the discussion are:

1. the orientation of the farm in relation to the main current direction,
2. extension of the farm over the water depth, and
3. farm footprint (more focused on dropper density).

Studies have identified that a main consideration for current modification is the angle of inference between longlines and current direction (Mascorda Cabre et al. 2021; Delaux et al. 2011; Plew, 2005).

In the study by Delaux et al. (2011), model results showed that, for small farms (i.e., equal or less than 10 long lines per farm block), the reduction in current velocity is more significant for small angles (<10 deg) and relatively uniform for larger angles (10 to 90 deg) of farms blocks to the main current direction. However, for larger farm blocks (more than 10 longlines), which is the case of the proposed spat farms, current reduction was minimised for farm block angles of 50 to 90 deg.

According to Plew (2005), optimal nutrient distribution occurs when longlines are oriented normal to the flow. However, this configuration also produces the greatest attenuation of currents. Aligning the longlines at low angles to the main currents, provided best performance in terms of minimising the reduction in velocities, while providing an even supply of nutrients to the mussels.

Example of current speed and direction was extracted from a current hindcast (details of hindcast in Appendix B) for 1 year (2020). The current roses indicate that at Site A the main flow is parallel to the coastline, going to the north-northwest and to the southeast, for both surface and bottom layers. At site D, main flow is to the north and to the south (Figure 3-15). The blocks/rows of the proposed spat nursery sites are orientated perpendicularly (≤ 90 degrees) to predominant current flow and the longlines are oriented parallel (i.e., running along the width of the rows), and thus, based on the existing literature (Plew 2005), Delaux et al. 2011), the impact on current attenuation is likely to be minimised.

In contrast to other submerged canopies, mussel lines do not extend to the surface or the sea floor but are rather suspended in the water column (Mascorda Cabre et al., 2021), and field studies imply that water flows are diverted both under and around marine farms (Plew et al., 2005; Rampazzo et al., 2013; Lin et al., 2016). Plew (2005) and Plew et al. (2006)



noted that when the gap between the dropper line and the seabed decreases, it restricts the vertical flow diversion and the current velocity underneath the farm increases. The proposed spat nursery sites are planned to be submerged, not extending to the surface or to the seabed, with a gap of 60% or more of the total water depth (60% accounts for the 3-m gap between the sea surface and submerged backbone lines, and the gap between the dropper lines and the seabed, i.e., 8-m long dropper lines in 20 to 40-m deep sites). Compared to 10-30% gap which is considered to be restrictive to the flow (Plew et al. 2006), the impact on the vertical flow diversion of the proposed farm is likely minimal.

Current attenuation within marine farms have been found to be reduced by 75% and up to 90% in extreme cases (Plew, 2013; Lin et al., 2016; Hulot et al., 2018; Zhong et al., 2022). Plew (2005) presents an analytical model for predicting the reduction in current velocities within the farm based on a range of dropper densities (Figure 3-17). The model predicts that velocities within the farm drop exponentially, and higher dropper densities increase the reduction.

The Golden Bay mussel farm studied by Plew (2005), had a dropper line density of $0.06 \text{ dropper.m}^{-2}$, which is in the same order of magnitude to the conditions proposed in the Raglan nursery application (0.04 to $0.08 \text{ dropper.m}^{-2}$). The current attenuation within the proposed nursery sites are therefore likely to be similar or potentially less than the Golden Bay farm noting that the proposed spat farm is in much deeper water and considering that the spats are also much smaller in size than mature mussels.

However, the effect of the farm on the current speed may not be restricted to the farm as the submerged canopies may form a wake, an area of reduced current velocities downstream, in the lee of the farm (Plew, 2005, Delaux et al., 2011).

Plew (2005) detected significant changes in the current velocities up to 100 m from the nearest longline. In contrast, an earlier study of a small farm of only 8-10 longlines, described in Waite (1989) and Gibbs et al. (1991), found little effect on current velocities beyond the farm.

Plew (2005) noted that the farm wake may have a nearly constant velocity across its width, but as the wake spreads downstream, it will develop a Gaussian profile. Due to the orientation of the currents at the sites (Figure 3-15) the farm wakes are expected to be in a north-northwest and south-southeast direction for all sites and depending on their potentially interacting for block A, B and C.

