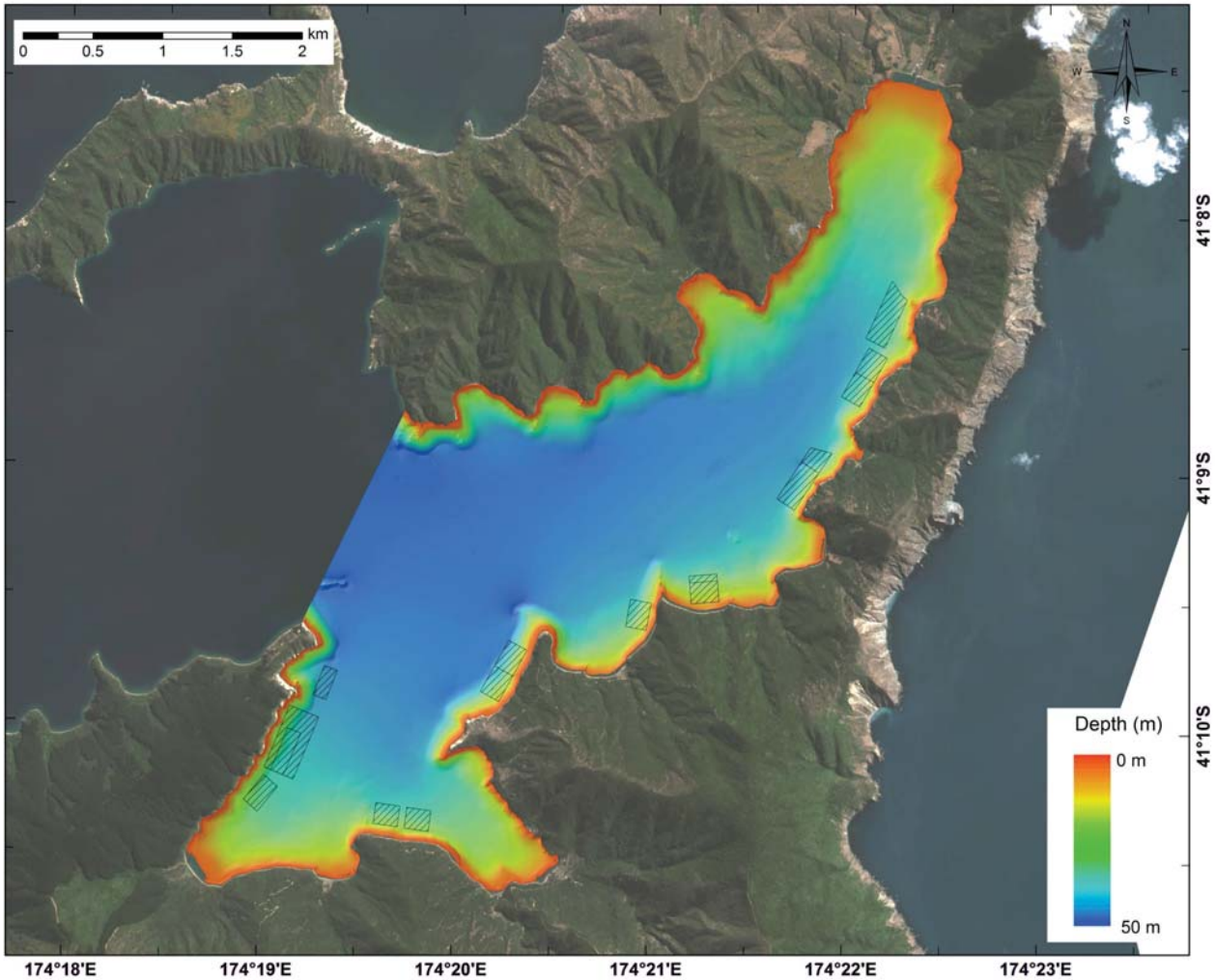
East Bay Seafloor Habitat Maps: A2 Folio Series

Prepared for Marlborough District Council

October 2017



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Taihoro Nukurangi

DML

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Quality Assurance Statement		
Alan Orpin	Reviewed by:	
Helen Neil	Formatting checked by:	
Andrew Laing	Approved for release by:	

East Bay Seafloor Habitat Maps. A2 folio series contains:

Legend

Map projection: NZTM
Datum: NZGD2000
Scale: 1:20,000 & 1:10,000
Data sources: Land Information New Zealand (LINZ) hydrographic survey of Queen Charlotte Sound / Tōtaranui and Tory Channel / Kura Te Au Hydrographic Survey (HS51). This survey comprises both hydrographic (LINZ) and habitat mapping (Marlborough District Council (MDC)), requirements which are met by a National Institute for Water and Atmospheric Research Limited (NIWA) led partnership with Discovery Marine Limited (DML). Aerial photography from KiwiImage.

Multibeam Echo-Sounder Data Acquisition:
The bathymetry and seafloor data for this map series compilation were collected from NIWA's research vessel RV *Ikatere* using a Kongsberg EM2040 high-resolution multibeam echo-sounder (MBES).

Data Analysis and Map Compilation:
Survey data were imported into *ArcGIS* for spatial analysis and map compilation.

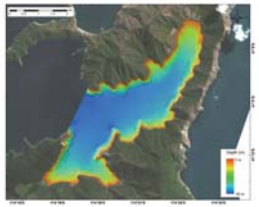
Overview

Marlborough District Council identified the need to understand the relationship of marine farm structures with the underlying substrate within Queen Charlotte Sound / Tōtaranui and Tory Channel / Kura Te Au. Here we provide an interim set of map products for inner East Bay, depicting multibeam bathymetry, backscatter, water-column information, and derived morphological-habitat information, in conjunction with marine farm structures. This mapping initiative was undertaken during October 2016 to June 2017 using NIWA's high-resolution multibeam echo-sounder (MBES) to map and identify seafloor types and water-column structures within the survey area. *ArcGIS* tools were used to spatially analyse and classify the physical-benthic environment. Benthic-terrain modelling classified the seafloor into zones based on bathymetric variability. These zones form the basis of a benthic terrain classification map. Bathymetric variability and backscatter are then used to derive morphologic and/or substrate classifications. This portfolio is accompanied by 3D visualisations which can be viewed with iView4D software (supplied) that illustrate the marine farm structures in the water over the seafloor. In addition, data used to generate the portfolio images are supplied as an ESRI file geodatabase.

Bathymetry (shape and depth of seafloor)

Bathymetry data reveal the shape and depth of the seafloor, and is illustrated as a sun-illuminated digital-elevation model (DEM) produced from the HS51 survey of Queen Charlotte Sound / Tōtaranui and Tory Channel / Kura Te Au. The DEM was produced from a 2 m gridded surface, and overlain on hillshaded relief to improve the depth visualisation. Depth contours are also shown.

East Bay - Bathymetry (2 m sun-illuminated digital elevation model)



Hillshade

Hillshades are a useful visual aid when illustrating bathymetric data as they help depth perception. A hillshade was generated with the sun-illumination from the northwest (315°), at an altitude of 45° above an artificial horizon. Images in this portfolio are underlain by a 2 m gridded hillshade.

East Bay - Hillshade (2 m, azimuth 315°, altitude 45°, v.e. 1x)

Backscatter (seafloor sediment)

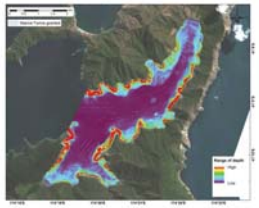
As well as water depth, a secondary signal of reflected sound intensity (backscatter) is recorded. Backscatter intensity can help identify the type of seafloor substrate; whether it is hard or soft, or sediments are coarse- or fine-grained. This provides valuable information about the physical benthic habitats. This region is predominately low- to medium-reflective seafloor (grey), indicative of fine-grained sediments.

East Bay - Backscatter (underlain by hillshade)

Range of depth

Depth range illustrates the difference between minimum and maximum depth within a selected spatial window. High values indicate features over which depth varies significantly whereas low values indicate areas with little depth change within the selected spatial window.

East Bay - Range of depth (6 x 6 m window)



Slope

Slope is the steepness of the seafloor gradient, classified according to the angle (in degrees) from the horizontal. Values near zero are flat areas, while higher values are areas that are increasingly steep.

East Bay - Slope (°) 6 x 6 m window

Standard deviation of slope

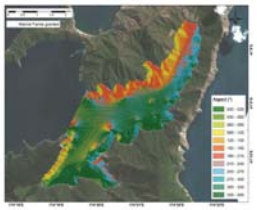
A statistical measure that is used to quantify variation in a set of values. Here, standard deviation was calculated over three cells (6 x 6 m window). A low standard deviation indicates that the individual cell slope values tend to be very close to the mean of the window slope value i.e. a low variation of slope within each window. A high standard deviation indicates that individual cell-slope values are spread across a wider range of values, i.e. there is a high variation of slope within each window.

East Bay - Standard deviation of slope (°) 6 x 6 m window

Aspect

Aspect is the direction of down-slope dip, with north at 0° (green) and south at 180° (red).

East Bay - Aspect (°) 6 x 6 m window



Rugosity

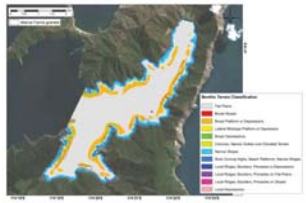
Rugosity (or roughness) of the seafloor is the ratio of surface area to planar area, and is a measure of terrain complexity. In the benthic environment, ecological diversity can generally be correlated with environmental complexity. As such, rugosity is often used to help identify areas with potentially high biodiversity.

East Bay - Rugosity (6 x 6 m window)

Benthic Terrain Classification

The information from the depth, slope, rugosity and other data sets is used to create a classification scheme for the benthic terrain. The resultant classification scheme derived here classifies inner East Bay as 68% flat plains, 14% broad platforms or depressions, 8% narrow slopes, and 8% rock outcrops/beach platforms. This classification scheme can form the basis of a targeted photographic and sampling programme.

East Bay - Benthic Terrain Classification



Benthic Terrain Classification cont.

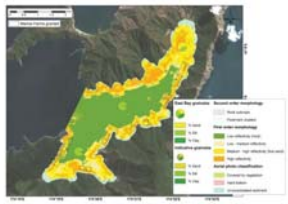
Under the marine farms in inner East Bay the seafloor is classified, by percentage of the class area as: 55% of the classes that include local ridges; 17% of the broad platforms or depressions; 10% of the broad depressions; and, 5% of the broad slopes (See Table 1 below).

Benthic Terrain Class	Area (m²) within East Bay	Area (m²) under farm	% of Class within East Bay	% of Class under farm
Flat Plains	7715640	148144	68%	2%
Broad Slopes	980	52	0.01%	5%
Broad Platform or Depressions	1587372	271236	14%	17%
Lateral Midslope Platform or Depression	180	0	0.002%	0%
Broad Depressions	90416	8912	1%	10%
Crevices, Narrow Gullies over elevated terrain	93696	2512	1%	3%
Narrow Slopes	872064	38520	8%	4%
Rock Outcrop Highs, Beach Platforms, Narrow Ridges	914880	1944	8%	0.2%
Rocky Outcrops (as a subset of above class)	*174443*	*2392*	*1.5%*	*1.14%*
Local Ridges, Boulders, Pinnacles in Depressions	3364	1016	0.03%	30%
Local Ridges, Boulders, Pinnacles on Flat Plains	29072	4532	0.3%	16%
Local Ridges, Boulders, Pinnacles on Slopes	3228	300	0.03%	9%
Local Depressions	33792	200	0.3%	1%

Seafloor Classification

The bathymetry and backscatter data, and the derivative benthic terrain model products, were jointly classified to identify and describe a variety of geomorphic features. These include four backscatter classes: 19% high backscatter reflectivity predominately on slopes; 24% medium-high backscatter reflectivity (fine sand) predominately on shoreline-slope aprons; 10% of low-medium backscatter reflectivity predominately within the embayed inlets; and, 47% low backscatter reflectivity (mud) predominately on flat seafloor of the central bay.

East Bay - Seafloor classification



Seafloor Classification cont.

Two second-order geomorphic features are also defined: rocky outcrops and clusters of pockmarks.

Grain-size of three samples from East Bay are illustrated here showing the validation of the substrate interpretation for backscatter reflectivity. A fourth indicative grain-size sample, from a similar seafloor area proximal to a marine farm comprising cages, is also illustrated.

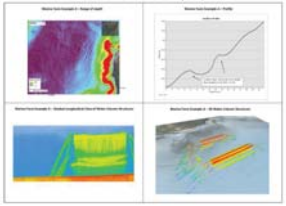
Under the marine farms in inner East Bay the seafloor is described, by percentage of the seafloor-backscatter classes, as: 8% of the high backscatter reflectivity; 8% of the medium-high backscatter reflectivity (fine sand); 6% of the low-medium backscatter reflectivity; and, 1% of the low backscatter reflectivity (mud) (see Table 2 below).

Seafloor Class	Area (m²) within East Bay	Area (m²) under farm	% of Class within East Bay	% of Class under farm
Low reflectivity (mud)	5007056	45339	47%	1%
Low-medium reflectivity	1057150	65288	10%	6%
Medium-high reflectivity (fine sand)	2546808	206073	24%	8%
High reflectivity	2007762	160726	19%	8%

Marine Farm: Example A

The derivative range of depth and a seafloor profile highlight the localised ridges under this marine farm example (A). The structures of the marine farm are clearly shown in the stacked-longitudinal view of the water column and the 3D view (also see supplied 3D visualisations, viewable with iView4D software). Note the structures in the middle of the farm are not visible due to the survey vessel being unable to safely navigate through the farm.

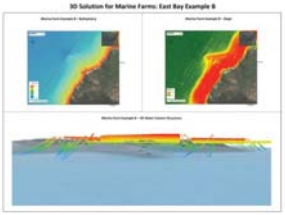
3D Solution for Marine Farms: East Bay Example A



A2 folio series contains (cont.):

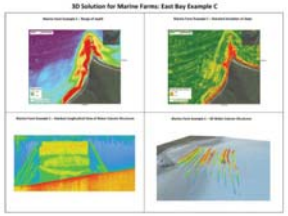
Marine Farm: Example B

Bathymetry and slope clearly show the localised ridges beneath this example (B) of a marine farm. They also illustrate the rocky outcrops that protrude seaward under the marine farm. The subsurface marine-farm structures and anchor lines are evident in the 3D view (also see supplied 3D visualisations, viewable with iView4D software).



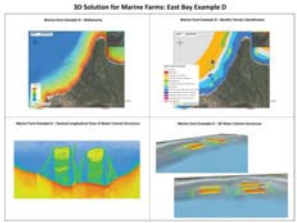
Marine Farm: Example C

Range of depth and standard deviation of slope are also useful in highlighting the localised ridges under marine farms where they lie over deepening seafloor. In this example (C) the prominent rocky ridge to the north of the marine farm is highlighted. The marine structures of the farm are clearly seen in the stacked longitudinal view of the water column. Curvature of the marine structures is due to tidal and wind-driven currents, evident in the 3D view (also see supplied 3D visualisations, viewable with iView4D software).



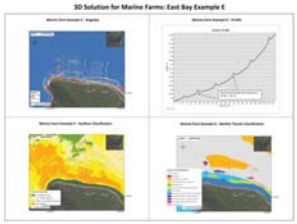
Marine Farm: Example D

A diverse range of benthic terrain classes ranging from rocky outcrops, local ridges, and slopes occur under marine farms when they lie over a deepening seafloor. Two sets of marine farm structures are evident in the stacked longitudinal view of the water column and the 3D view (also see supplied 3D visualisations, viewable with iView4D software). The high-resolution of the water-column data shows the criss-cross nature of the anchor lines between the structures.



Marine Farm: Example E

The utility of rugosity for visualising the localised ridges, and the roughness of the ridges, beneath the marine farm and the blocks used to anchor the structures is shown here. Differences in first order morphology of the seafloor beneath, and outside, of a marine farm can be evident in the derived Seafloor Classification. In this example (E), the benthic terrain classification indicates that this marine farm lies mainly over flat plains and broad platforms.



Marine Farm: Example F

Bathymetry, along with standard deviation of slope, highlight the localised elevations beneath this marine farm. The midwater marine farm structures (cages) are clearly visible in the stacked longitudinal view of the water column and the 3D view (also see supplied 3D visualisations, viewable with iView4D software). In this example (F), the structures in the middle of the farm are not visible due to the survey vessel being unable to safely navigate close to the farm.

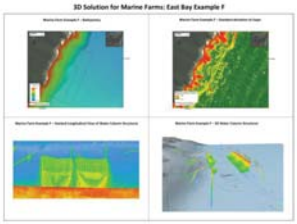


Table 1: Area of Benthic Terrain Classes

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Table 2: Area of Seafloor Classes

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Under the auspices of Queen Charlotte Sound / Tōtaranui
and Tory Channel / Kura Te Au Hydrographic Survey LINZ Project HYD-2016/17-01 (HS51).

Contact:
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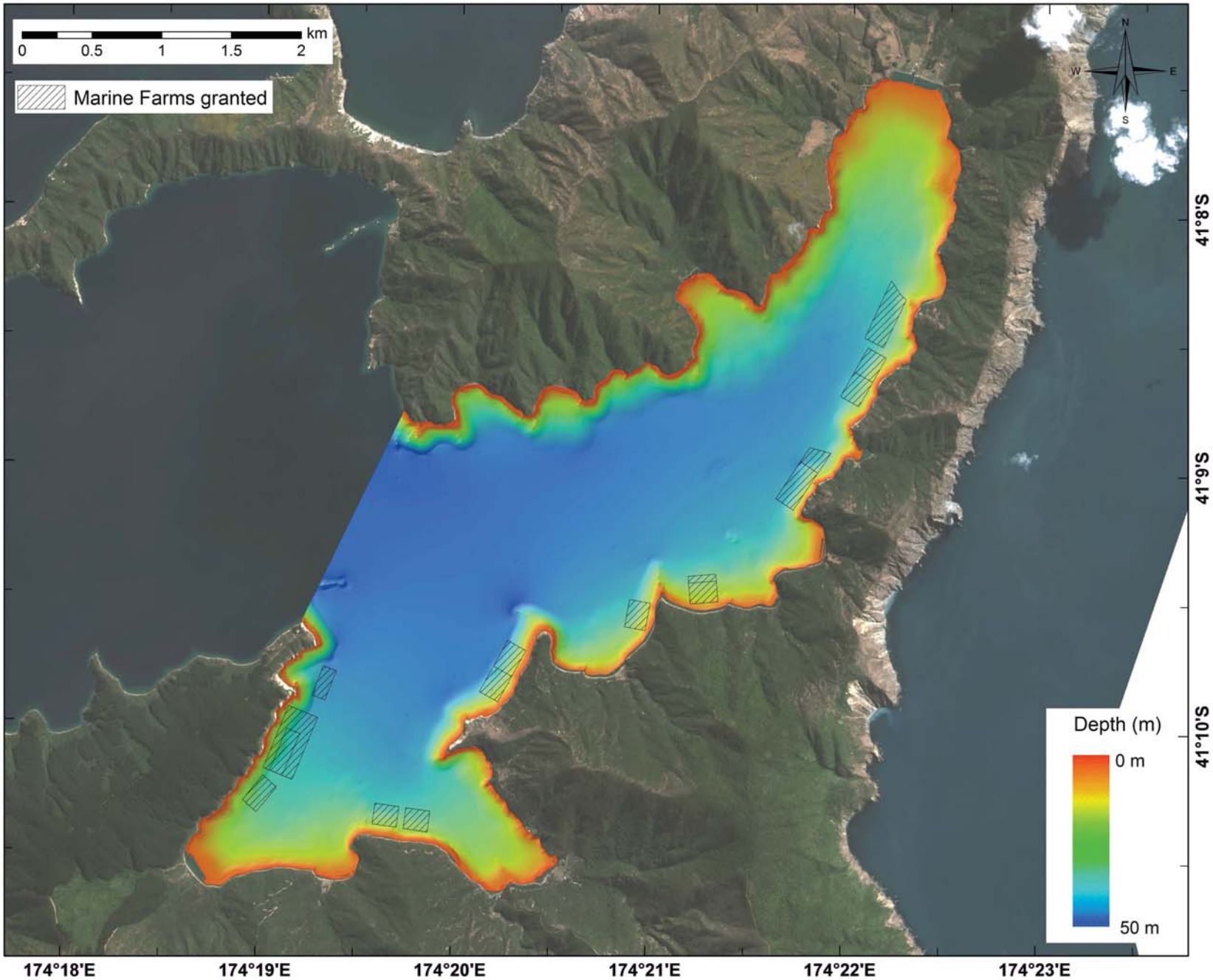
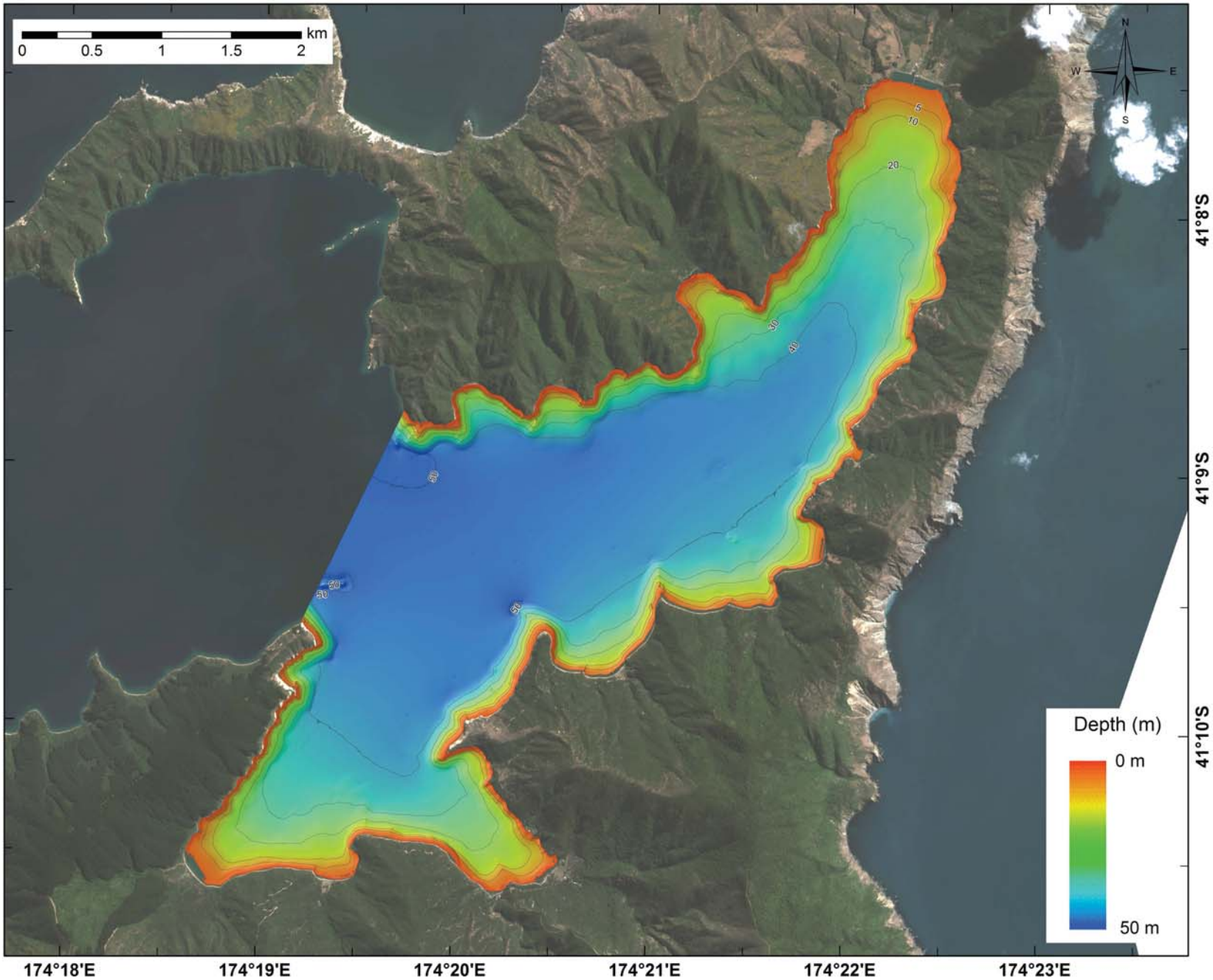
National Projects Manager

