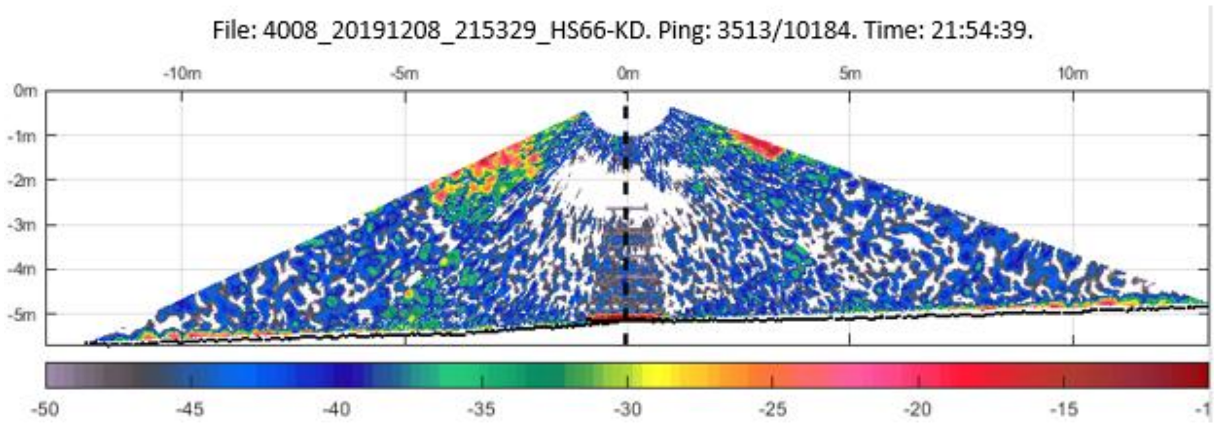
Pelorus Sound / Te Hoiere Quality Assurance Checks of Backscatter Data Quality

Western Marlborough Sounds Hydrographic Survey (HS66)

Prepared for Discovery Marine Limited (DML) and iXblue Pty Limited On behalf of Land Information New Zealand and the Marlborough District Council

October 2020



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Executive summary

As the science provider for the Western Marlborough Sounds hydrographic survey project (HYD-2018/19-01, HS66) for Land Information New Zealand (LINZ) and the Marlborough District Council (MDC), NIWA was contracted by Discovery Marine Ltd (DML) and iXblue Pty Ltd to contribute to the survey through the provision of acquisition and quality assessment services. This included the undertaking of ground truthing fieldwork, data checking, and readying underpinning benthic and water column data for future science products. A key component of the work package provided a briefing to survey personnel in order that coastal and marine farm observations (and photographs) were undertake in accordance with NIWA provided guidance and data sheets, as well as Marine Mammal Observations (MMO) and photographs that would enable NIWA to provide a sightings report. The report herein summarises the quality assessment of the seabed backscatter and water column data recorded by multibeam echo sounders.

All multibeam echosounder data delivered to NIWA have been screened for acoustic backscatter and water-column information and are assessed as fit and ready for future scientific purposes. Overall, the seabed backscatter and water-column data provided by DML and iXblue are of high quality. However, there are some issues that we identified in the quality assurance workflows that are worthy of further consideration for future surveys of this type.

Backscatter data from the multibeam echosounders used in HS66 have been analysed only to a level that allowed an assessment of data completeness for quality assurance and readiness for future scientific investigation. These data will need to be fully processed before quantitative analysis can proceed.

1 Introduction

After several decades of technological development, multibeam echosounders (MBES) have become a standard remote-sensing tool with which to map seafloor bathymetry. These systems are also popular for their additional capability to record the strength of the echo returned from the seafloor (usually termed “backscatter”), which is strongly dependent on seafloor type and structure, and can thus be used to infer seafloor geology, geomorphology, and habitats. Modern MBES have the capability to record a third data type: the strength of the echo returned from the section of water column travelled by the transmitted pulse before it reaches the seafloor. These commonly termed “water-column data” have already shown much potential in a range of marine applications, including the detection and study of gas seeps, suspended sediments, or fish schools. Another possible application of MBES water-column data is the detection and mapping of underwater vegetation extending substantially from the seabed, such as kelp.