In a tidal environment the extent of the wake is expected to be similar to the tidal excursion. For the Golden Bay mussel farm studied by Plew (2005), with similar dropper

density to the proposed spat farm in this study, the furthest point of the wake detected was approximately 2.4 km.

An example of a year (2020) of current hindcast data is presented in Figure 3-16. Average surface current is 0.17 m.s^{-1} for Site A and 0.16 m.s^{-1} for site D and average bottom current is 0.09 m.s^{-1} for both sites. Slower currents mean the impacts of the proposed spat nursery aquaculture activities are expected to be localised and minor with respect to currents/hydrodynamics and hence no significant impact on the dynamic equilibrium of any beach within the environs or the movement of any detritus.

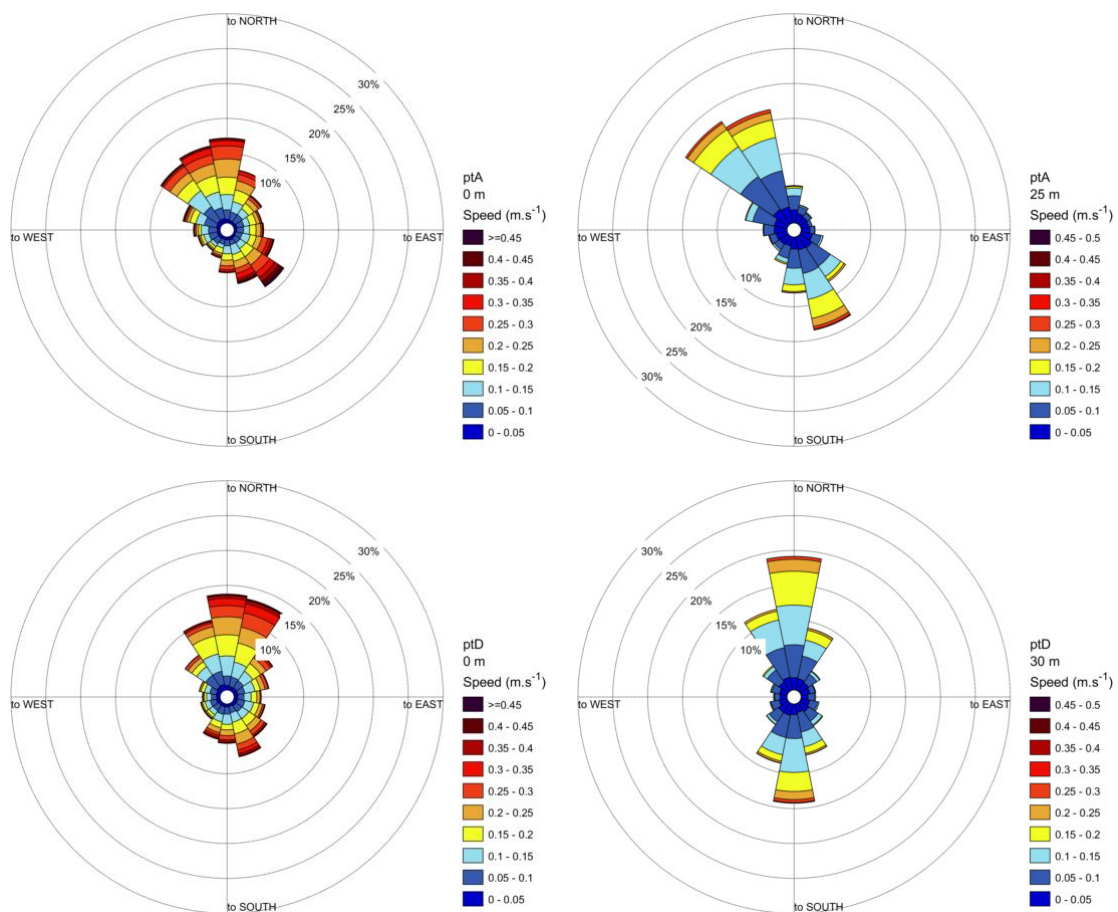


Figure 3-15 Current roses for year 2020 for Site A (top) and Site D (bottom) at surface (left) and near bottom (right). Direction follows the cartesian convention (i.e. 'going to'). Data extracted from ROMS hindcast.