helen.neil@niwa.co.nz

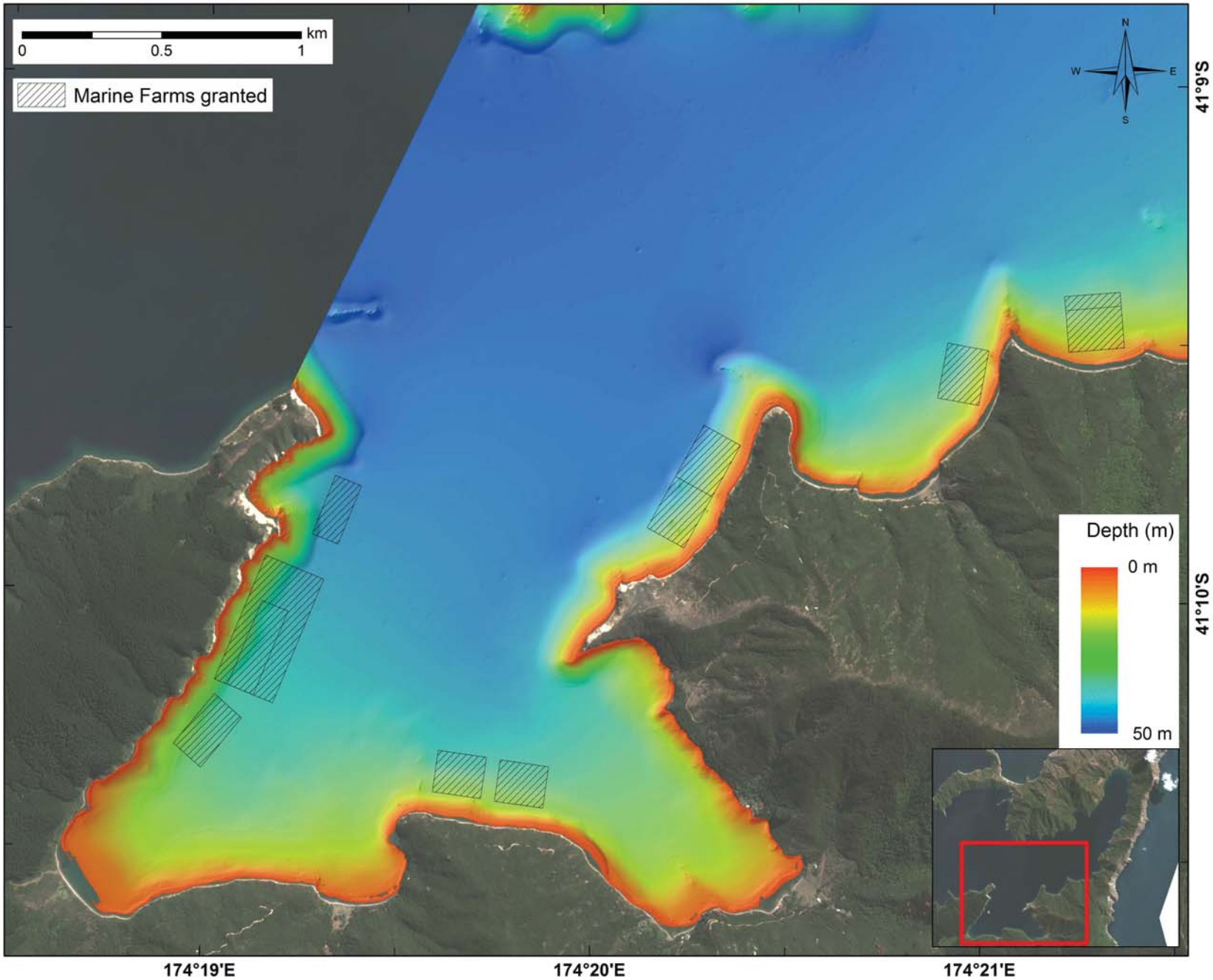
East Bay - Bathymetry (2 m sun-illuminated digital elevation model)



East Bay - Bathymetry (with bathymetric contours)



East Bay - Bathymetry (2 m sun-illuminated digital elevation model)



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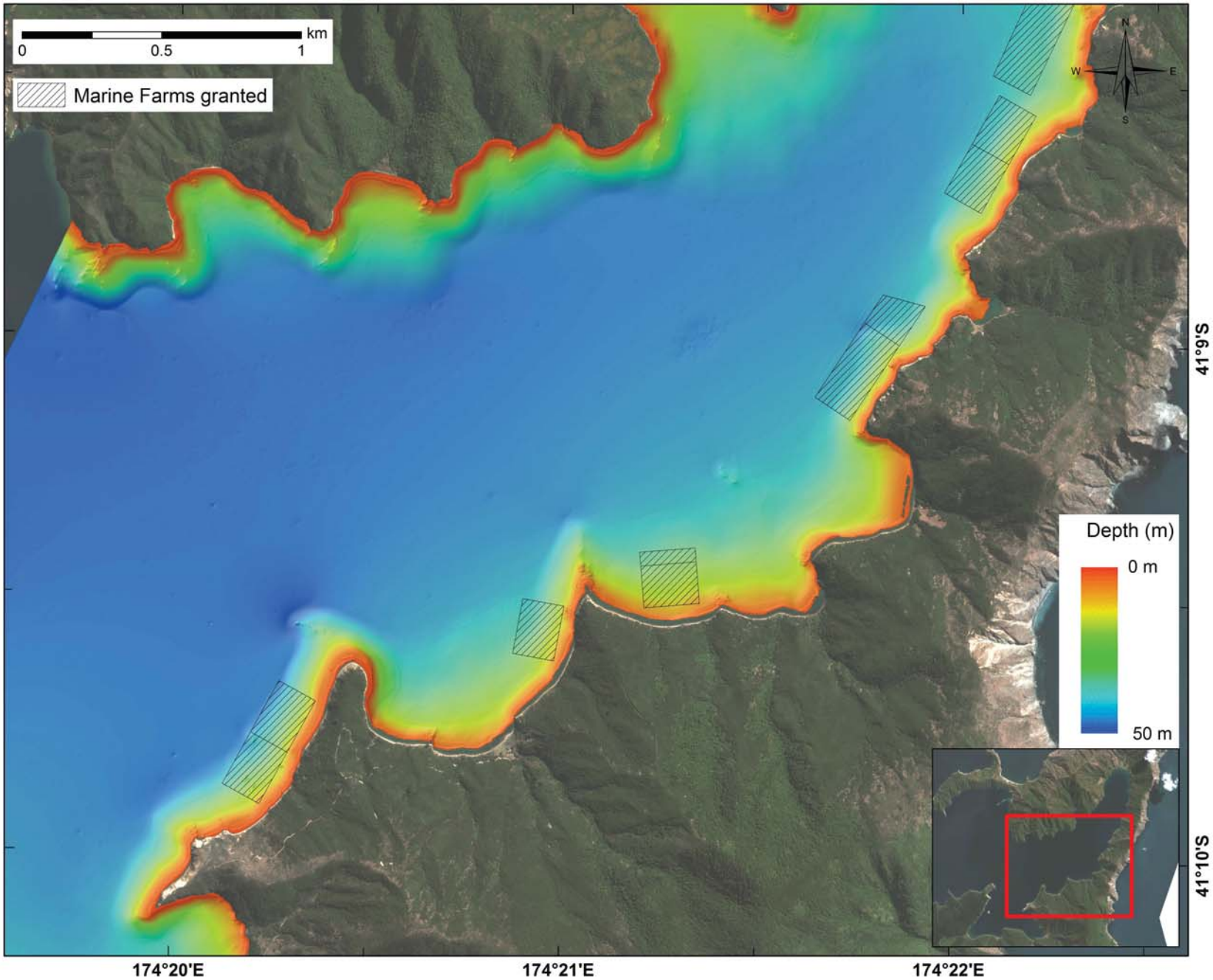

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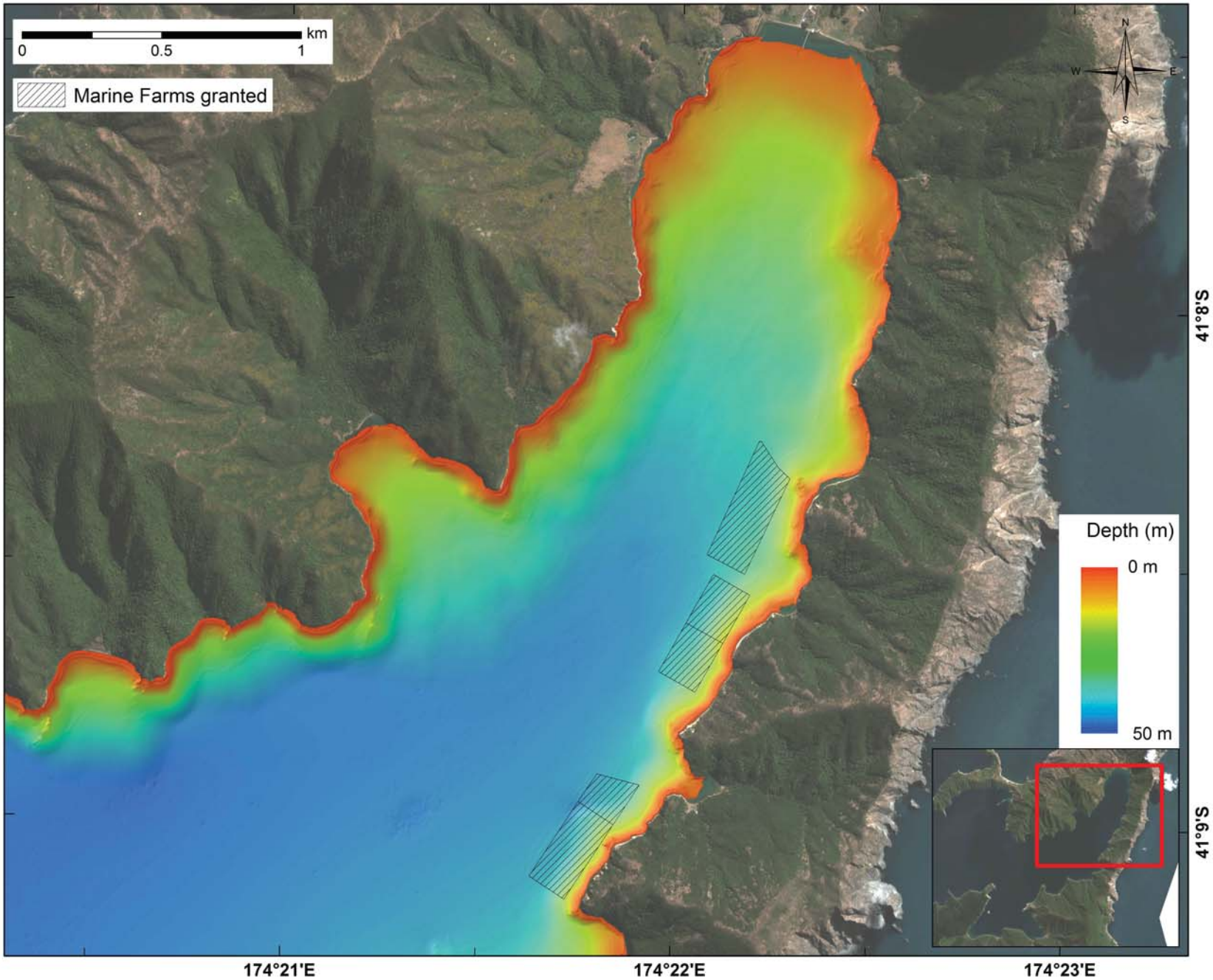
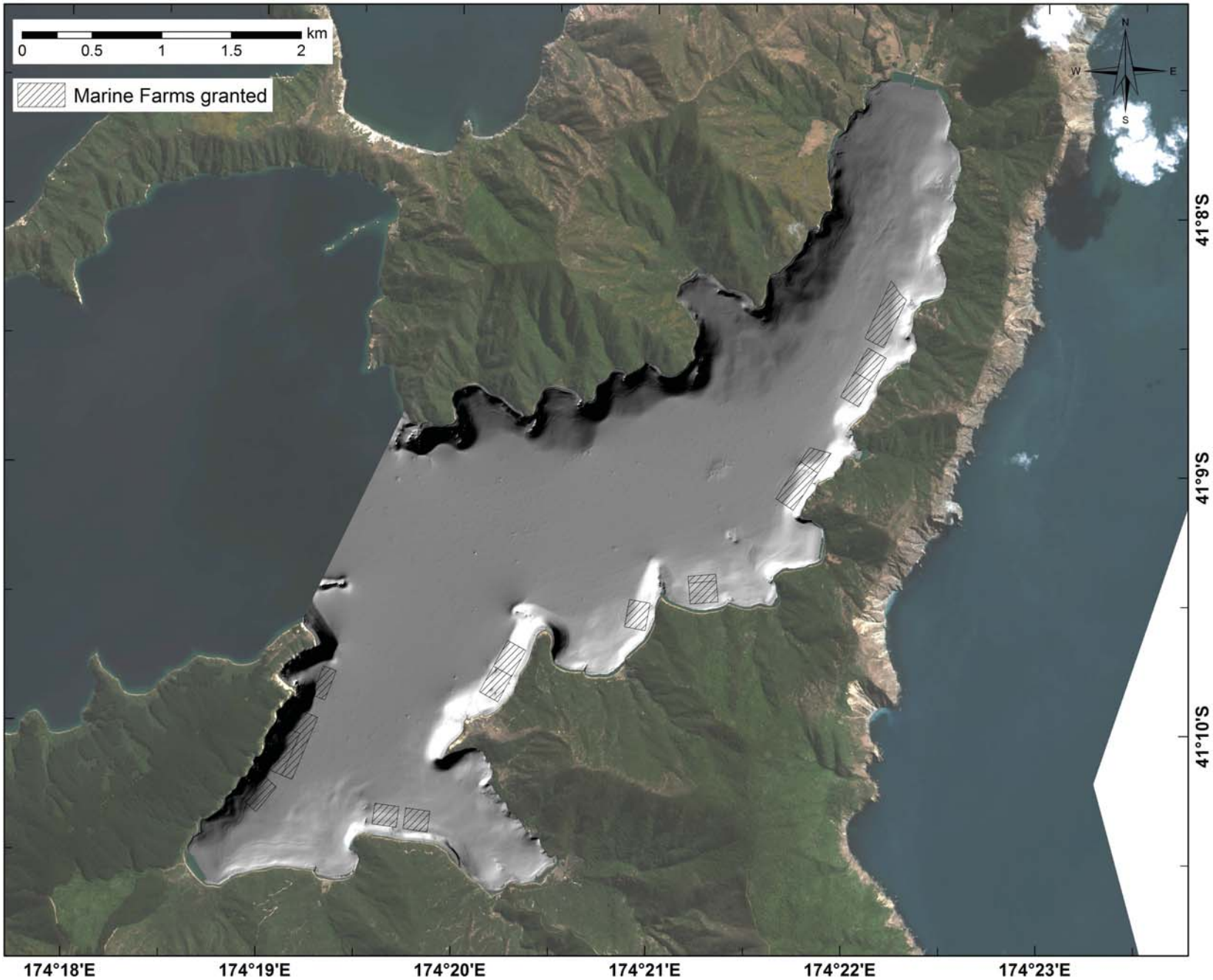
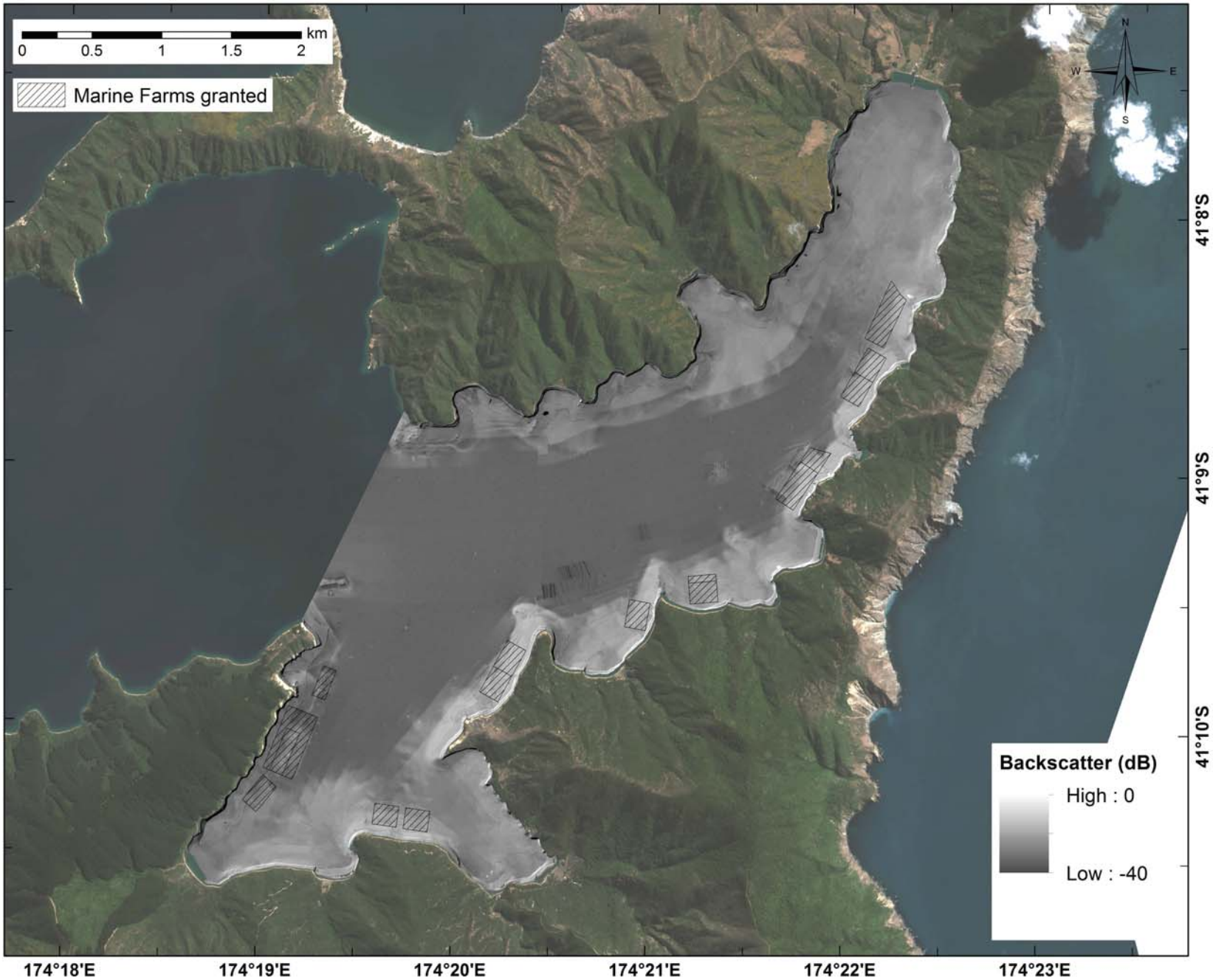


East Bay - Hillshade (2 m, azimuth 315°, altitude 45°, v.e. 1x)



East Bay - Backscatter (underlain by hillshade)