Discovery Marine Limited (DML) and iXblue Pty Limited conducted a bathymetric mapping survey of the seabed in Pelorus Sound / Te Hoiere using multibeam echosounders (MBES) for the Western Marlborough Sounds hydrographic survey (HYD-2018/19-01, HS66) for Land Information New Zealand (LINZ) and the Marlborough District Council (MDC). These contractors employed two different MBES systems to map their respective areas of the seabed: DML used a Reson SeaBat T50; and iXblue used a Kongsberg EM2040D. For both MBES systems, the acquisition of bathymetry/seabed backscatter data and water-column data was written to separate file formats. For the T50, bathymetric/seabed backscatter data was written to a Quincy *.db* format while the water-column data was written to a separate file in a Reson *s7k* format. Seabed backscatter data was exported from the processed *.db* files to a *GSF* file format. While the EM2040D writes bathymetric/seabed backscatter data to an *.all* file format, and the water-column data to a *.wcd* data format.

NIWA was contracted to contribute to the hydrographic survey and through provision of post-acquisition services, namely: participation in the primary backscatter reference compensations, data checking and readying underpinning benthic and water-column data for future science products. NIWA’s contribution builds on approaches drawn from the Queen Charlotte Sound / Tōtaranui and Tory Channel / Kura Te Au Hydrographic Survey (LINZ Project HYD-2016/17-01, HS51) hydrographic survey (Neil et al., 2018).

The report herein provides a factual summary of the seabed and water-column backscatter quality assurance (QA) workflows undertaken by NIWA.

2 Backscatter reference surface

A reference surface is a selected area of naturally flat and featureless seafloor, upon which several passes of the MBES are carried out in reciprocal directions. In additional to the morphological requirements of flat and featureless seafloor is the need for the seafloor sediments to have a consistent homogenous grainsize composition. This ensures a consistent seafloor backscatter response of the seafloor to the acoustic signal transmitted from the MBES.

This reference surface area is surveyed by a MBES with extremely high density of soundings to ensure a statistically ‘perfect’ seafloor representation in both bathymetry and backscatter responses.

The purpose of a reference surface is twofold:

1. the quality assurance of the MBES system performance, specifically during turns;
2. a comparative ‘standard’ for the backscatter measurements by the MBES.

The latter purpose is especially important in surveys that utilise different MBES systems (such as the case with the HS66 survey project) over prolonged survey durations where the MBES performance and environment (water properties) may change over time.