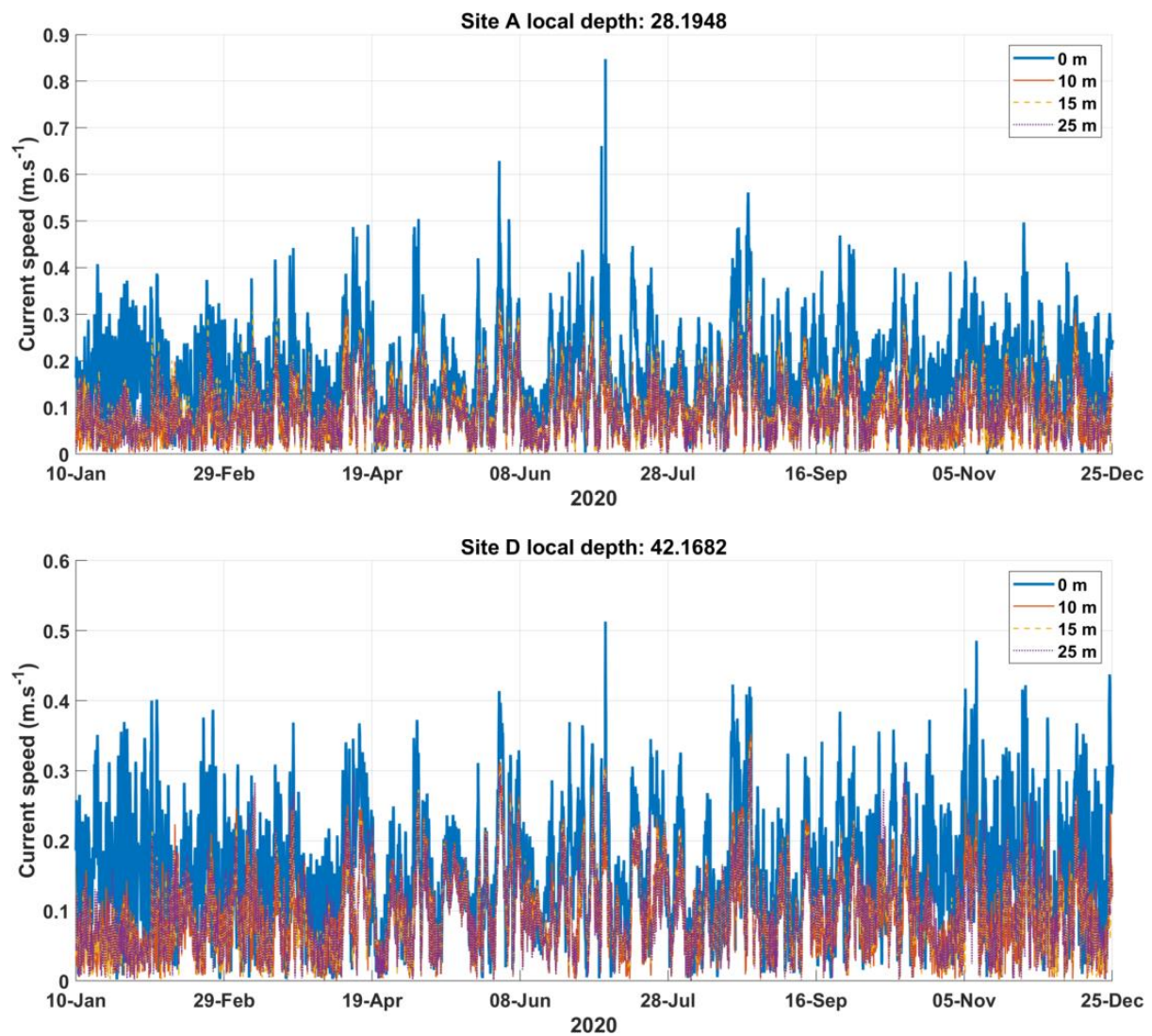


Figure 3-16 Timeseries of current speed for year 2020 for Site A (top) and Site D (bottom) for different depths. Data extracted from ROMS hindcast.