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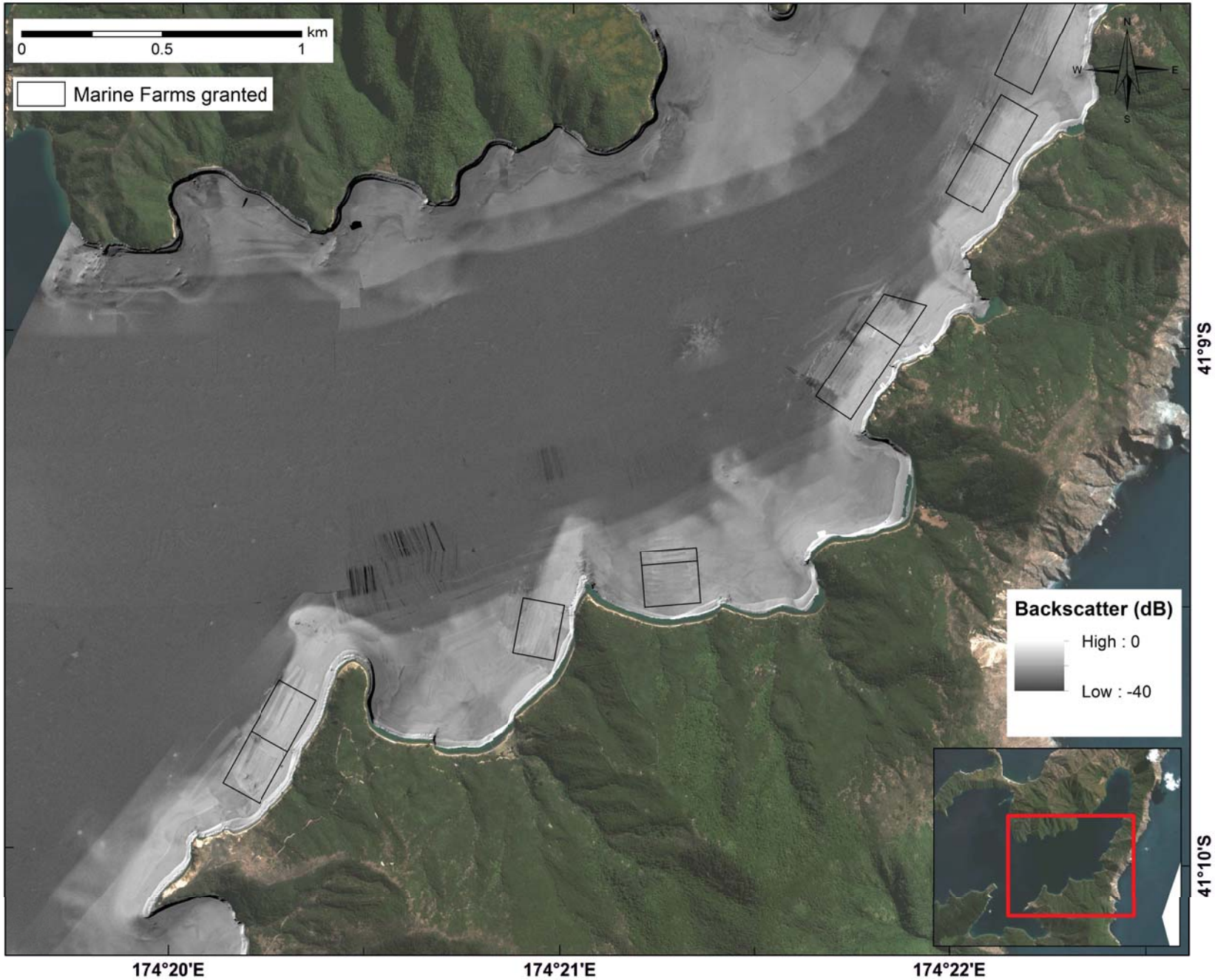

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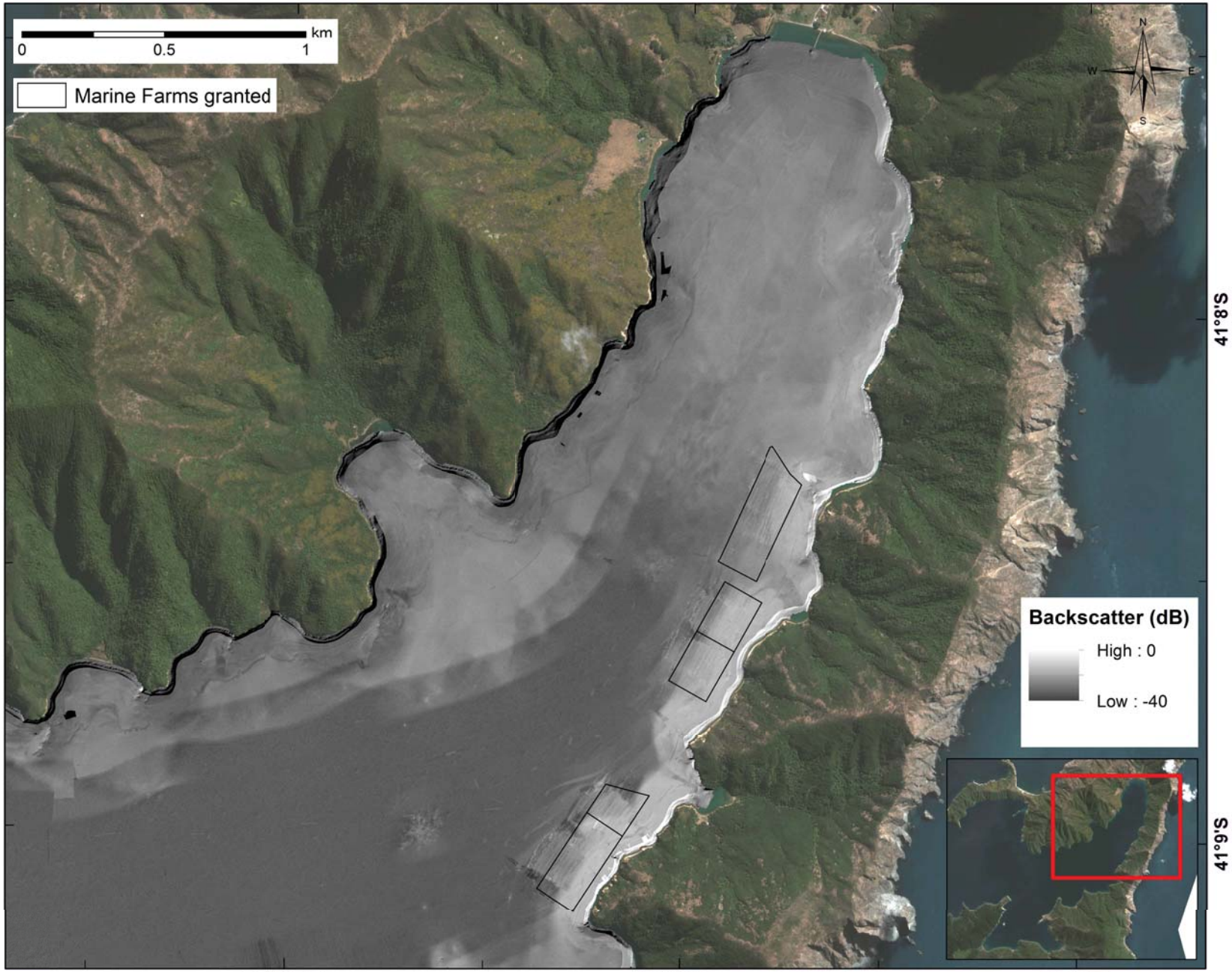
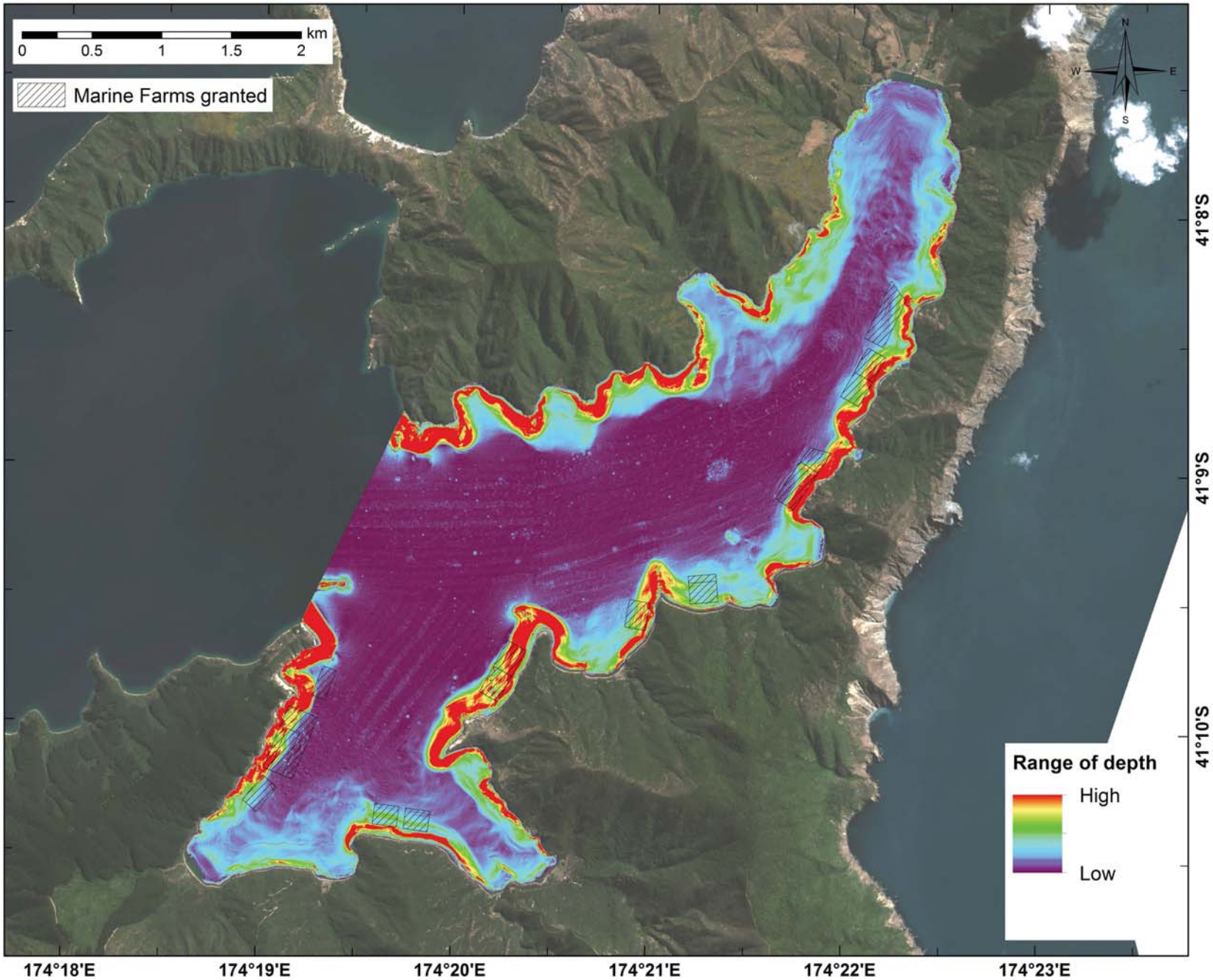


East Bay - Range of depth (6 x 6 m window)



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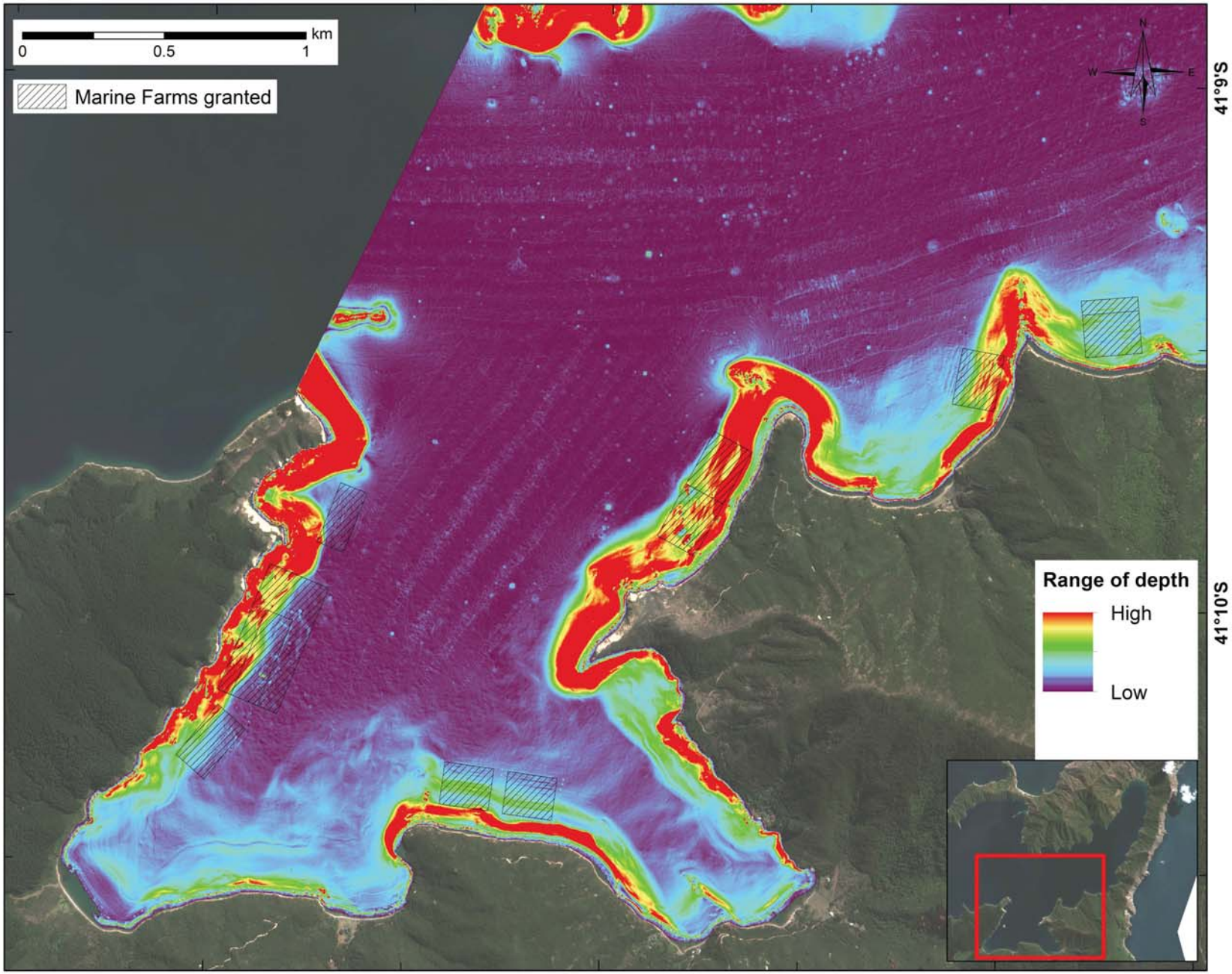

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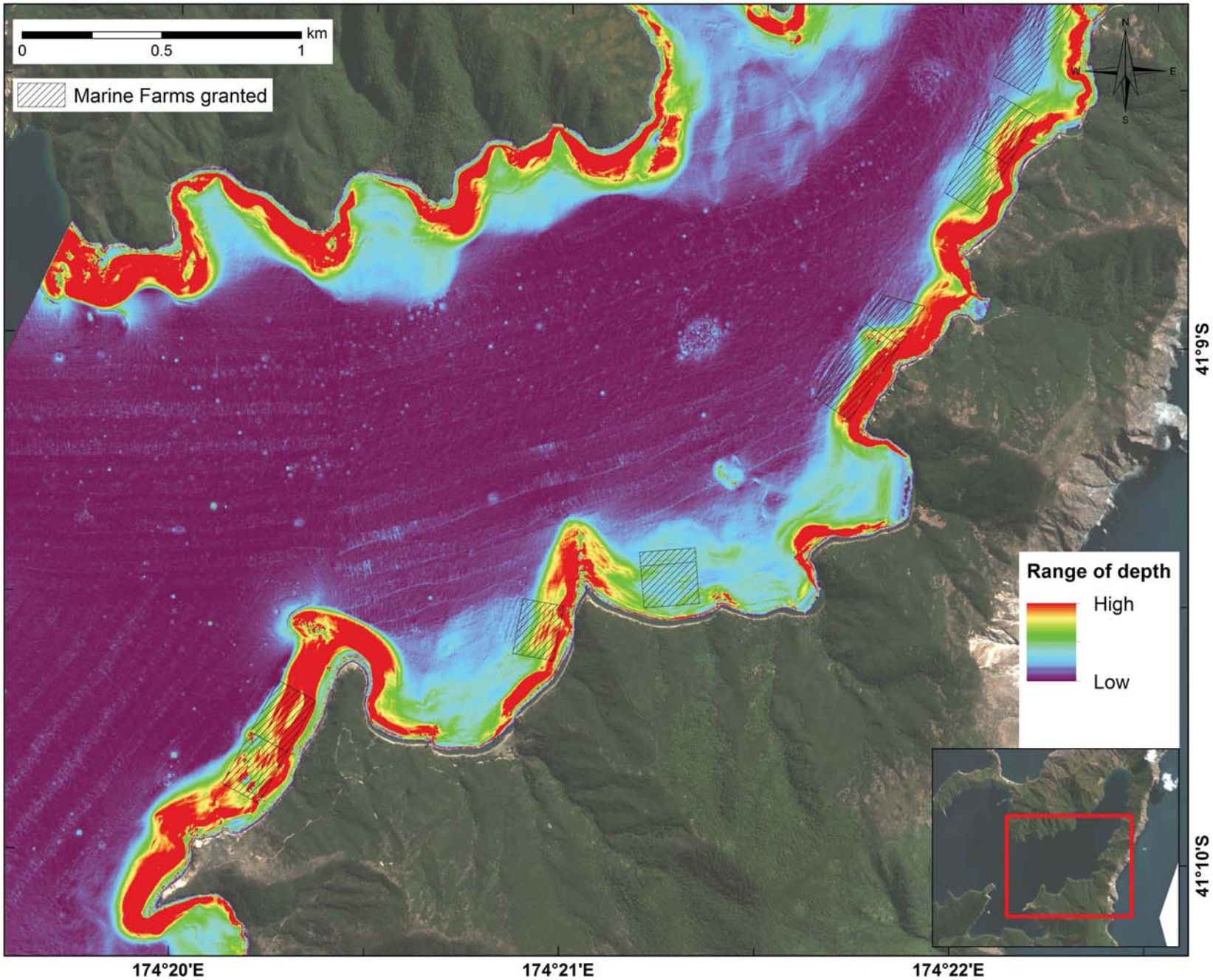