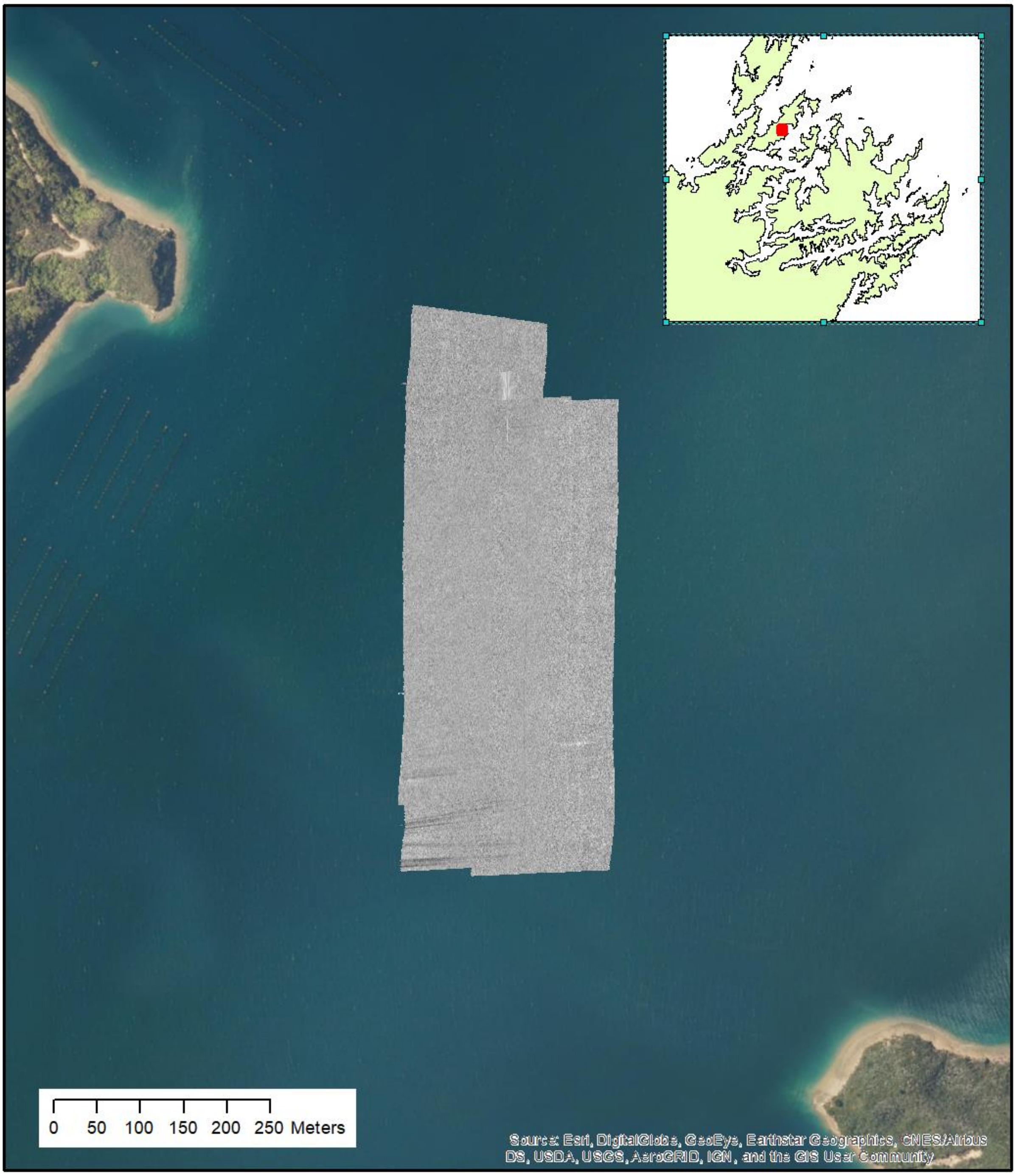

Figure 2-1: Example of the unprocessed seafloor backscatter data collected at the Waitata Bay reference surface.

The reference surface for this survey was selected by DML and iXblue to suit the morphological and seafloor sediment homogeneity requirements, and to be within acceptable transit distances to both surveyors' areas of work. A site (Figure 2-1) was selected in Waitata Bay (40° 58.47'S 173° 54.80'E) and was presented to NIWA for validation and the first of the reference surface data was acquired by DML and iXblue under the supervision of NIWA on the 15th November 2019. At this visit by NIWA, the MBES acquisition settings and survey line design for the data collection of compensation check lines were agreed upon. During the duration of the survey, this reference surface was surveyed a total of seven times by DML and iXblue.

On 8 February 2020, iXblue carried out a survey of the reference surface in Waikawa Bay (41° 15.12'S 174° 03.36'E) that was formerly used for the HS51 survey. The data acquired from this survey will allow the results of any backscatter compensation analysis undertaken in the HS66 survey to be comparable to that undertaken during HS51.

3 Methods

To minimise the effects of changes of acoustic energy transmitted by the different MBES, all data acquisition for survey was conducted using a controlled frequency (300 kHz) and pulse length. All acoustic signals were transmitted in a continuous wave (CW) pulse with the frequency modulated (FM) pulse disabled. These controls allow for a consistent backscatter response to the seabed and water column across all depths.

The acquired seafloor backscatter and water-column data were checked following the regular offsite data backup to examine for irregular and unexplained changes in the backscatter signal which could be indicative of system errors. Any such errors may affect the quality of the final science-based outcomes resulting from the survey.

3.1 Seabed backscatter data

Seabed backscatter data (*.gsf* files for the Reson T50 and *.all* files for the EM2040D) were assessed for quality using FMGT, which is a software program by QPS designed to visualize and analyse backscatter data from multibeam sonars. In order to assess the backscatter quality, FMGT was used to perform some basic corrections within the backscatter signals. The software read multiple files of backscatter data, applied some minimal corrections, and then created a 2-dimensional representation of the seafloor from which an assessment of the data completeness and readiness for future quantitative analysis can be made. (Figure 3-1).

For the purposes of data-quality assurance, the seabed backscatter data was processed in FMGT to three primary stages. Each one of these three stages depend on the output of the previous stage.