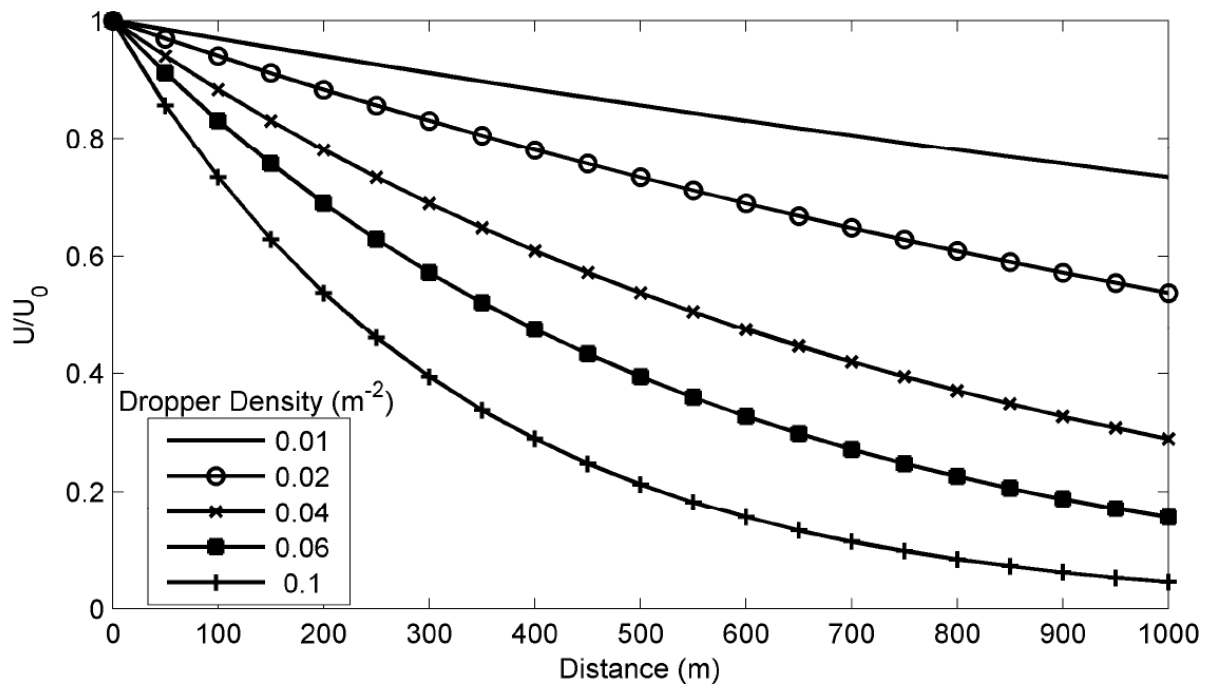


Figure 3-17 Analytical prediction for current attenuation through farm. A range of mussel dropper densities (droppers. m^{-2}) are shown (Source: Plew 2005).

4. Summary of effects

The effects of the spat catching farm on the wave and current attenuation, foreshore, and surf breaks of national and regional significance are summarised in Table 4-1. The assessment presented below considers the results for the most conservative transmission coefficient (i.e. 64% transmission).

Assuming a threshold of 1% H_s change due to the impact of offshore structures on the propagation of wave energy to the coast (as adopted in *South Taranaki Bight Iron Sand Extraction Project. Tran-Tasman Resources Ltd Marine Consent Decision* (2014)), the impacts of the proposed spat collecting lines are considered to be no more than minor. In a similar manner, wave direction modifications by the proposed spat lines are expected to be very small (<2 degrees) following the definition reported by Mead (2013) for South Taranaki and are not expected to impact the quality of the surfable waves.

The current attenuation is based on the qualitative comparison of the proposed farm orientation, dropper density and local current speed to the values found in the literature considered to minimize farm turbulence and attenuation effects (Plew 2005; Plew et al. 2006; Delaux et al. 2011).