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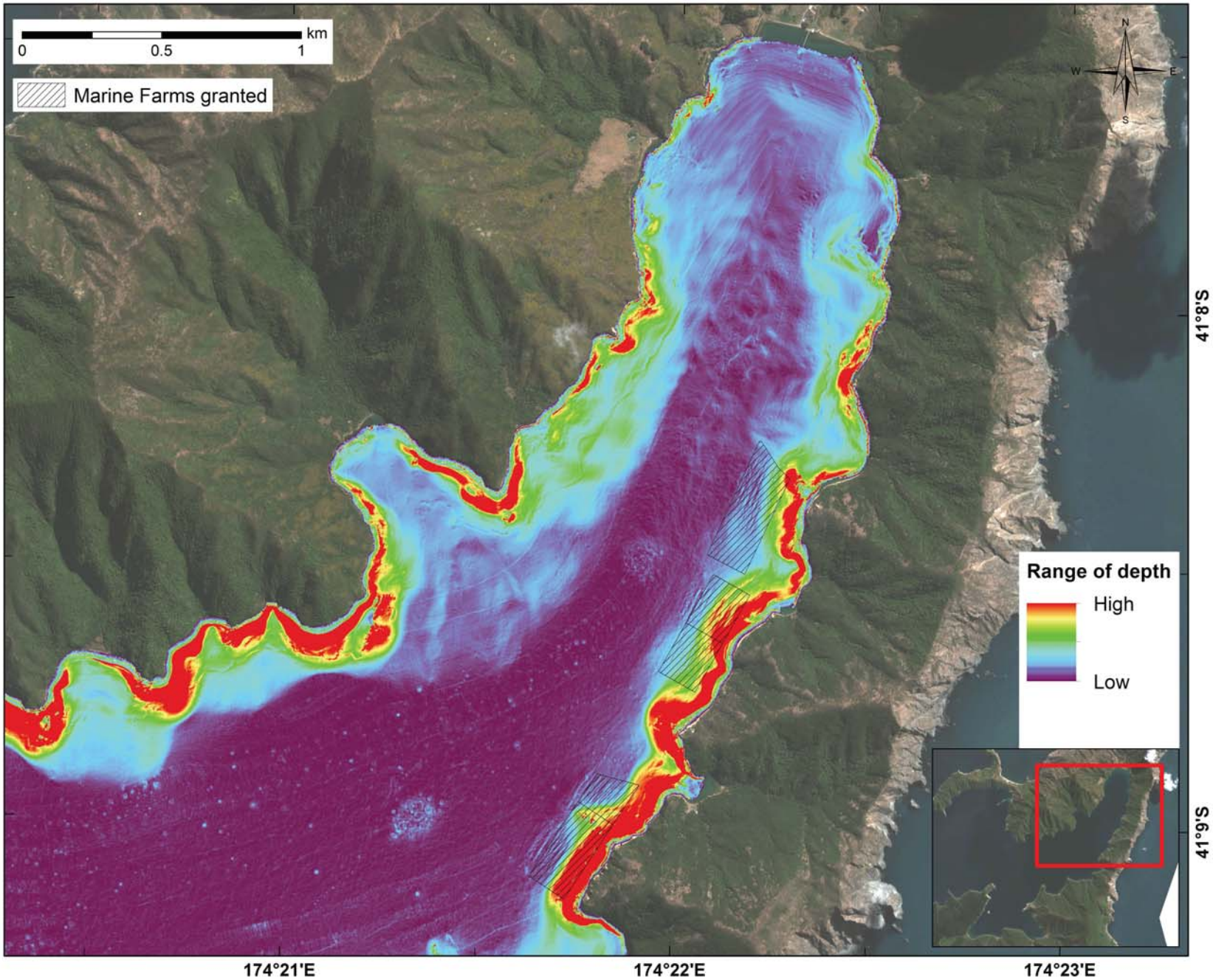
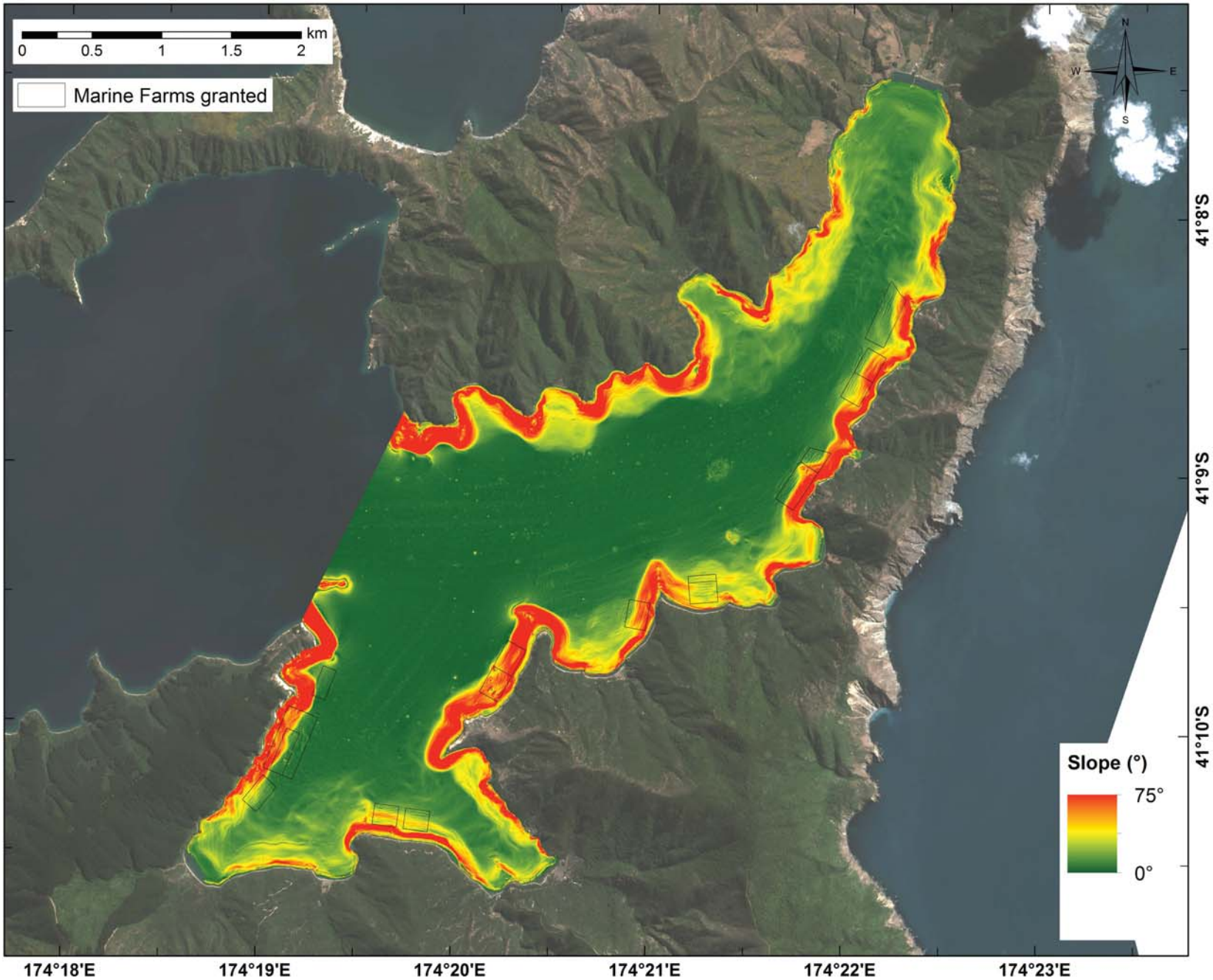


East Bay - Slope (°) 6 x 6 m window



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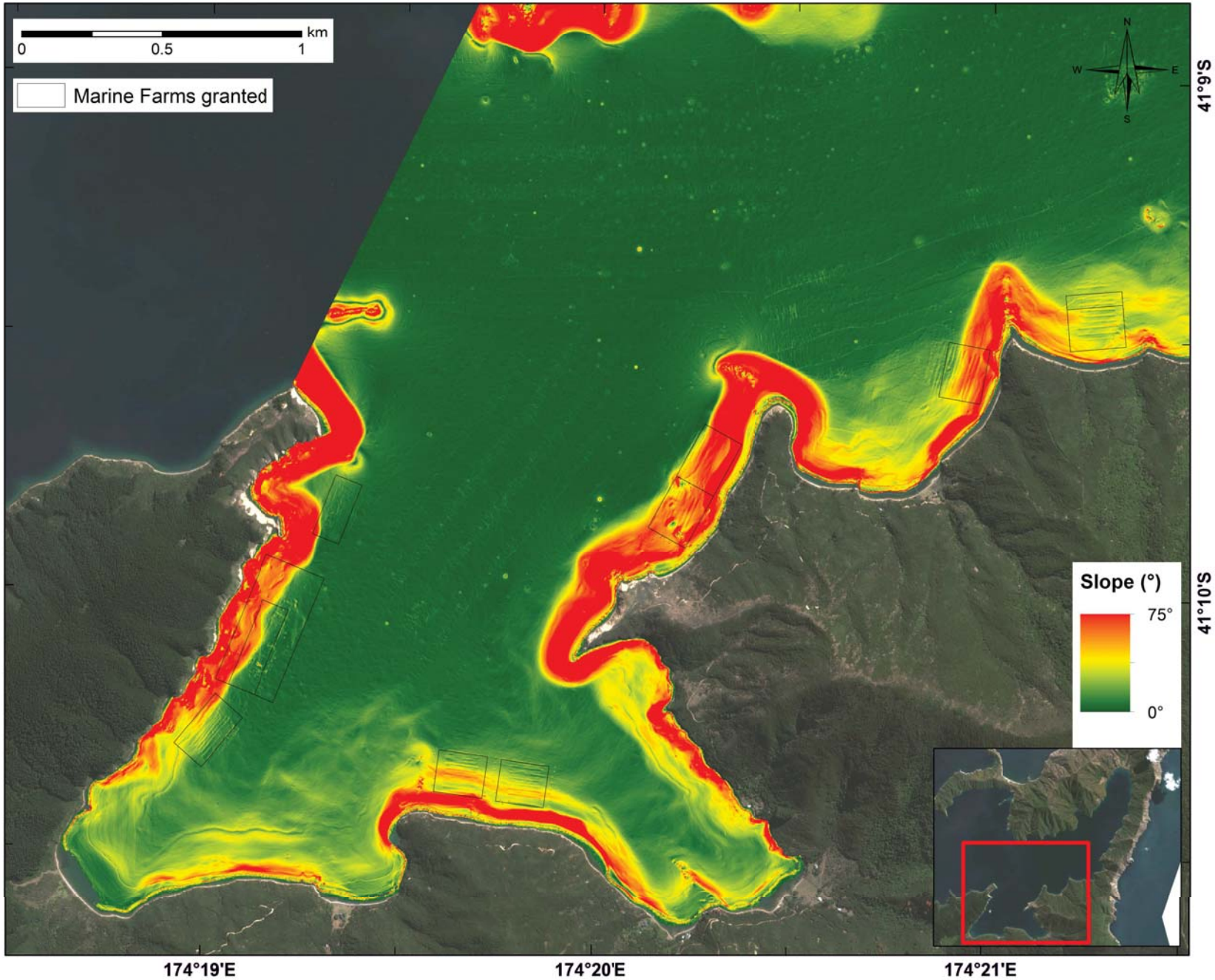

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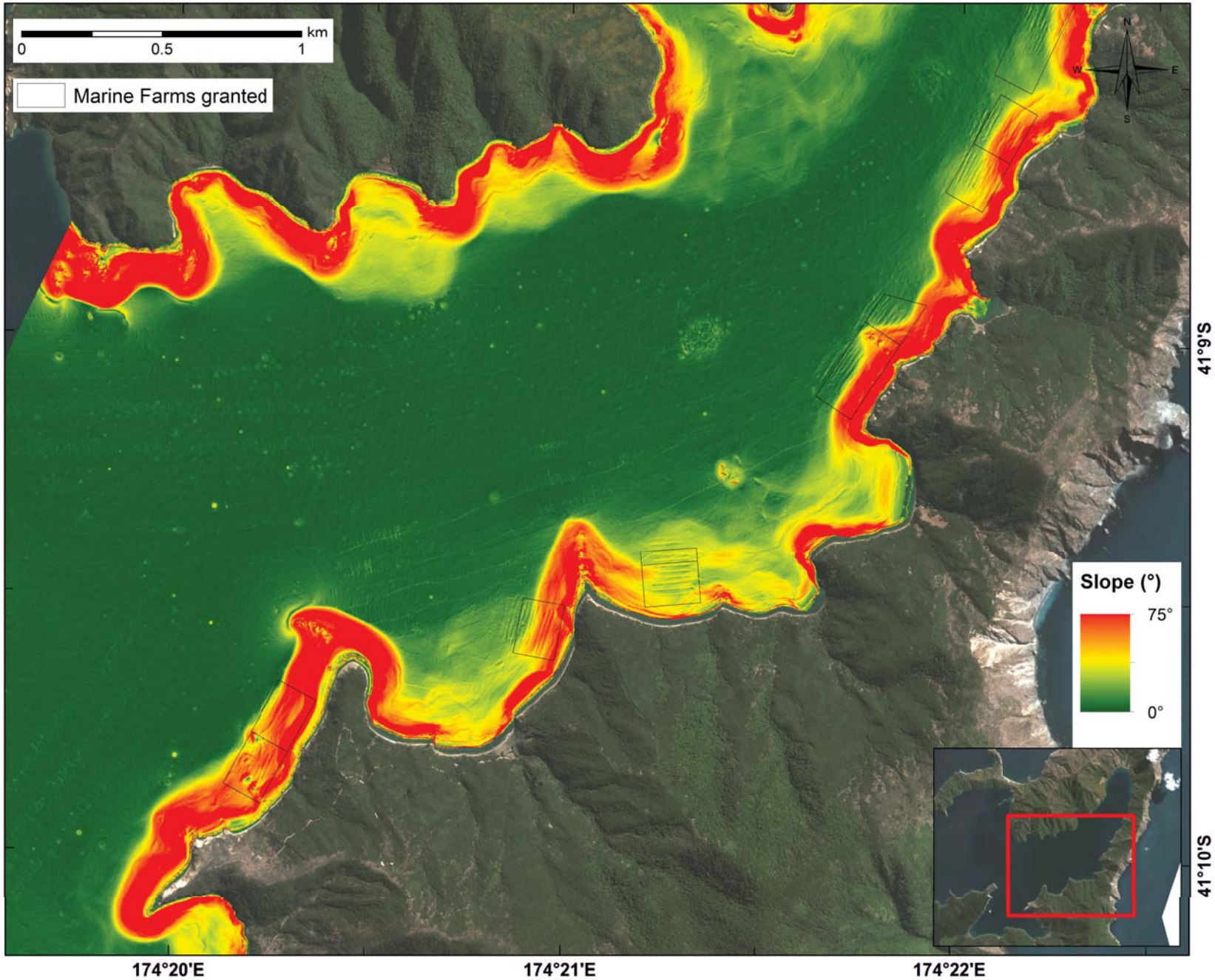

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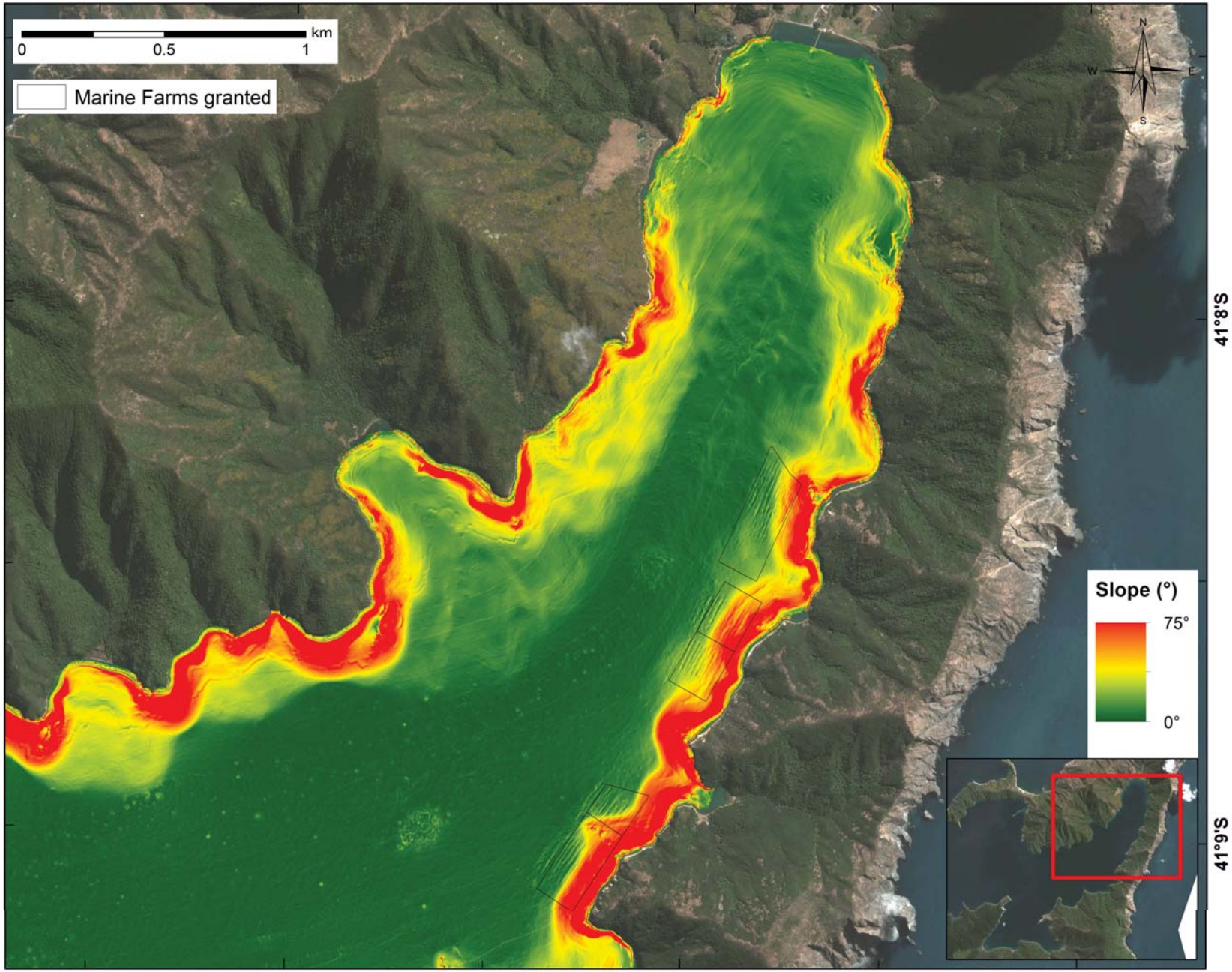
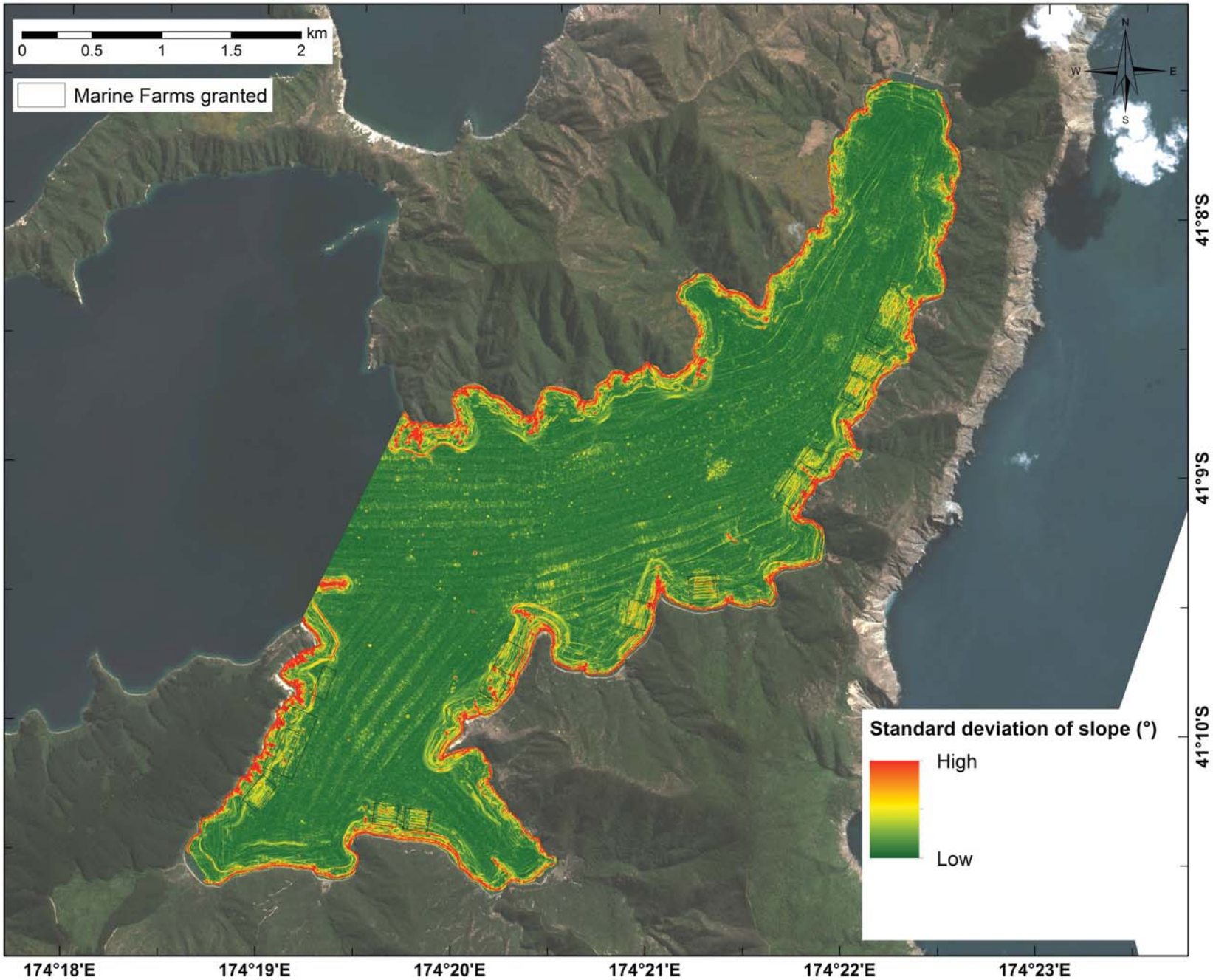
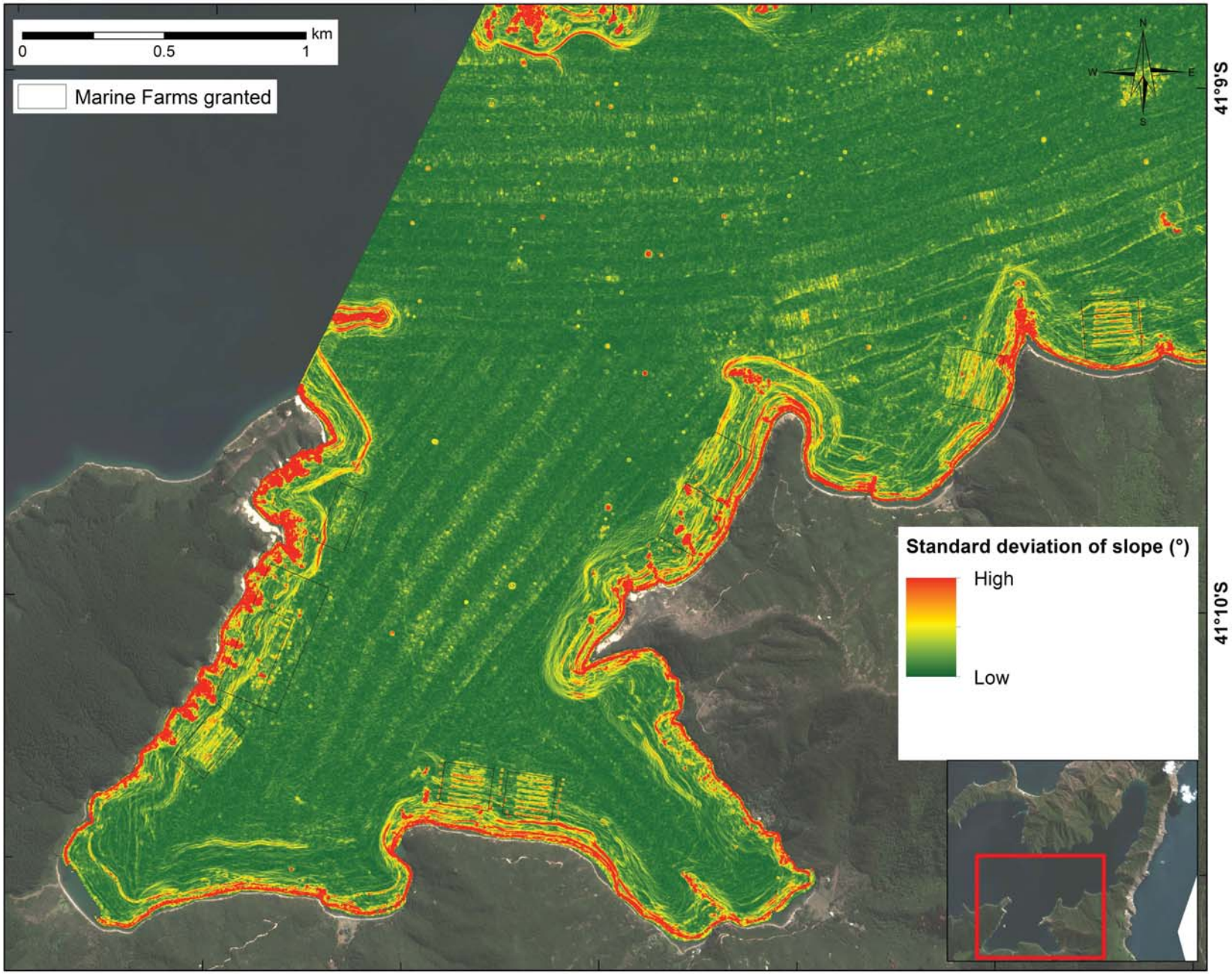