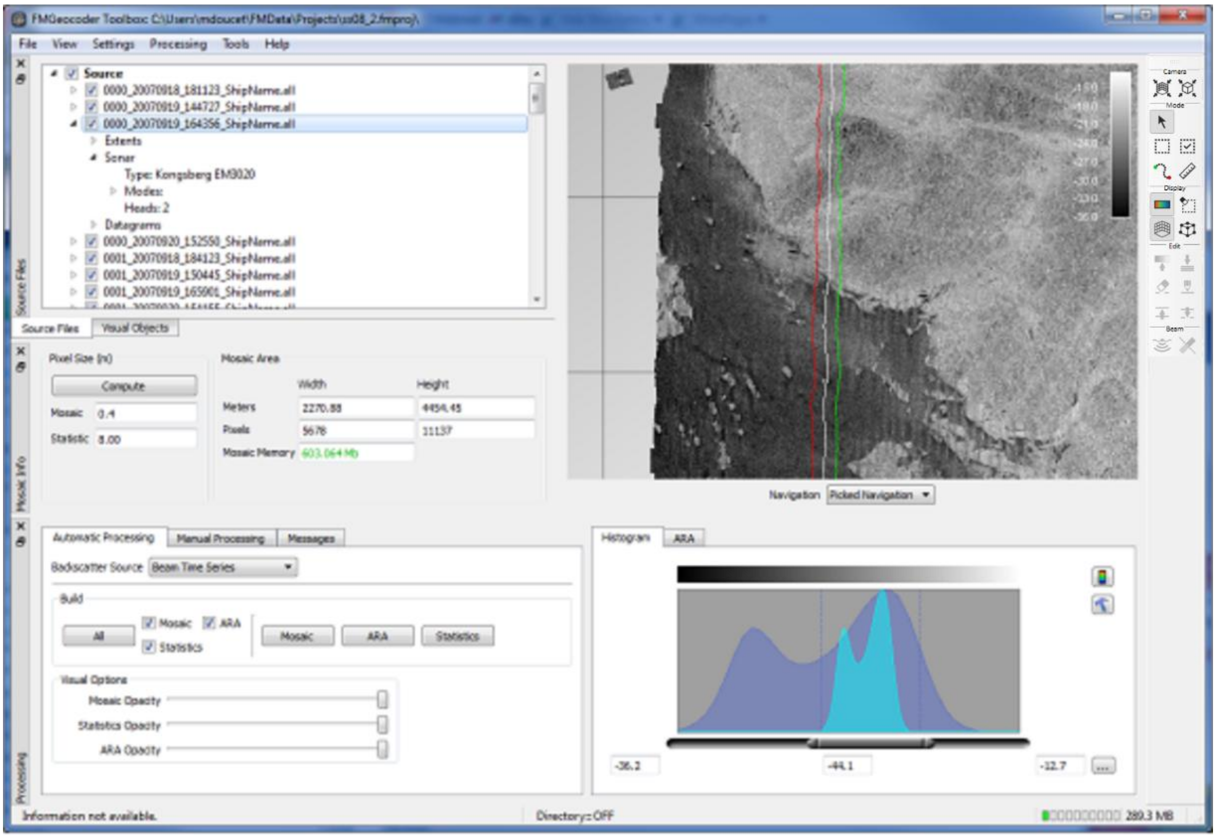

Figure 3-1: Screenshot from the FMGT software used to process and assess seabed backscatter data.

The Coverage stage extracts the navigation from each line and creates the visual port and starboard extents, and track lines that are shown in the FMGT Map View.

The Backscatter, or 'Adjust' stage extracts the raw backscatter time series for each beam from the source file and performs some potential adjustments to the data. These adjustments include some signal level adjustment due to range and transmission loss, beam incidence angle and beam footprint area adjustments.

The Filter stage performs adjustments to the backscatter swath based on beam incidence angle and finally perform an antialiasing pass on the resulting swath backscatter data.

The result is rendered as a 2-dimensional image that can be checked for systematic errors from the MBES, such as striping, gradual power loss or missing pings.

3.2 Water-column backscatter data

Using specially developed software code to process the MBES data files (Schimel et al., 2020), the water-column data and the necessary ancillary information (ping time; vessel position, roll, pitch, and heading; beam steering angle, etc.) were extracted from the MBES raw data files (*.s7k* files for the Reson SeaBat T50 and *.wcd* files for the EM2040D) and geometrically processed to obtain the position of each water-column data sample in the swath space (distances upwards and towards starboard, with origin at the sonar head) and in projected coordinates (UTM 59 zone South easting and northing, and height above the ellipsoid).

The bottom detection information was extracted and geometrically processed in the same way. The level of each sample as found in the records, that is, the "sample amplitude in 0.5 dB resolution" found in the water-column datagrams.