Coastal processes are generally not expected to be significantly affected by the reduction in wave height. A high-level analysis on longshore transport has been conducted using an empirical formula (Kamphuis, 2000) and considering the changes in the nearshore related to a reduction in wave height from 2% to 10% and change in wave direction by ± 1.2 degrees (Table 1). The analysis indicates a reduction in longshore transport due to these changes. For the most frequent waves (southwest, with 82% occurrence in the offshore area, Table 2-1), this suggests a potential reduction of about 2-20% in longshore transport to the north and the attenuation may slightly reduce the potential storm erosion. For the rest of the time (approximately 19%), waves typically approach from the West or Northwest. This pattern suggests a reduction in southward sediment transport. The percentage change represents very small and localized changes along the beach and is site-dependent, e.g., the highest changes in significant wave height (10%) occur only at sites B-C within a narrow, discrete region for the conditions simulated (Figure 3-3 top right).

Table 4-1 Summary of effects.

Physical elements	Qualitative and/or quantitative assessment	Effects statement
Wave attenuation	8.5-15% potential reduction in wave height in the lee of the farm depending on Site and incident wave direction.	Localised and minor
	Change in wave direction less than 1.7 degrees.	Very small
Current attenuation	Farm is aligned with flow to minimise attenuation.	Localised and minor
	More than 60% gap in water column giving local depth and length of longlines, i.e. not restricting flow. Sites present slow currents in a high wave energy area. Potentially more localised effect on the flow over a smaller area compared to areas with faster currents.	
Effect on foreshore	4-10% potential reduction in wave height on the nearshore directly in front of the sites. Percent reduction depending on Site and incident wave direction.	Minor
	Change in wave direction less than 1.2 degrees.	Very small
	2-20% potential reduction in longshore transport along the beach, site dependent.	Very small and localized
Effect on surf breaks of national significance	1% change contour do not extend to the surf breaks of national significance.	Less than minor
	No change in wave direction near the surf breaks.	
Effect on surf breaks of regional significance	Potential 3-4% change near Te Akau for northwest waves and 2-4% change near Ruapuke for northwest and west waves. Northwest waves have low occurrence.	Minor
	Change in wave direction less than 0.3 degrees.	Very small



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Appendix A: Wave hindcast

The long-term hindcast wave modelling was performed using a modified version of Simulating WAve Nearshore (SWAN) . This section describes details of the wave model and the technique employed in the simulations.

SWAN is a third-generation ocean wave propagation model which solves the spectral action density balance equation (Booij et al., 1999). The model simulates the growth, refraction and decay of each frequency-direction component of the complete sea state, providing a realistic description of the wave field as it changes in time and space. Physical processes that can be modelled include the generation of waves by surface wind, dissipation by white-capping, resonant nonlinear interaction between the wave components, bottom friction and depth-induced wave breaking dissipation. A detailed description of the model equations, parametrisations and numerical schemes can be found in Holthuijsen et al. (2007) and in the SWAN documentation .

The wave hindcast was selected from a 10-year period, from 2010 to 2019. The model was configured in non-stationary mode including all third-generation physics. The ST6 configuration (Rogers et al., 2012) and the bottom friction scheme of Collins (1972) with coefficient of 0.015 were applied. Depth-induced wave breaking dissipation was modelled according to Battjes and Janssen (1978). The wave spectra were discretised with 36 directional bins (10 deg directional resolution) and up to 41 frequencies logarithmically spaced between 0.041 and 1.864 Hz at 10% increments.

A dynamical downscaling nesting approach was applied to resolve the regional North Island area, with a regular SWAN nest with resolutions of ~4 km.

Full spectral boundaries for the parent SWAN hindcast domain were prescribed from a global implementation of the WAVEWATCHIII (WW3) spectral wave model (Tolman, 1991), run at 0.5 deg resolution with the source terms of Ardhuin et al. (2010).

The model was forced with surface winds from a configuration of the Weather Research and Forecasting (WRF) as described in the previous subsection.

Appendix B: Current hindcast

The 1-year current data was extracted from the Moana Backbone data set. The hindcast dataset has hourly outputs over a 27-year period, from 1993 to 2020. Model results are available for temperature, salinity, velocity (u, v, w), and sea surface elevation.

The Moana Backbone model is a 25+ years 3D hydrodynamic hindcast for New Zealand waters which consists of a high-resolution 3D ROMS model with outputs calibrated and validated against field data available around New Zealand. For this project, no local measurement have been considered.