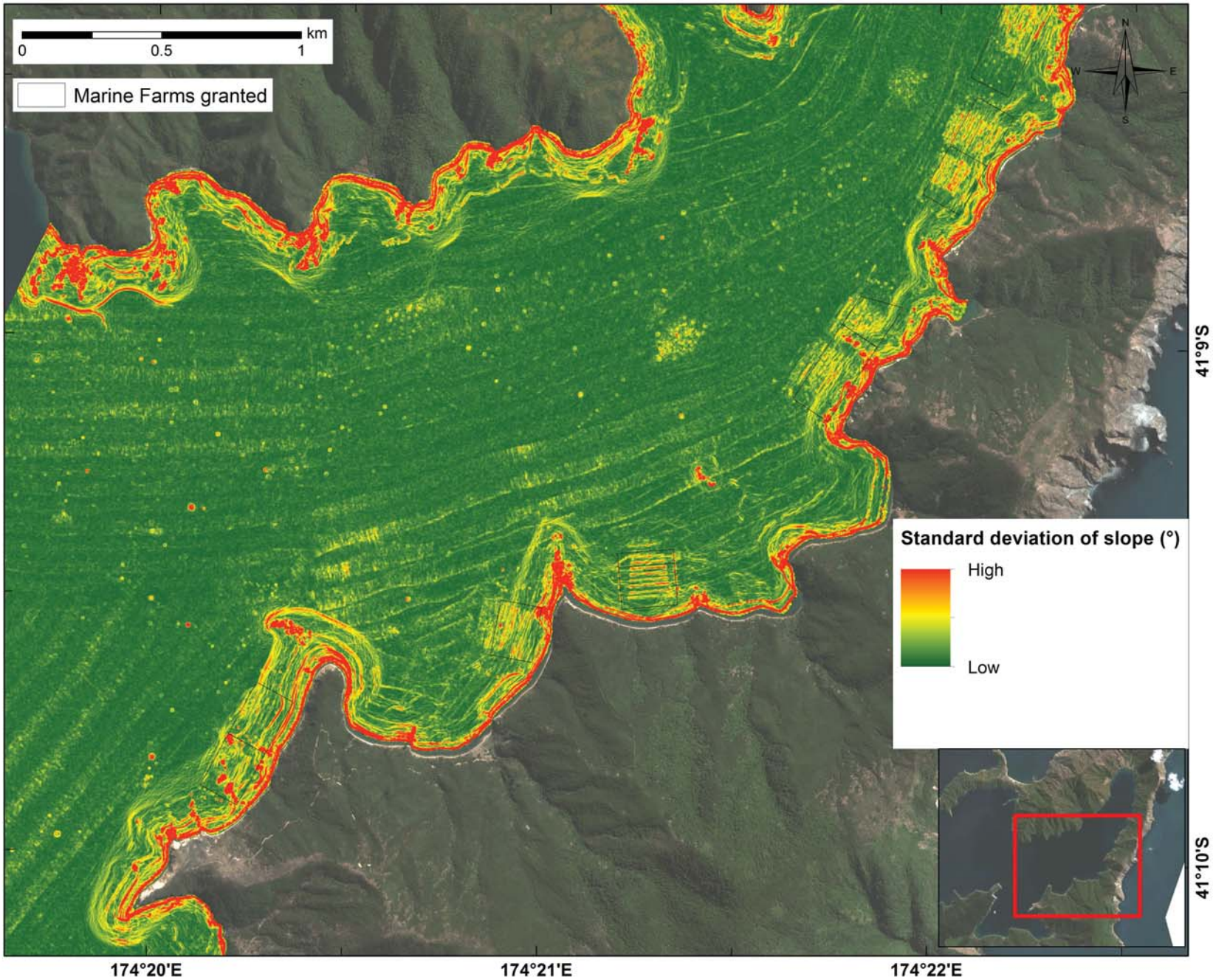
East Bay - Standard deviation of slope (°) 6 x 6 m window



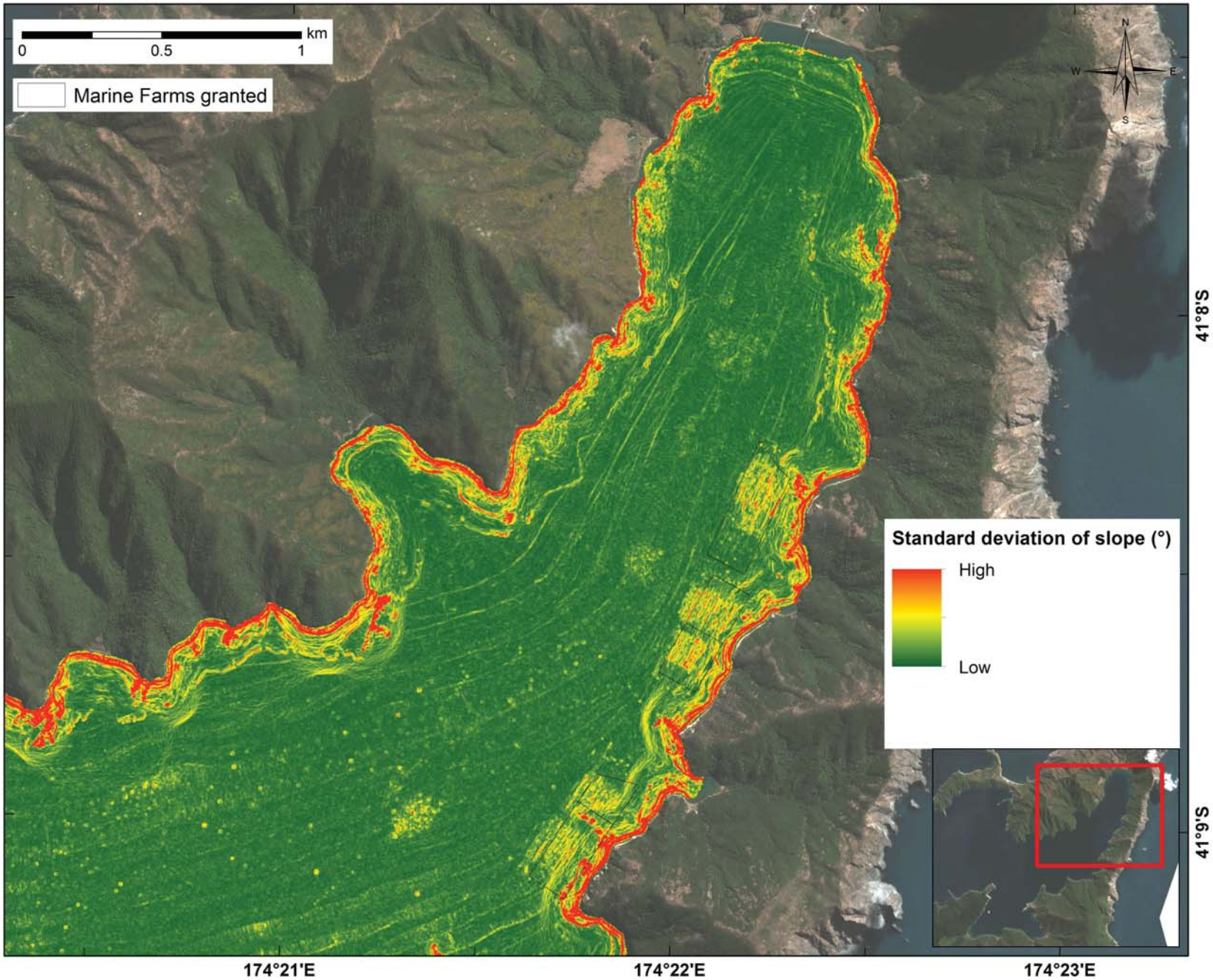
East Bay - Standard deviation of slope (°) 6 x 6 m window



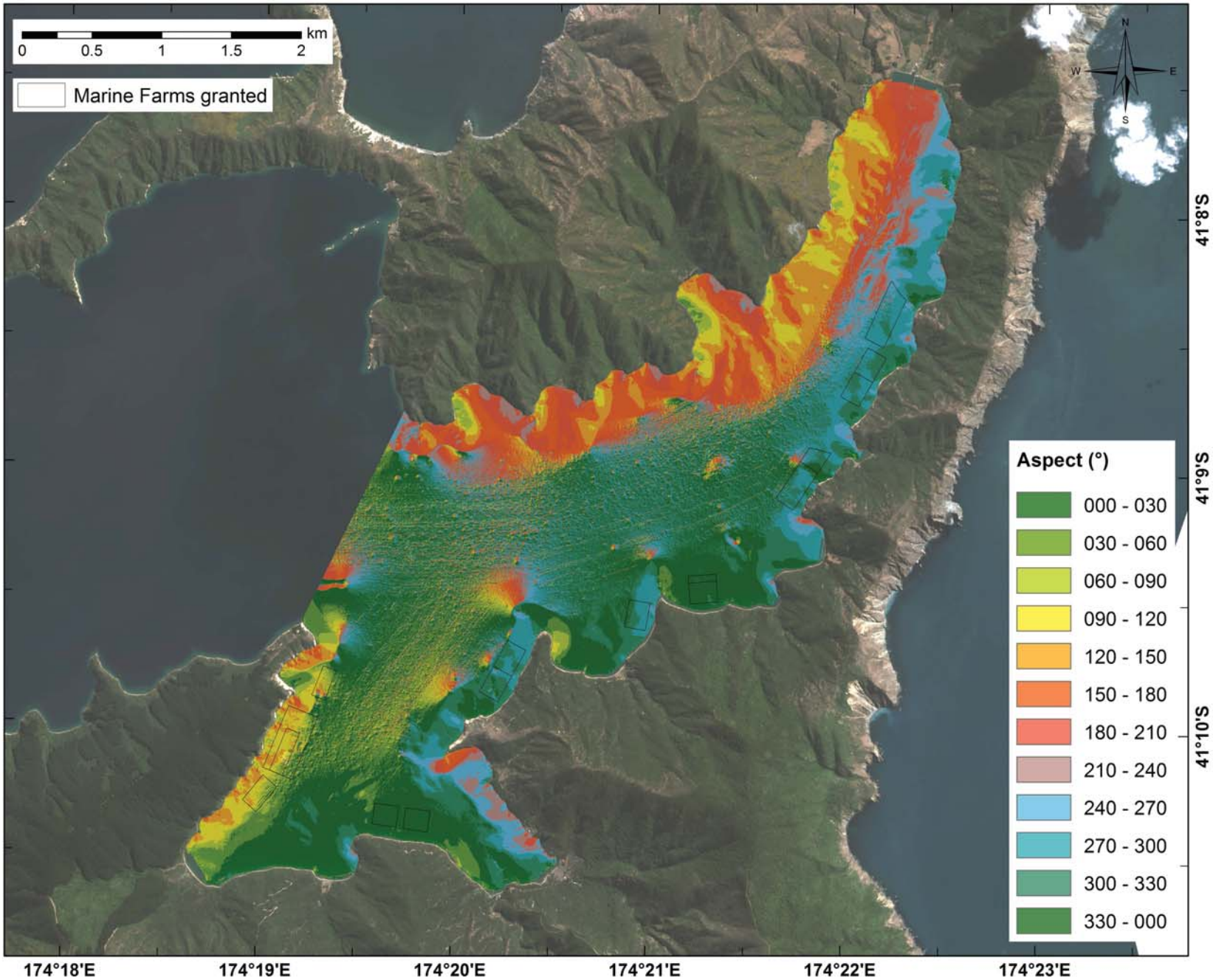
East Bay - Standard deviation of slope (°) 6 x 6 m window



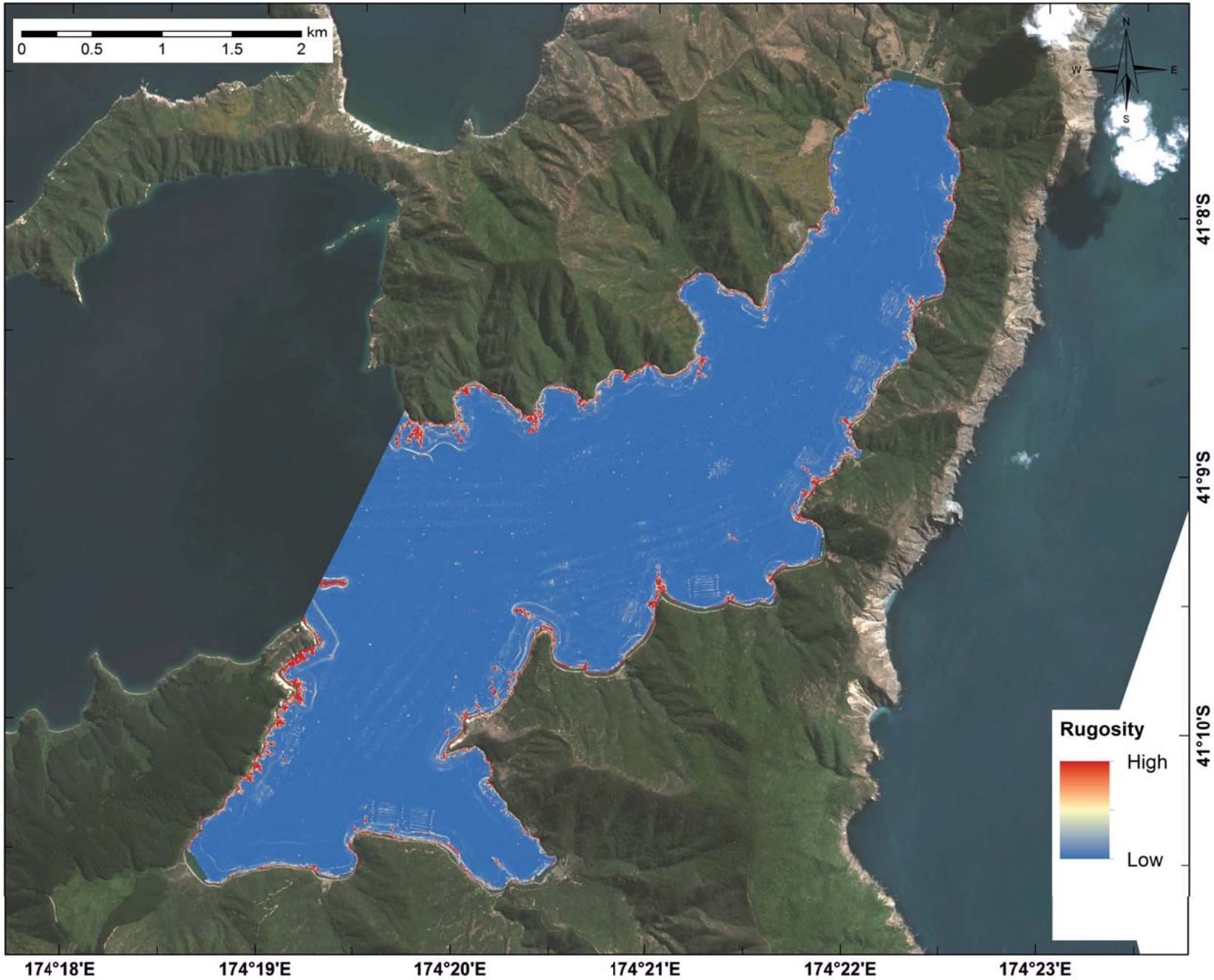
East Bay - Standard deviation of slope (°) 6 x 6 m window



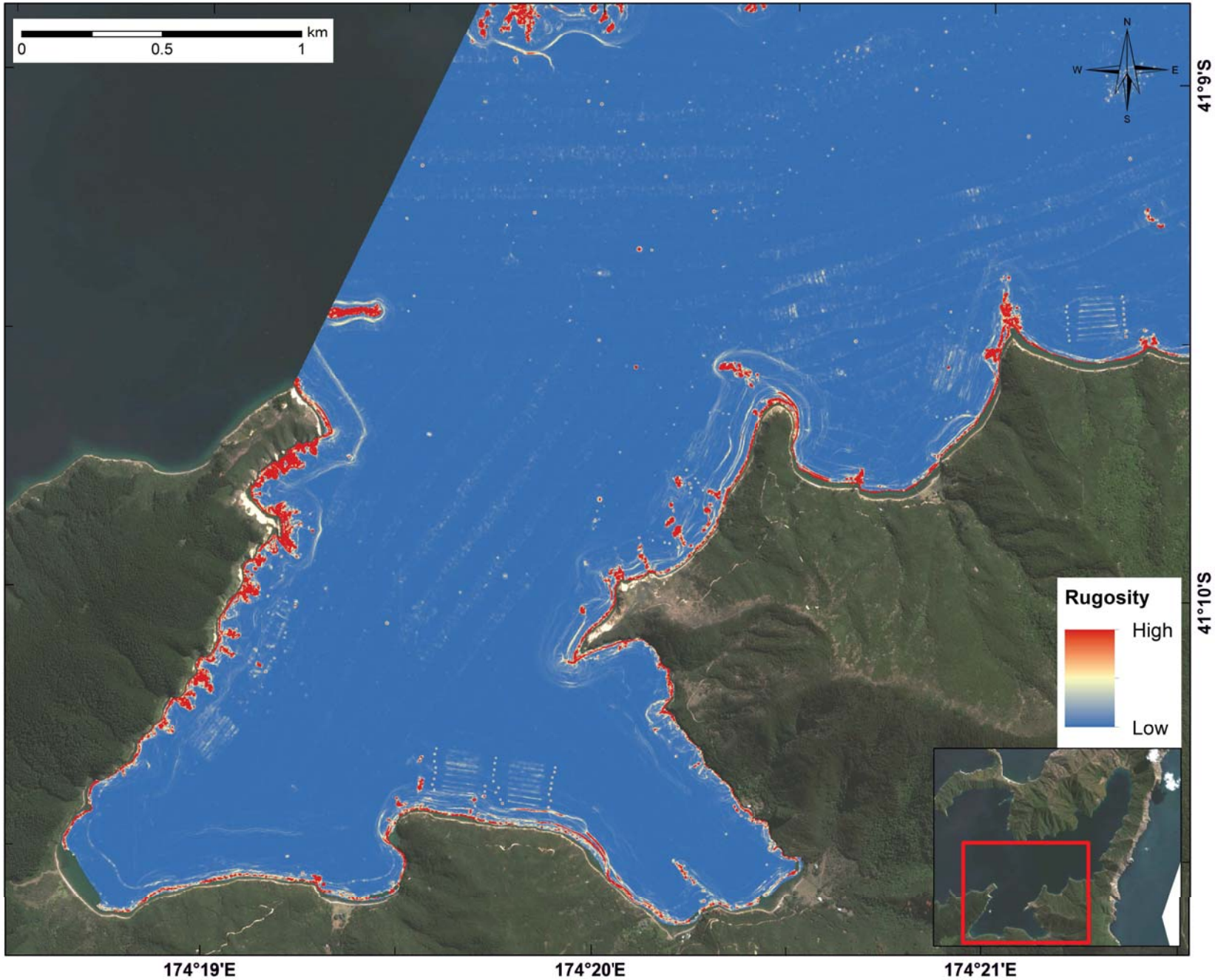
East Bay - Aspect (°) 6 x 6 m window



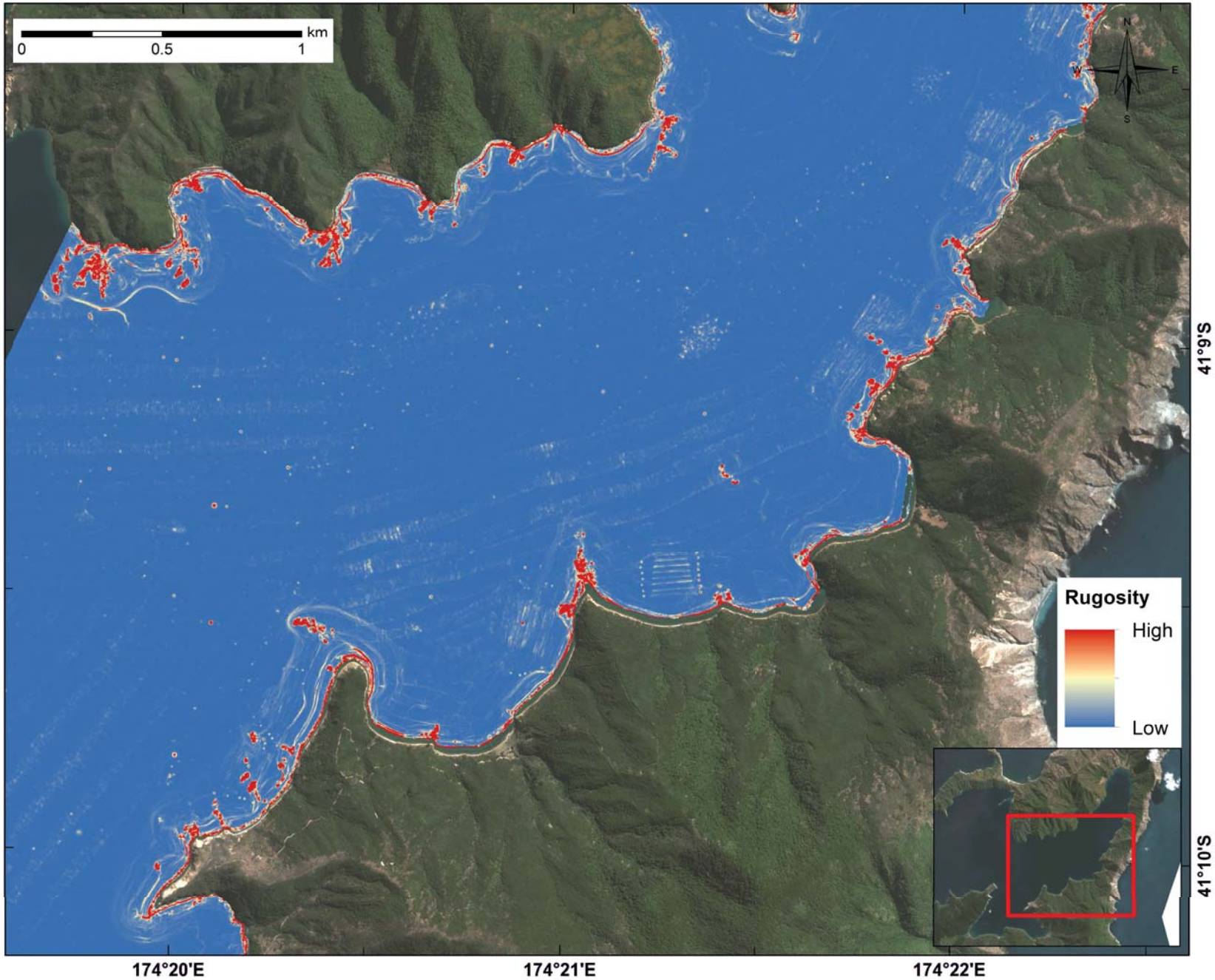
East Bay - Rugosity (6 x 6 m window)