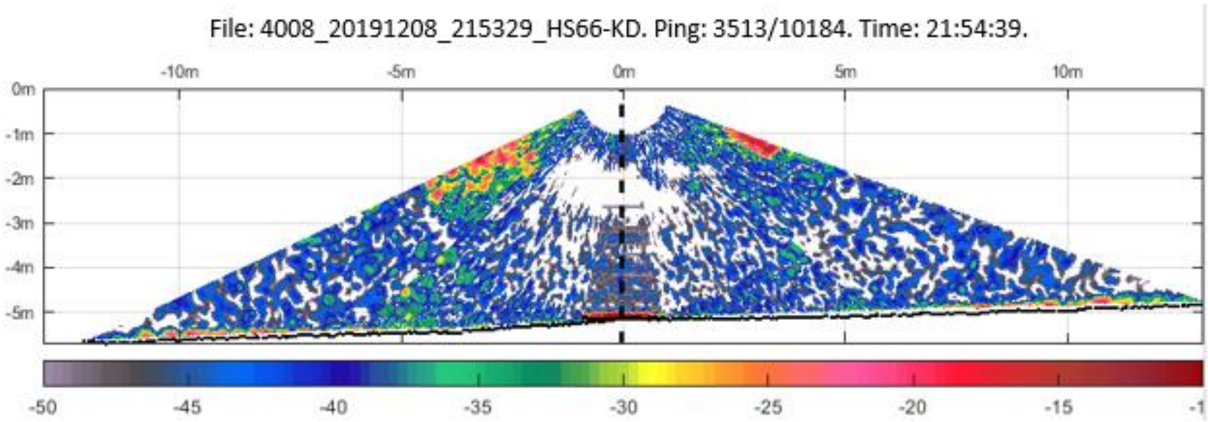

Figure 3-2: Vertical slice of MBES water-column data after processing.