The ROMS spatial resolution is approximately 5x5 km and include the whole New Zealand (Figure 6 1). The ROMS model was run in three-dimensional mode and was nested within the he global GLORYS/Mercator reanalysis 12v1 (latest version from Nov 2018) at daily intervals and 8 km spatial resolution (Ferry et al., 2012). The atmospheric forcings were sourced from the CFSR reanalysis (Saha et al. 2010). Spectral tidal forcings were imposed at the ROMS domain boundaries by the Oregon State University Tidal Inverse Solution (OTIS), widely used to force regional and coastal domains in hydrodynamic models (Egbert and Erofeeva, 2002). A total of 11 tidal constituents were used.

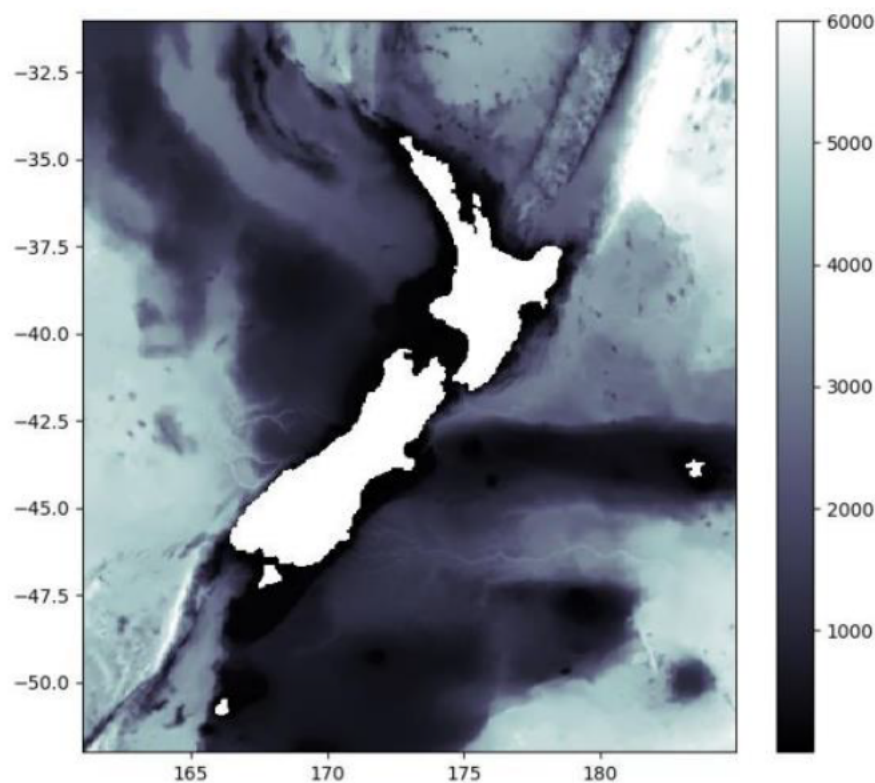


Figure B-1 Bathymetry map showing the extents of the hydrodynamic regional ROMS 3D domain at approximately 5 by 5 km resolution.



From: [REDACTED]
To: [REDACTED]
Subject: Re: Permission to upload Hydrodynamics assessment
Date: Friday, 25 September 2026 4:31:56 pm
Attachments: [image.png](#)
[image.png](#)
[image.png](#)

Hi Rebecca,

Yes, I can confirm that it is fine to upload it with the application.

Thank you

Regards

Alexis

MetOcean Solutions



Dr Alexis Berthot

Manager Project Consultancy
Research and Innovation Hub | Science & Innovation

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From: Rebecca Clarkson [REDACTED]
Sent: Friday, September 25, 2026 14:00
To: Alexis Berthot [REDACTED]
Subject: Permission to upload Hydrodynamics assessment

Kia ora Alexis, we are just about to lodge our Fast-track application and I've just noticed your report has a confidentiality clause.

Can you please confirm by return email that we can upload it with the application?

Many thanks, Rebecca

Ngā mihi,

REBECCA CLARKSON | PRINCIPAL ADVISOR

M: [REDACTED]
E: [REDACTED]
W: aquaculturedirect.co.nz