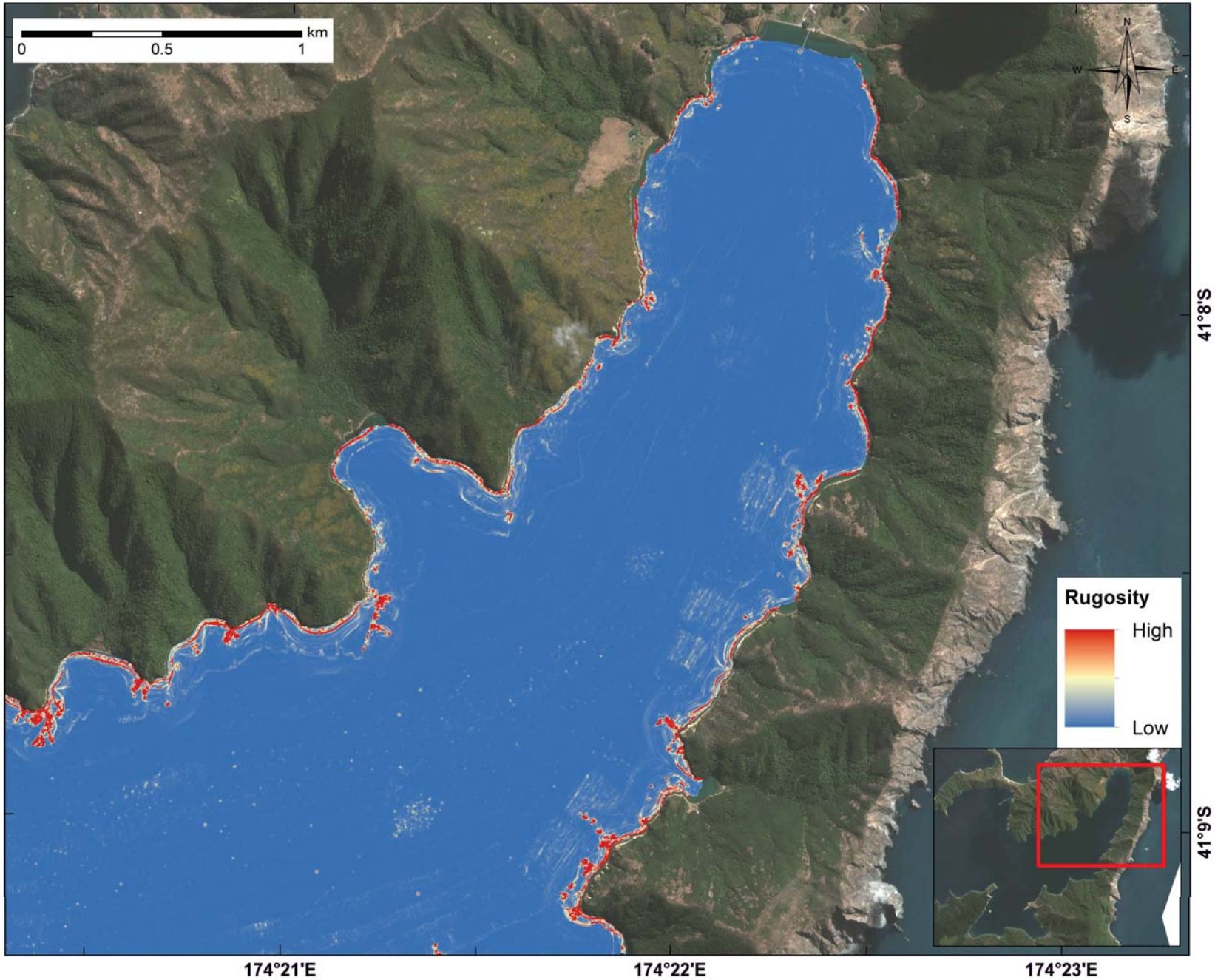
East Bay - Rugosity (6 x 6 m window)



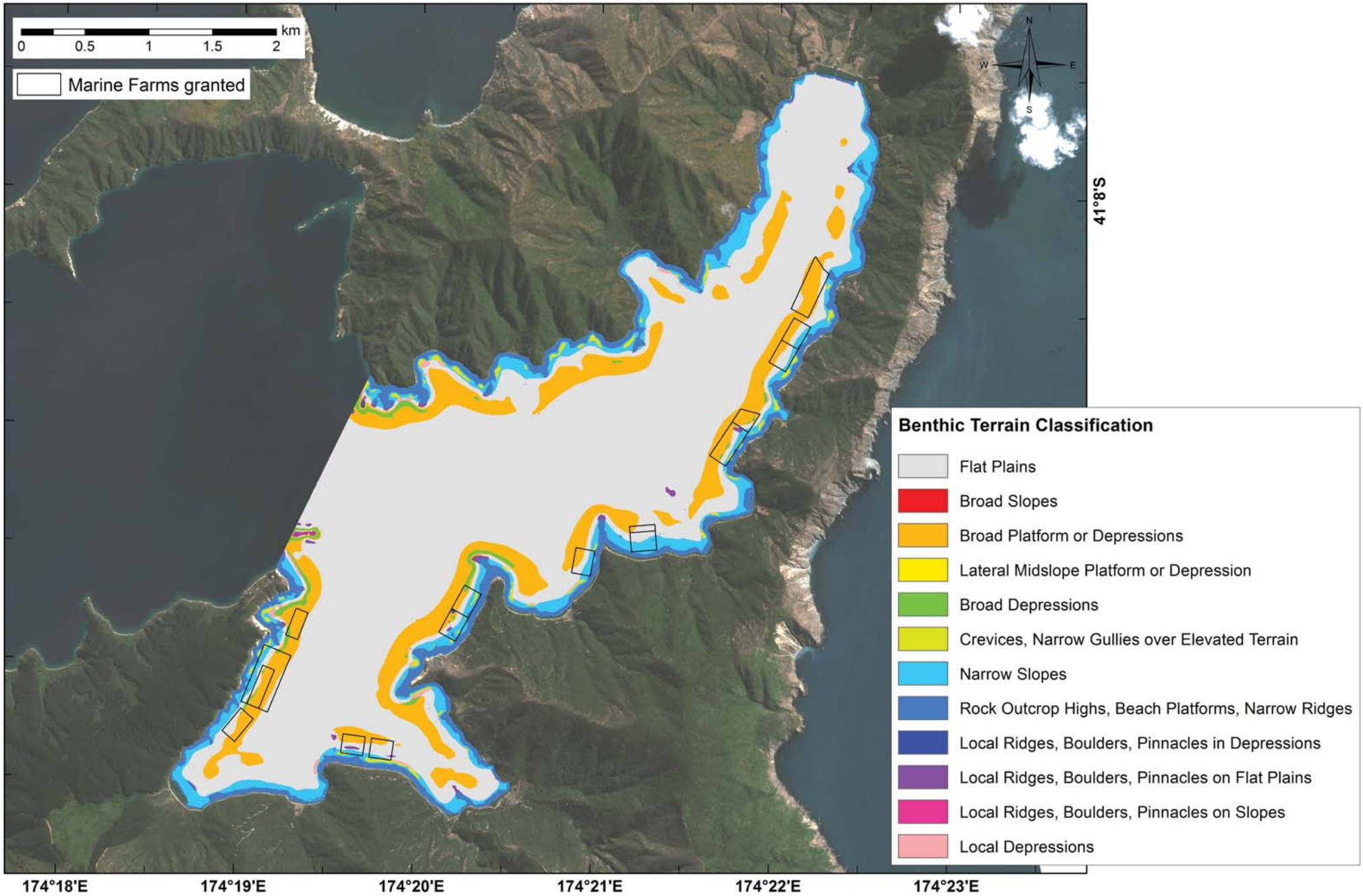
East Bay - Rugosity (6 x 6 m window)



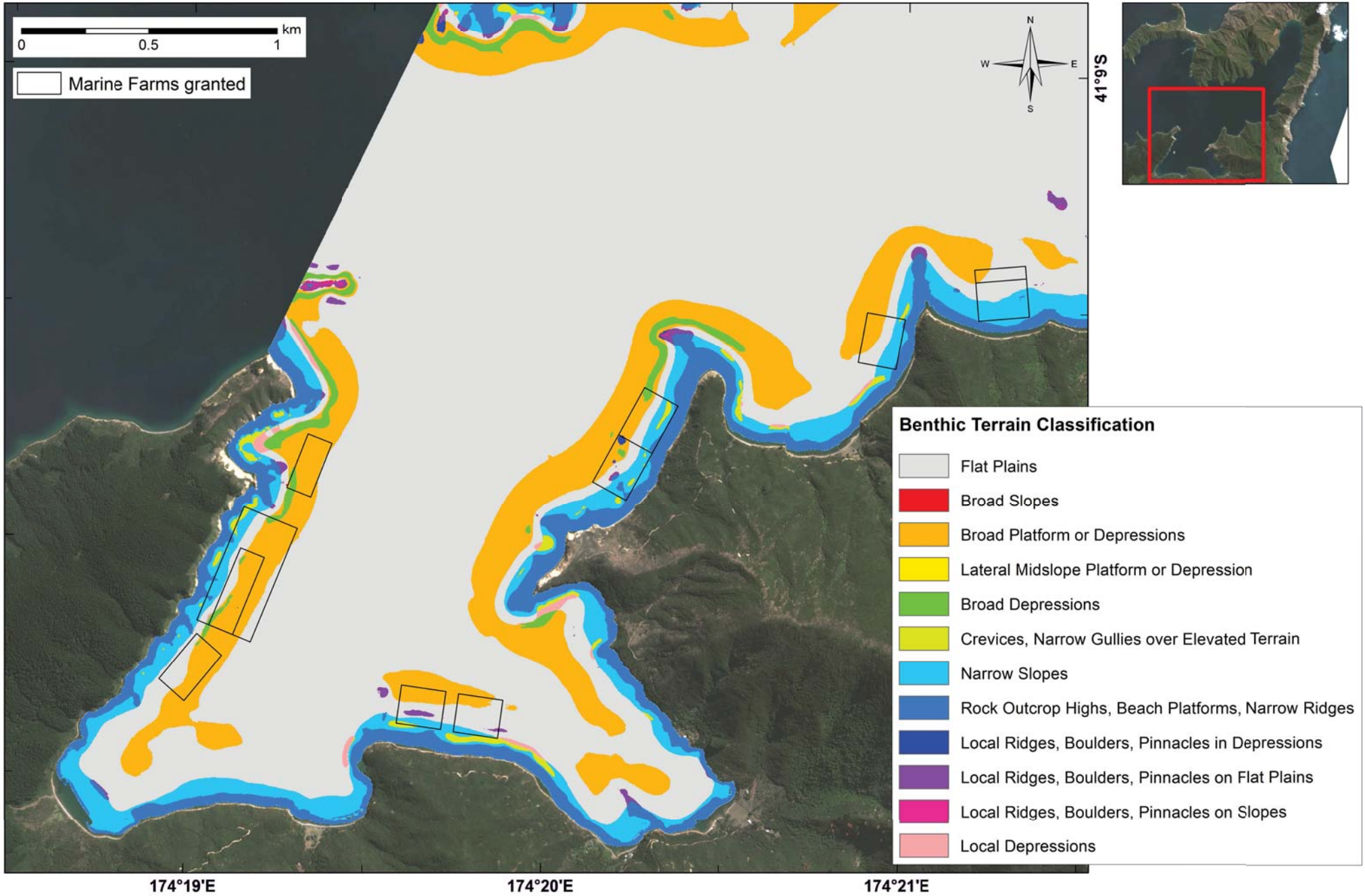
East Bay - Rugosity (6 x 6 m window)



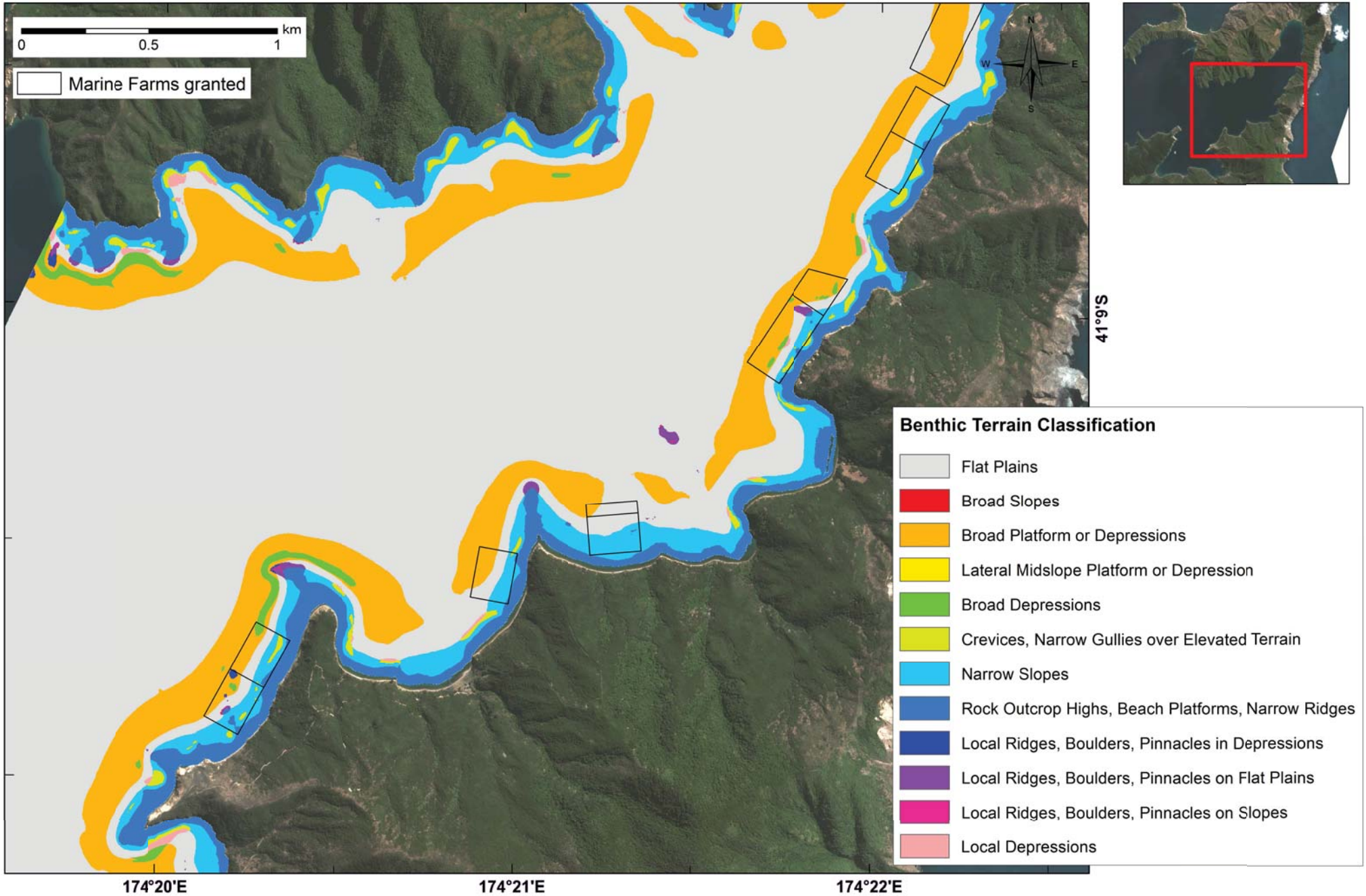
East Bay - Benthic Terrain Classification



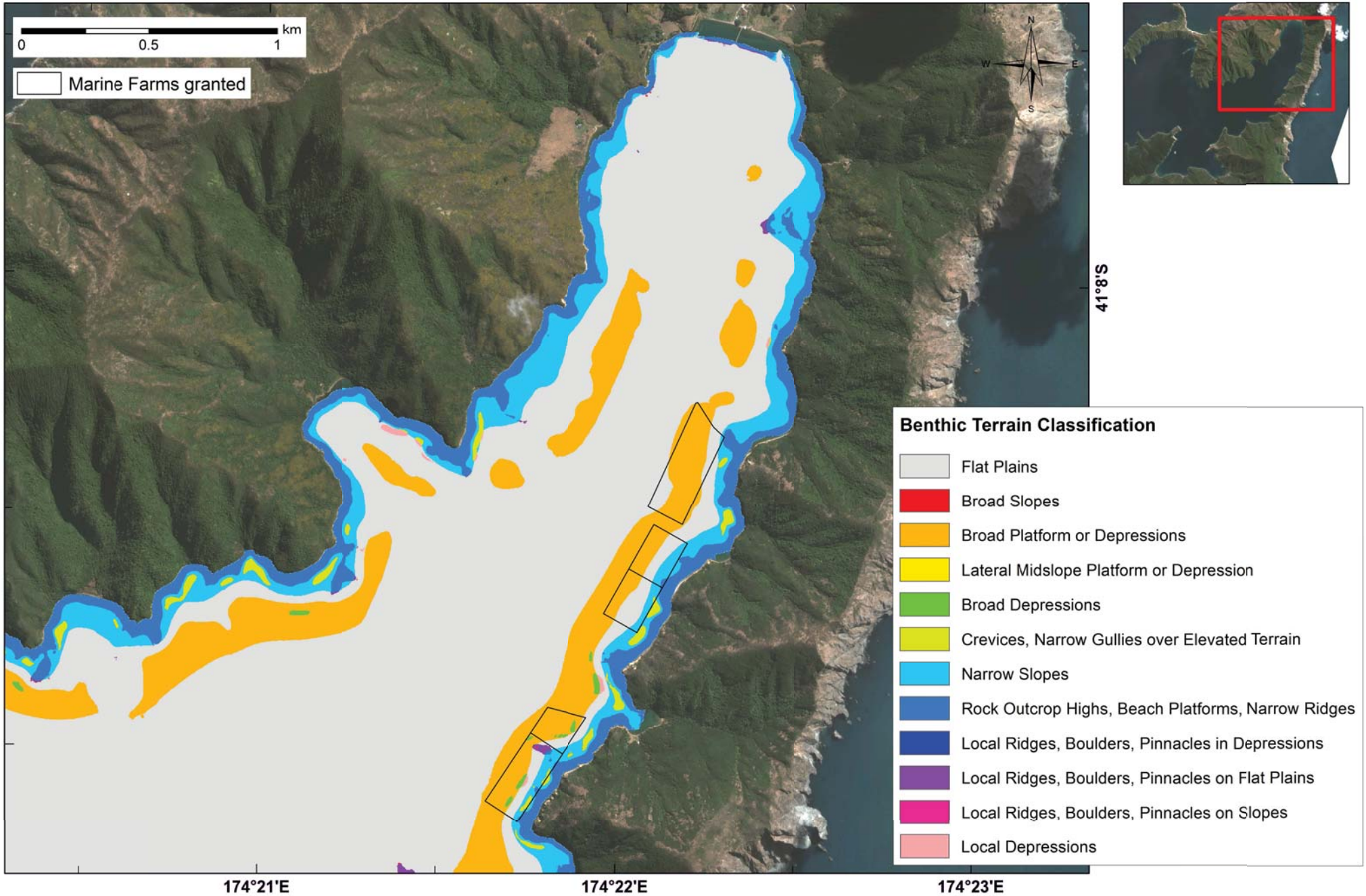
East Bay - Benthic Terrain Classification