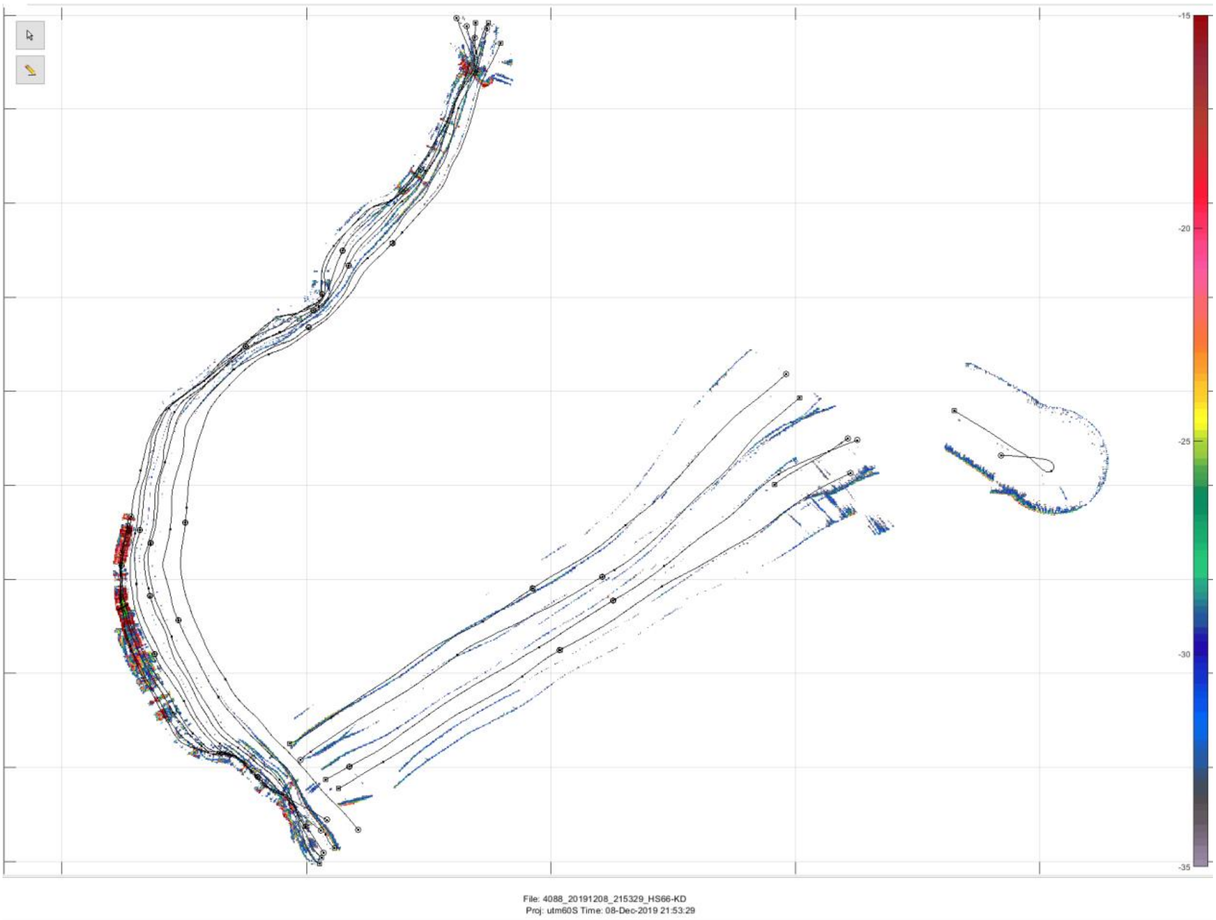

Figure 3-3: Example of horizontal stacking of data from a MBES along a rocky coastline highlighting areas of high water-column acoustic reflectivity.

The software code implements a slant-range signal normalization (SRSN) to essentially reduce the level at all ranges to a comparable level. In any single ping, the algorithm calculates the average level across all beams for every range and subtracts it from the level of all samples at the corresponding range. Then, the algorithm adds a reference level calculated as the average level of all samples of the 11 most central beams above the seabed. Figure 3-2 shows an example of water-column data from a single ping after application of the SRSN algorithm.

For display and analysis, the data filtered after application of the SRSN algorithm were gridded at a 2 m resolution in all three projected dimensions (easting, northing, height). This allowed extracting horizontal "slices" of the filtered dataset at set depths (Figure 3-3).

4 Results

The multibeam echosounder data from the EM2040D and T50 MBES delivered have all been screened for acoustic seabed and water-column backscatter information and is assessed as fit for future scientific purposes. Maps depicting the area where seabed and water-column backscatter for Pelorus Sound/Te Hoiere where assessed for quality are shown in the appendices.

For the delivered acoustic backscatter from the EM2040D did sometimes show data segment gaps with a duration of ~1 second. Upon further enquiry we see these gaps as being inconsequential when weighed against the additional resourcing required to fill-in the missing segments and the large scale of the overall data coverage.

There were a very few instances where the water-column data were not recorded fully for some lines. In these instances, the bathymetry and seabed backscatter files do have a 100% seafloor coverage. Areas of missing water column are inconsequential when weighed against the additional resourcing required to fill-in the missing segments and the large overall data coverage shows that ~99.6% of the total have accompanying water-column data.

5 Lessons learnt

Overall, the seabed backscatter and water-column data provided by DML and iXblue are of high quality and fit for future scientific purposes. However, there are some issues that we identified in the quality assurance workflows are worthy of further consideration for any future surveys:

- **Timeliness of data delivery from the field**. The time lag between data acquisition and the land-based screening for quality assessment needs to be reduced as the field-survey teams are operating to tight timelines and typically leave areas as soon as acquisition is completed. However, because acquisition occurred up to a fortnight ahead of data drops, subsequent workflows finalising the quality assessment ultimately led to a lag of many weeks. Should data issues occur (in acquisition quality or collation) solutions or reruns may not always be practical or even feasible.

- **Expected area surveyed**. The quality assessment process happens in a 'blind' environment in that the data from the field are delivered and processed as collections of files without any knowledge by the reviewer of the geographic coverage that the files should represent. The resulting products are screened for unexpected changes in backscatter, but coverage completeness cannot be assessed. For future surveys of this type, it would be advantageous to have data deliveries accompanied by a map indicating the expected geographic coverage for these data so that any issues that may result from missing files are addressed in a timely manner.

6 References

Land Information New Zealand (LINZ), 2019. Hydrographic Survey Specification – Western Marlborough Sounds v.5 Project Number HYD-2018/19-01 (HS66).

Neil H.L., Mackay K., Wilcox S., Kane T., Lamarche G., Wallen B., Orpin A., Steinmetz T., Pallentin A. (2018) What lies beneath? Guide to Survey Results and Graphical Portfolio, Queen Charlotte Sound/Tōtaranui and Tory Channel/Kura Te Au (HS51) Survey. *NIWA Client Report* 2018085WN.