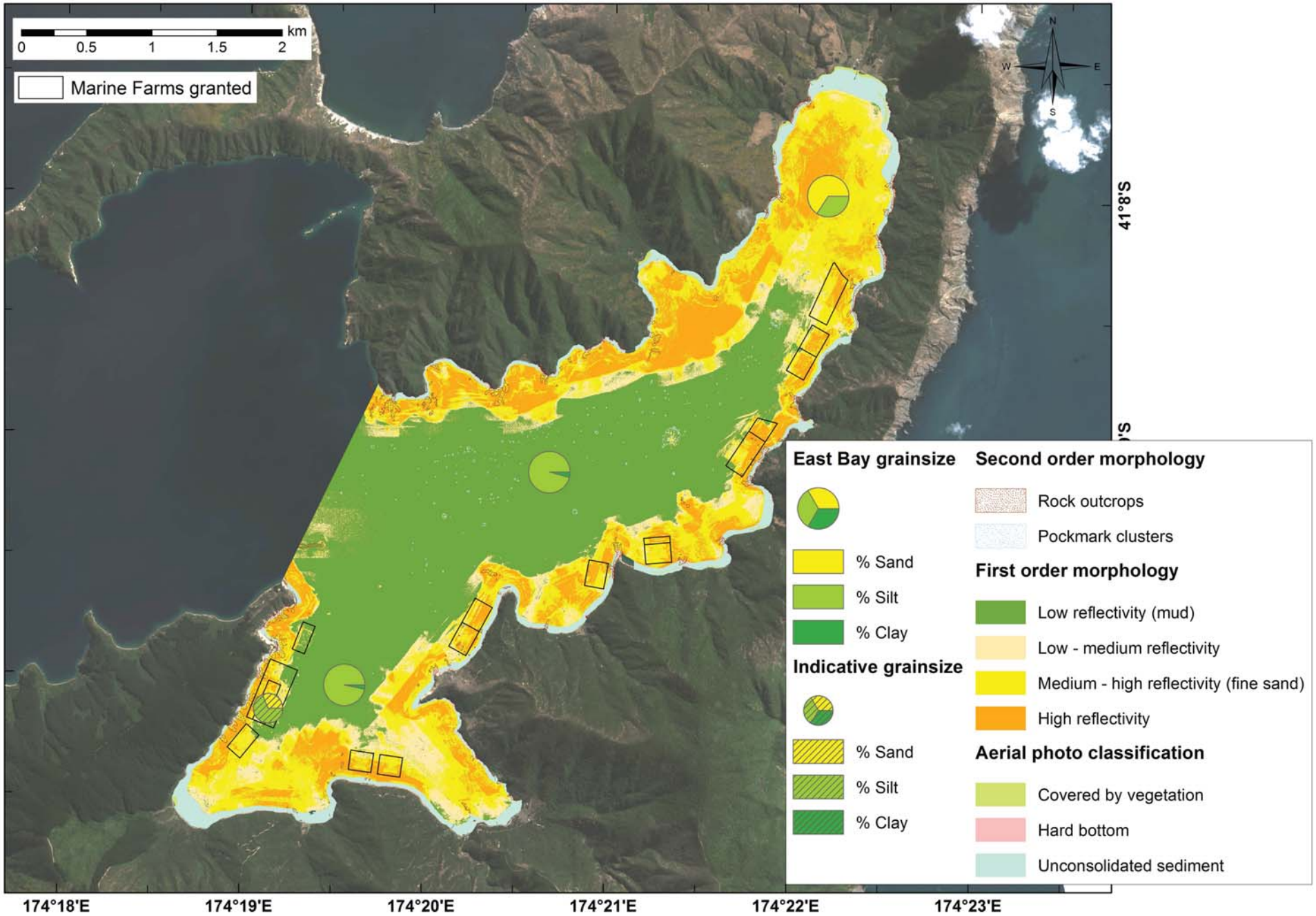
East Bay - Benthic Terrain Classification



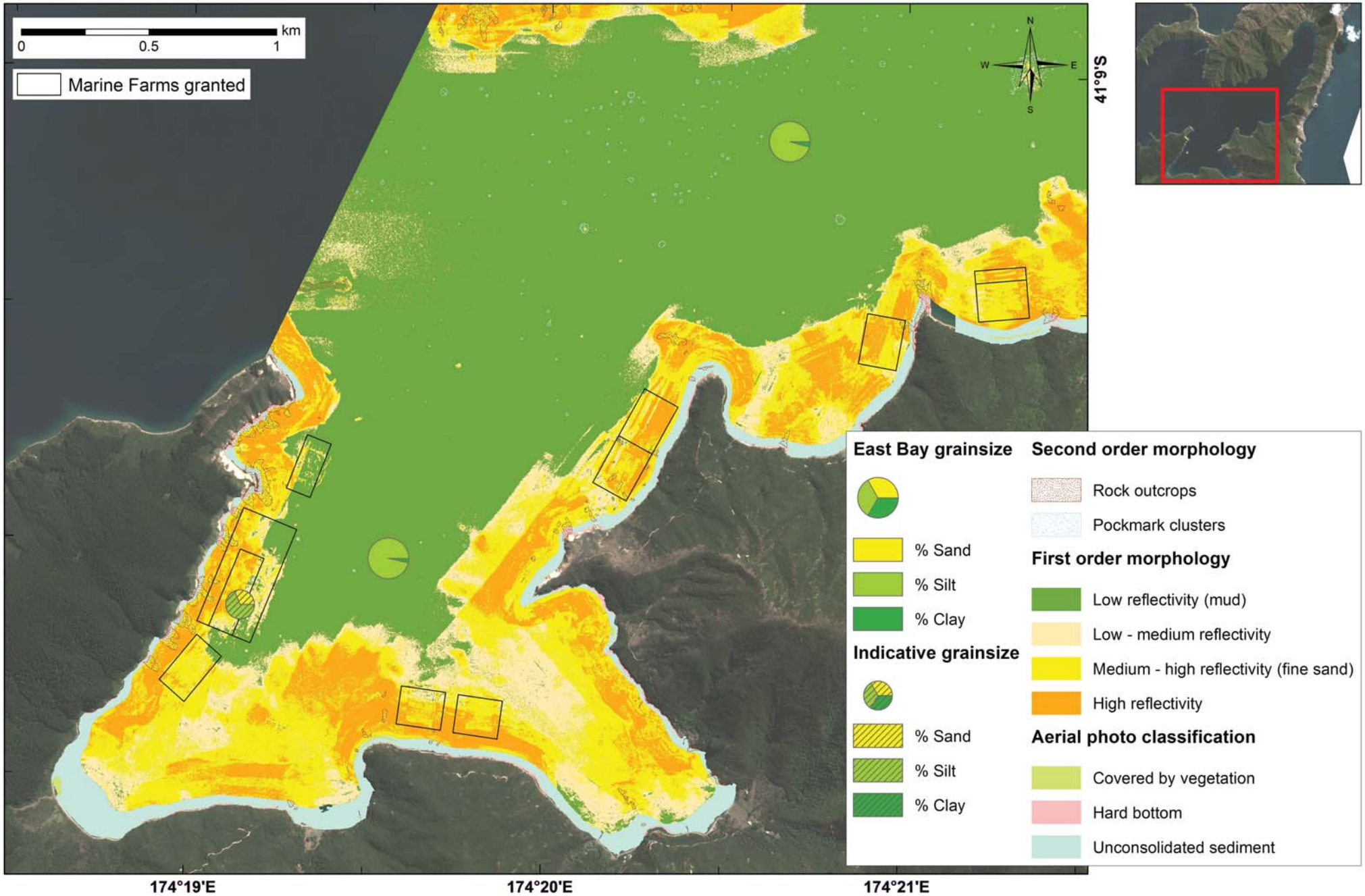
East Bay - Benthic Terrain Classification



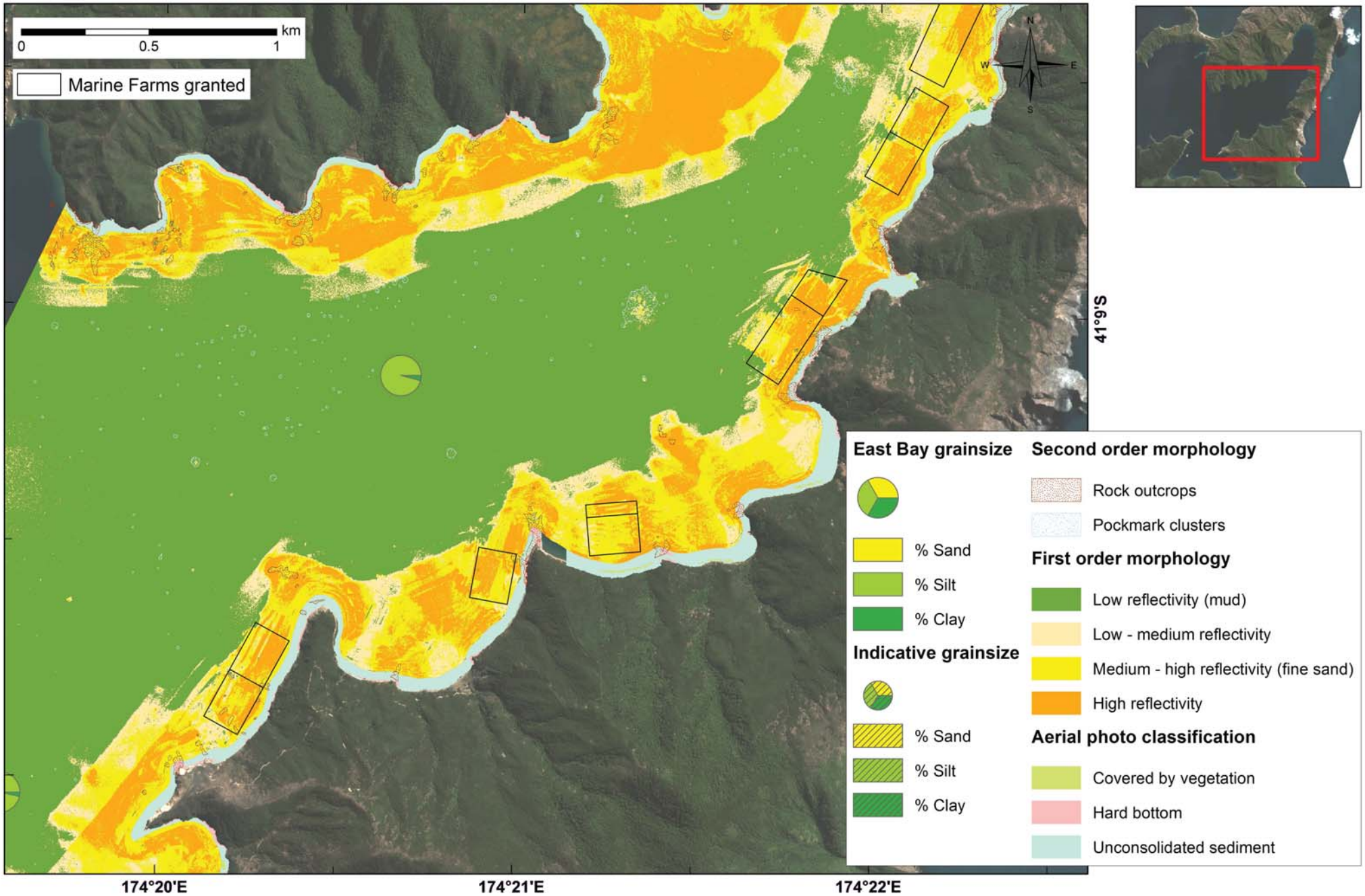
East Bay - Seafloor classification



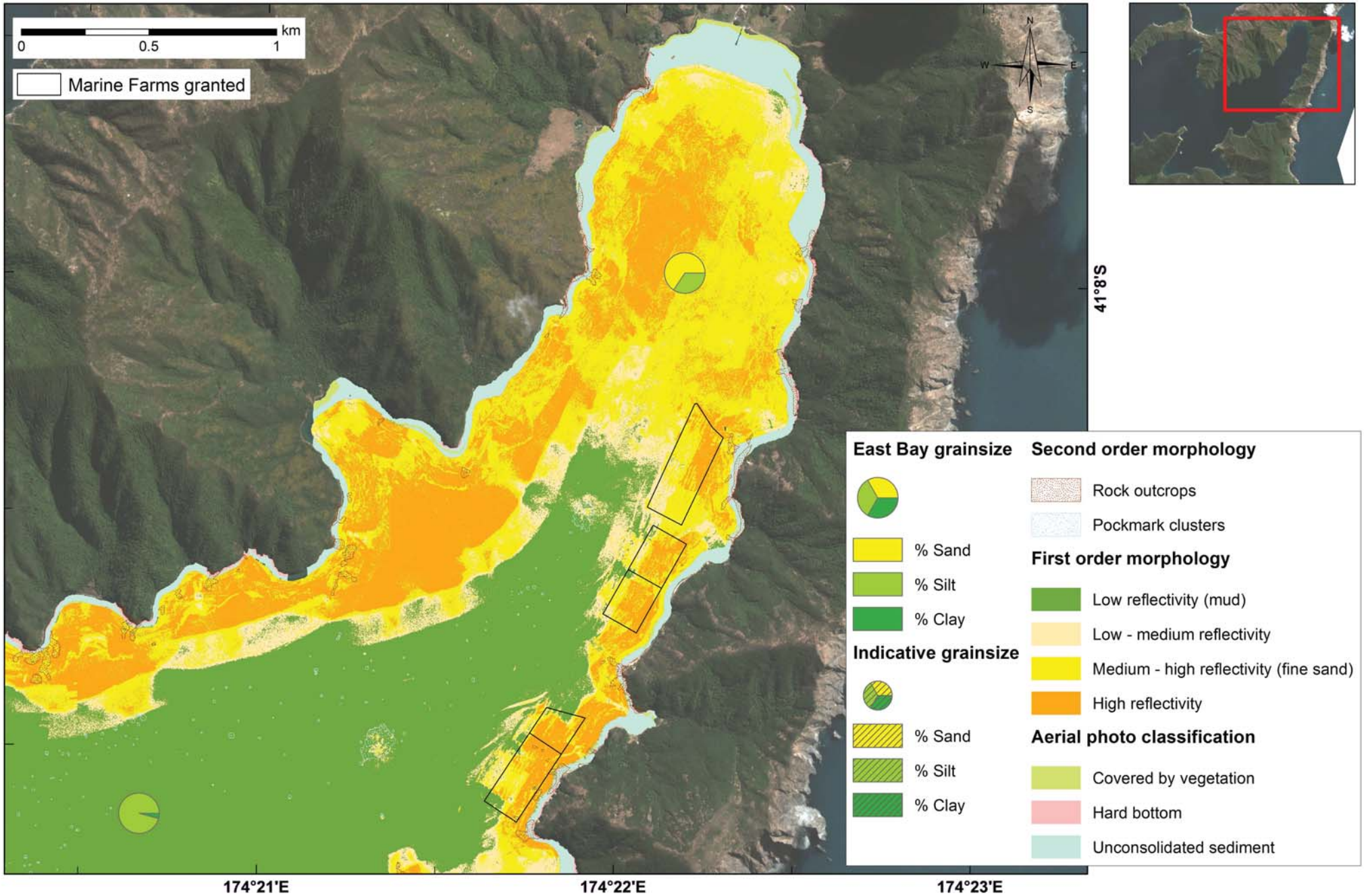
East Bay - Seafloor classification



East Bay - Seafloor classification

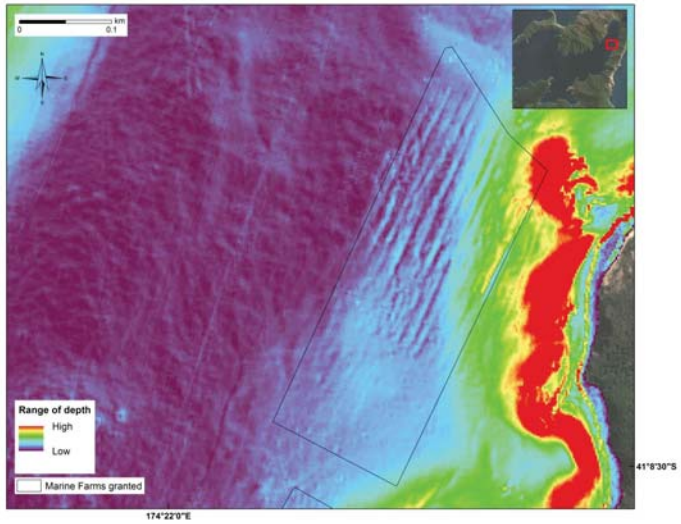


East Bay - Seafloor classification

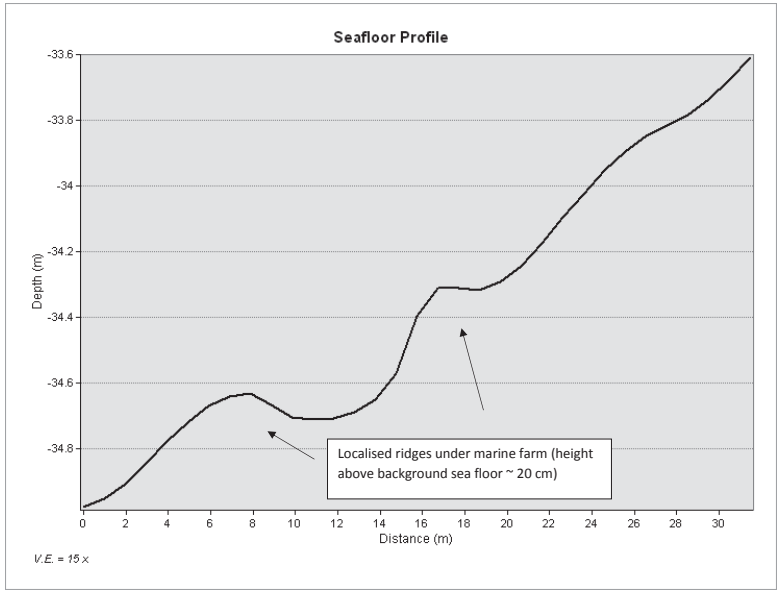


3D Solution for Marine Farms: East Bay Example A

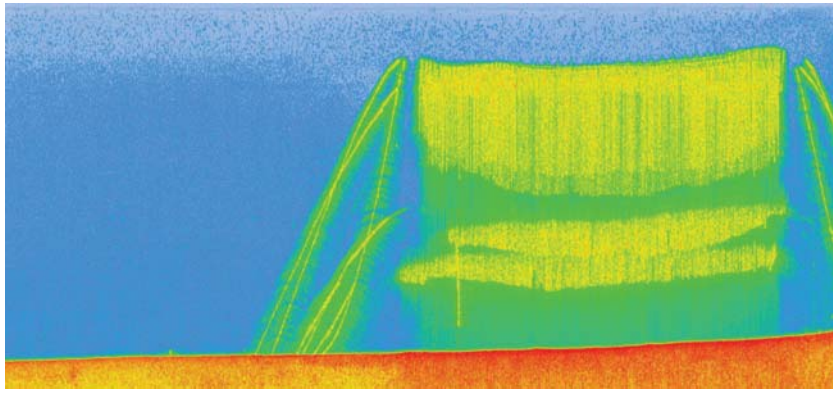
Marine Farm Example A – Range of depth



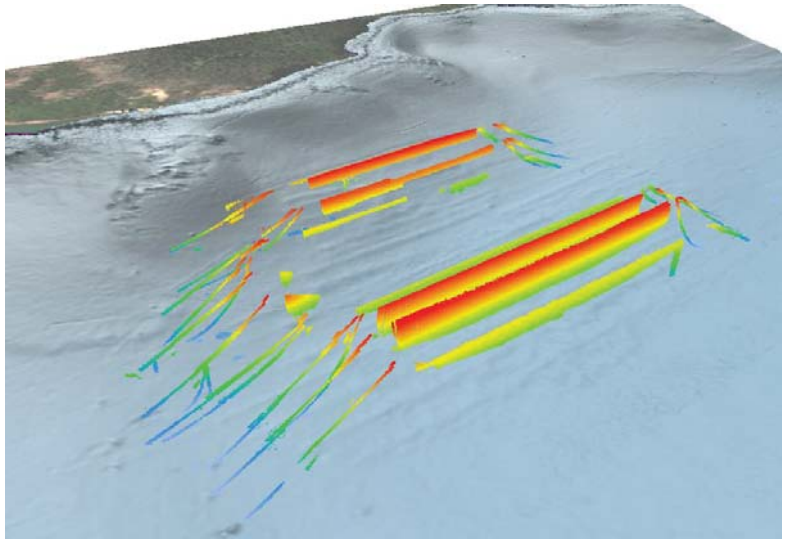
Marine Farm Example A – Profile



Marine Farm Example A – Stacked Longitudinal View of Water Column Structures

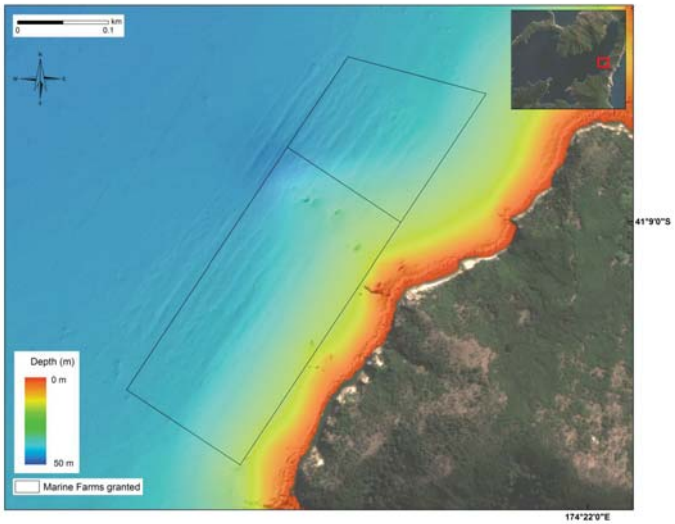


Marine Farm Example A – 3D Water Column Structures

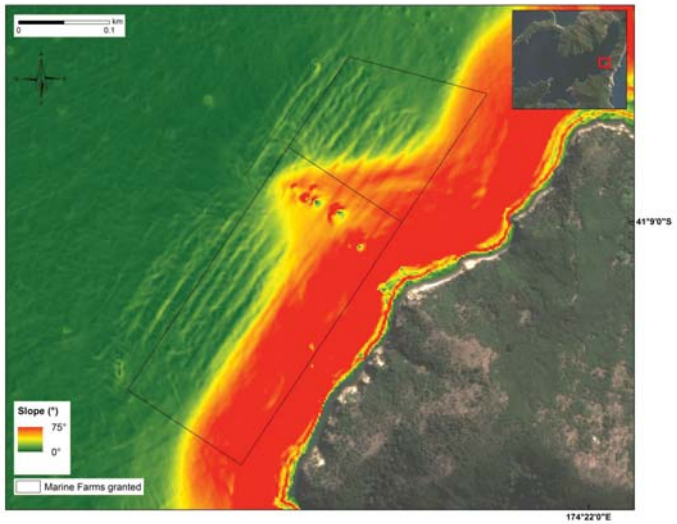


3D Solution for Marine Farms: East Bay Example B

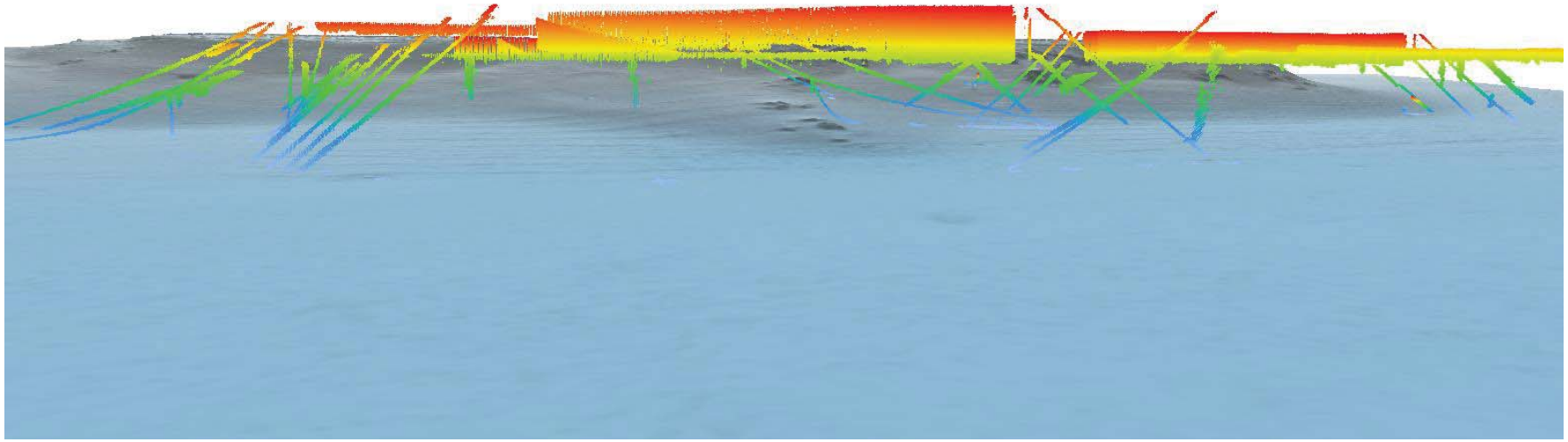
Marine Farm Example B – Bathymetry



Marine Farm Example B – Slope

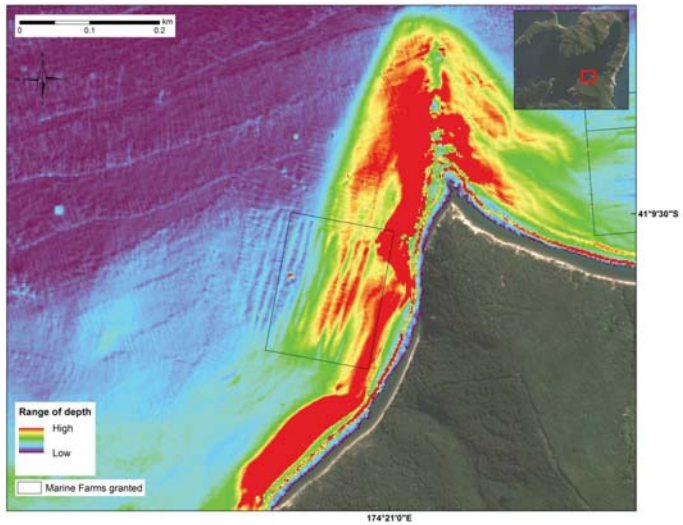


Marine Farm Example B – 3D Water Column Structures

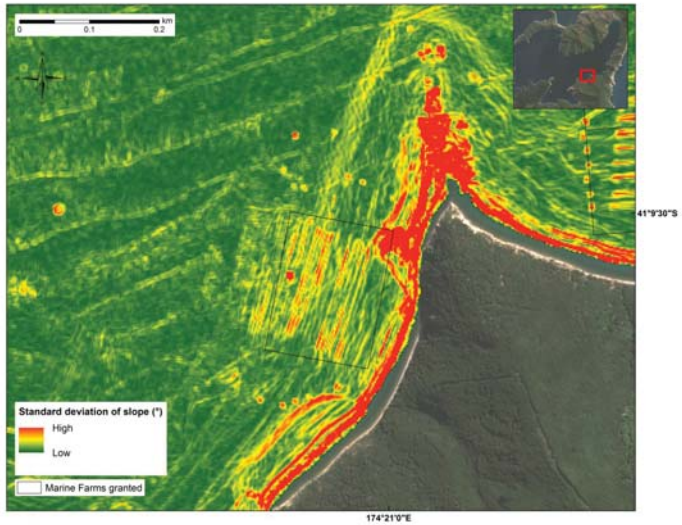


3D Solution for Marine Farms: East Bay Example C

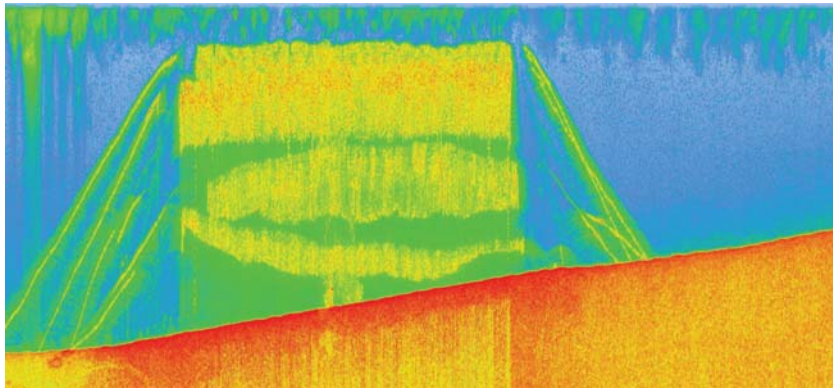
Marine Farm Example C – Range of depth



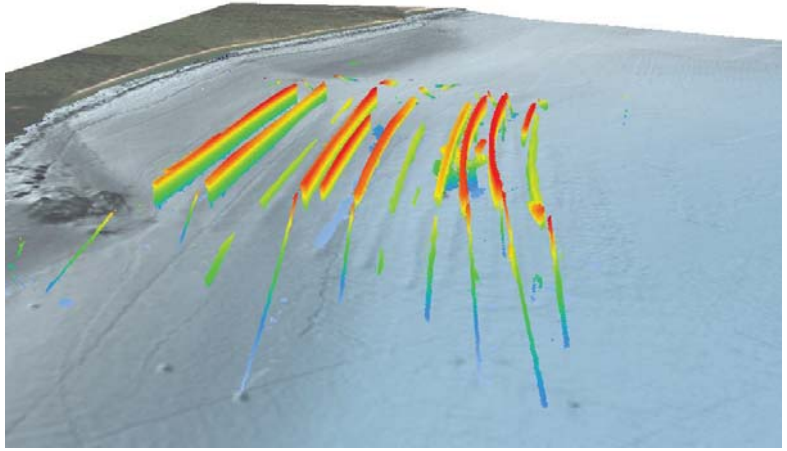
Marine Farm Example C – Standard deviation of slope



Marine Farm Example C – Stacked Longitudinal View of Water Column Structures

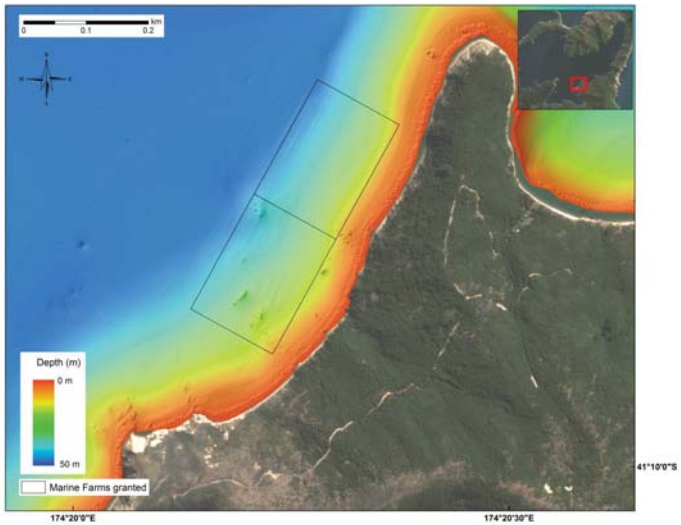


Marine Farm Example C – 3D Water Column Structures

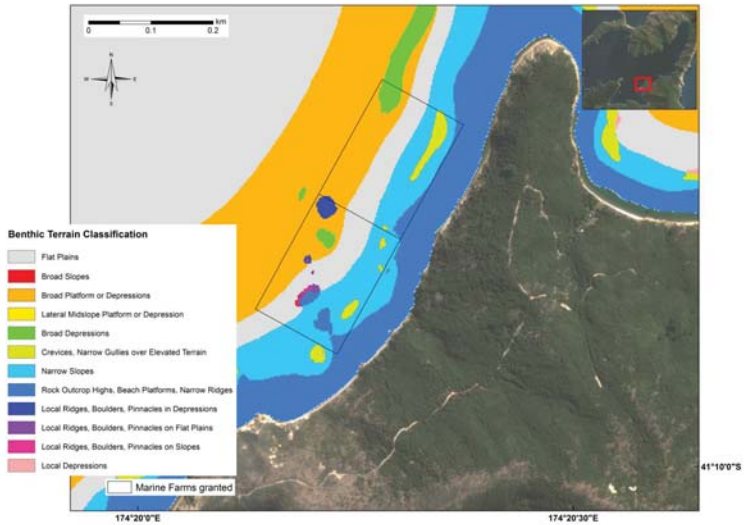


3D Solution for Marine Farms: East Bay Example D

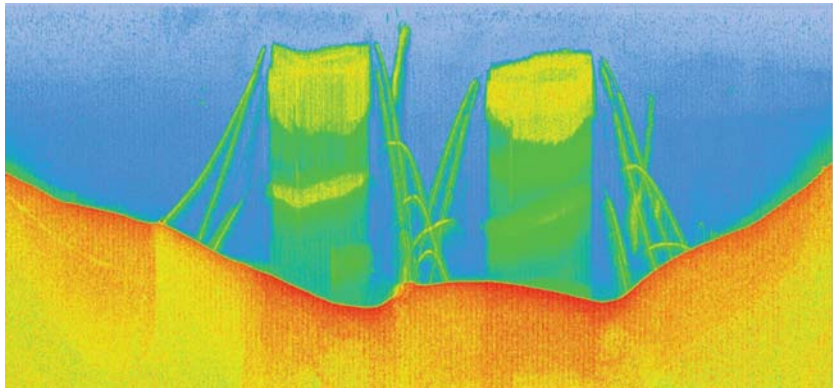
Marine Farm Example D – Bathymetry



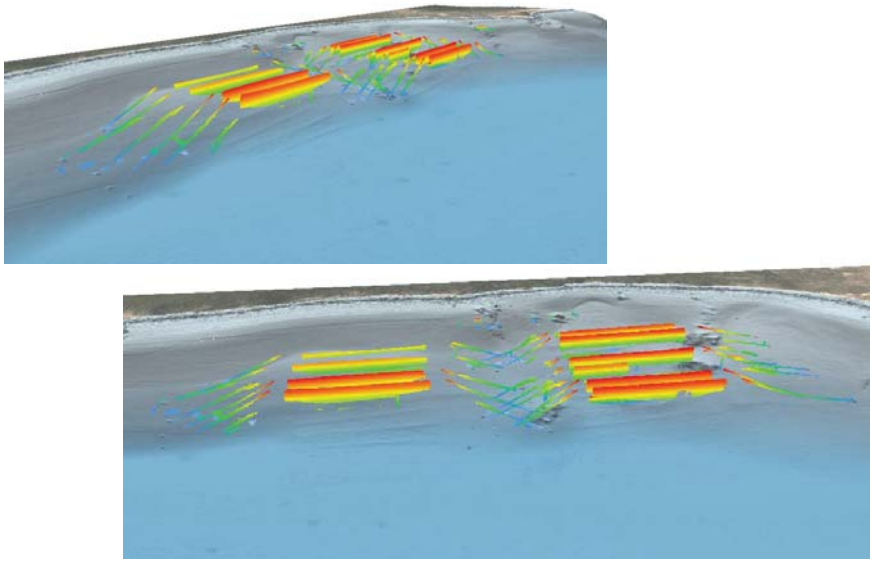
Marine Farm Example D – Benthic Terrain Classification



Marine Farm Example D – Stacked Longitudinal View of Water Column Structures



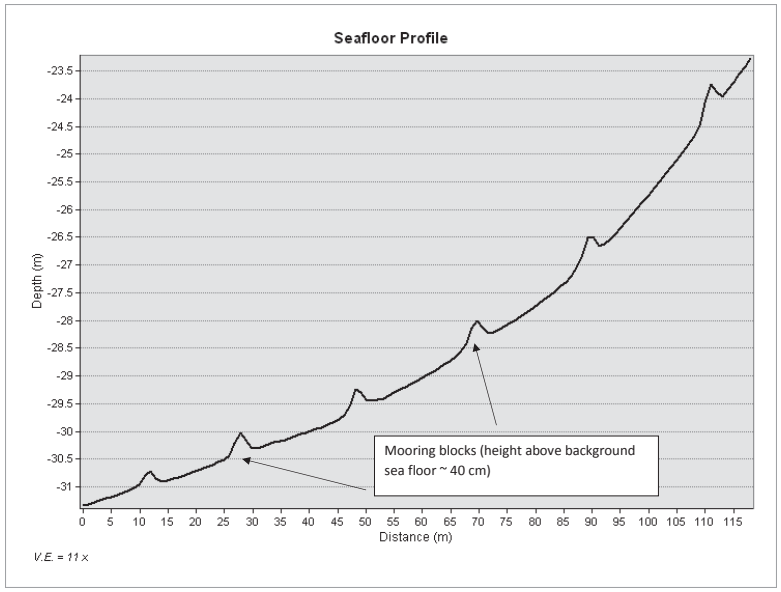
Marine Farm Example D – 3D Water Column Structures



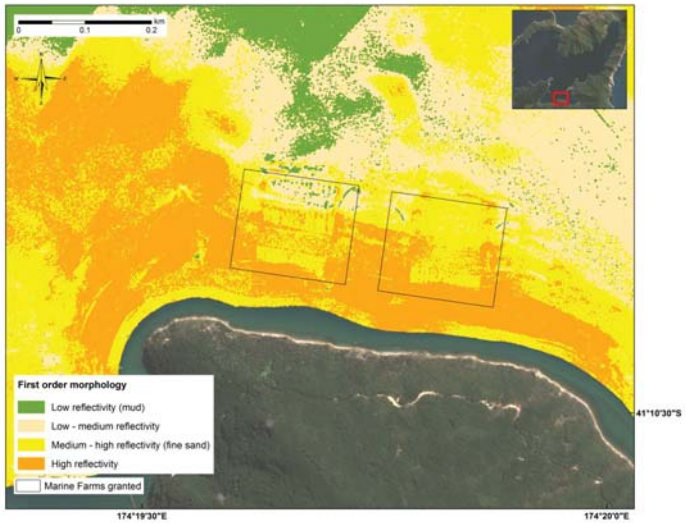
3D Solution for Marine Farms: East Bay Example E

Marine Farm Example E – Rugosity

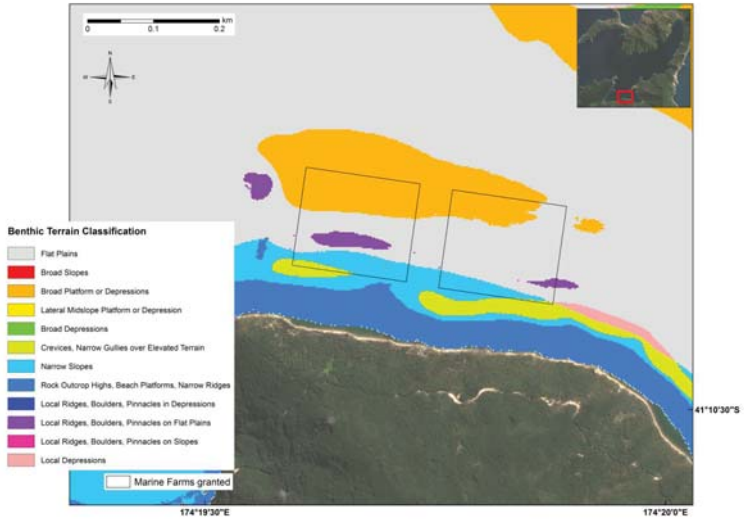
Marine Farm Example E – Profile



Marine Farm Example E – Seafloor Classification

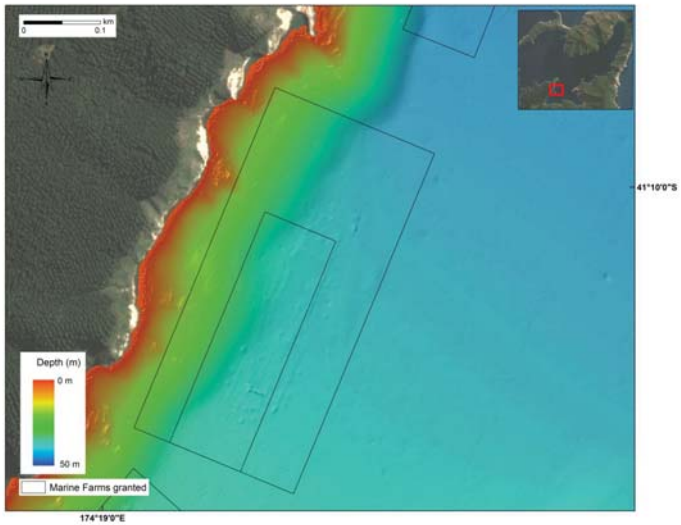


Marine Farm Example E – Benthic Terrain Classification

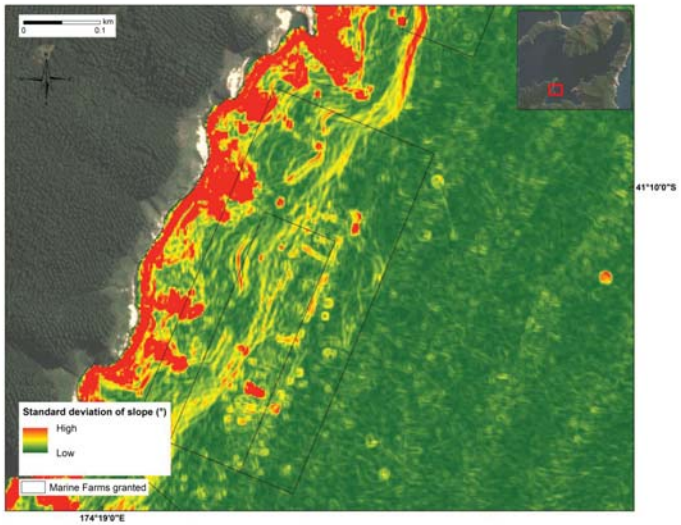


3D Solution for Marine Farms: East Bay Example F

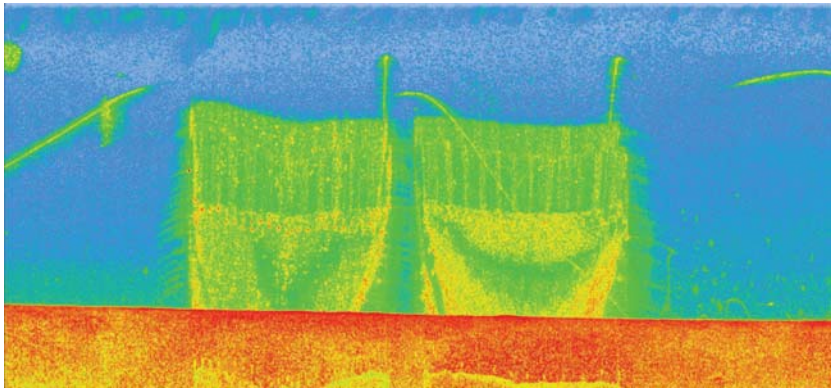
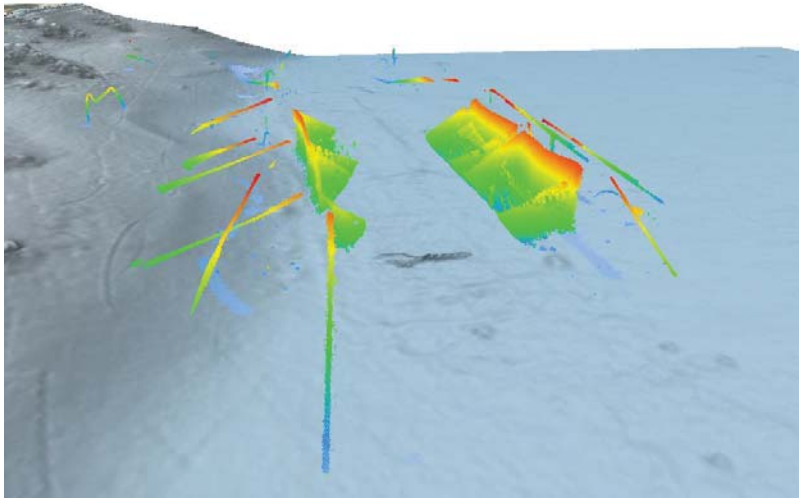
Marine Farm Example F – Bathymetry



Marine Farm Example F – Standard deviation of slope



Marine Farm Example F – Stacked Longitudinal View of Water Column Structures



Marine Farm Example F – 3D Water Column Structures