Schimel, A.C.G., Brown, C.J., Ierodiaconou, D. (2020) Automated Filtering of Multibeam Water column Data to Detect Relative Abundance of Giant Kelp (Macrocystis pyrifera). *Remote Sens.* 2020, 12: 1371.

Appendix A Maps

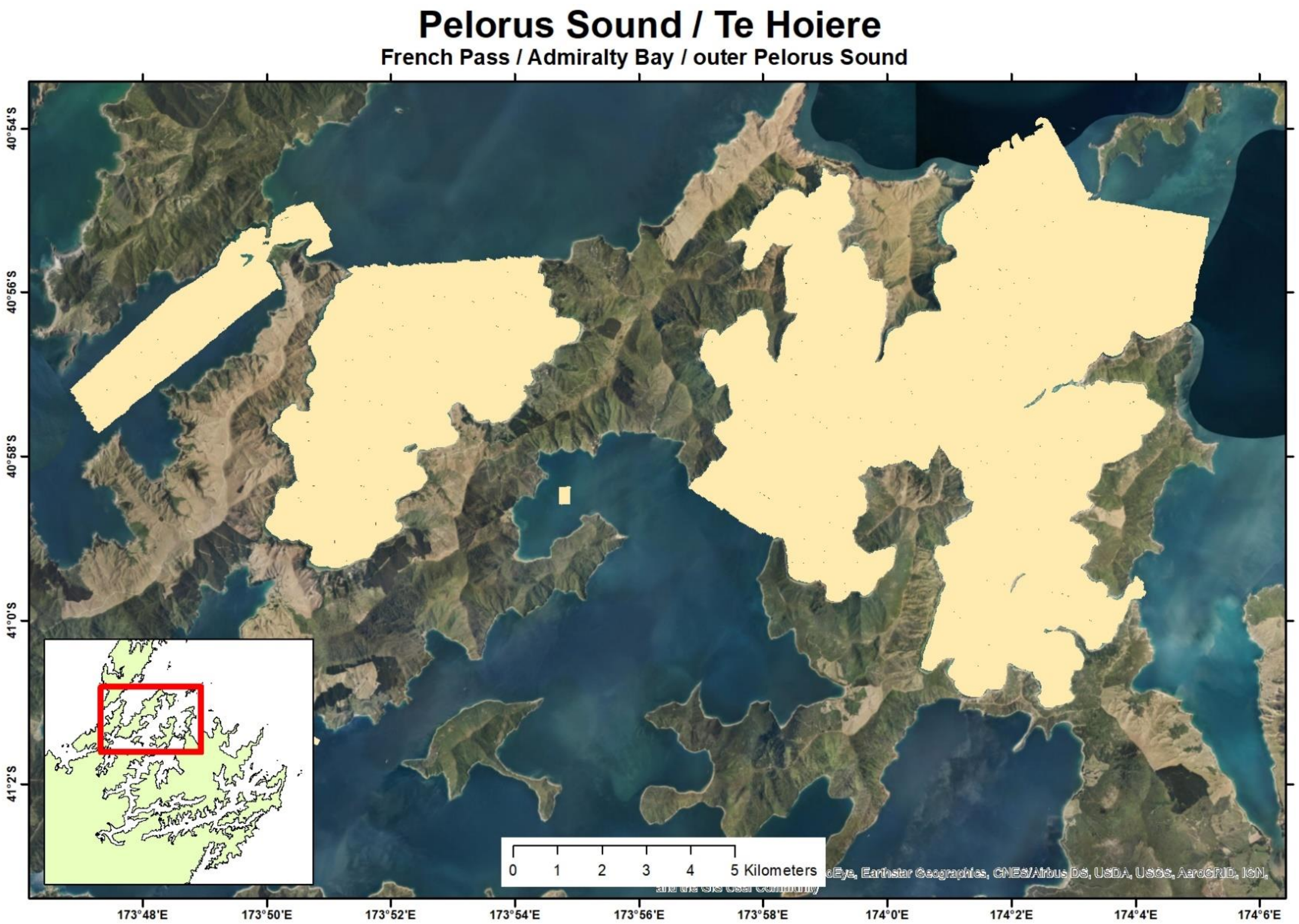

Figure A-1: Area examined for seabed and water-column backscatter quality in French Pass, Admiralty Bay and outer Pelorus Sound / Te Hoiere.

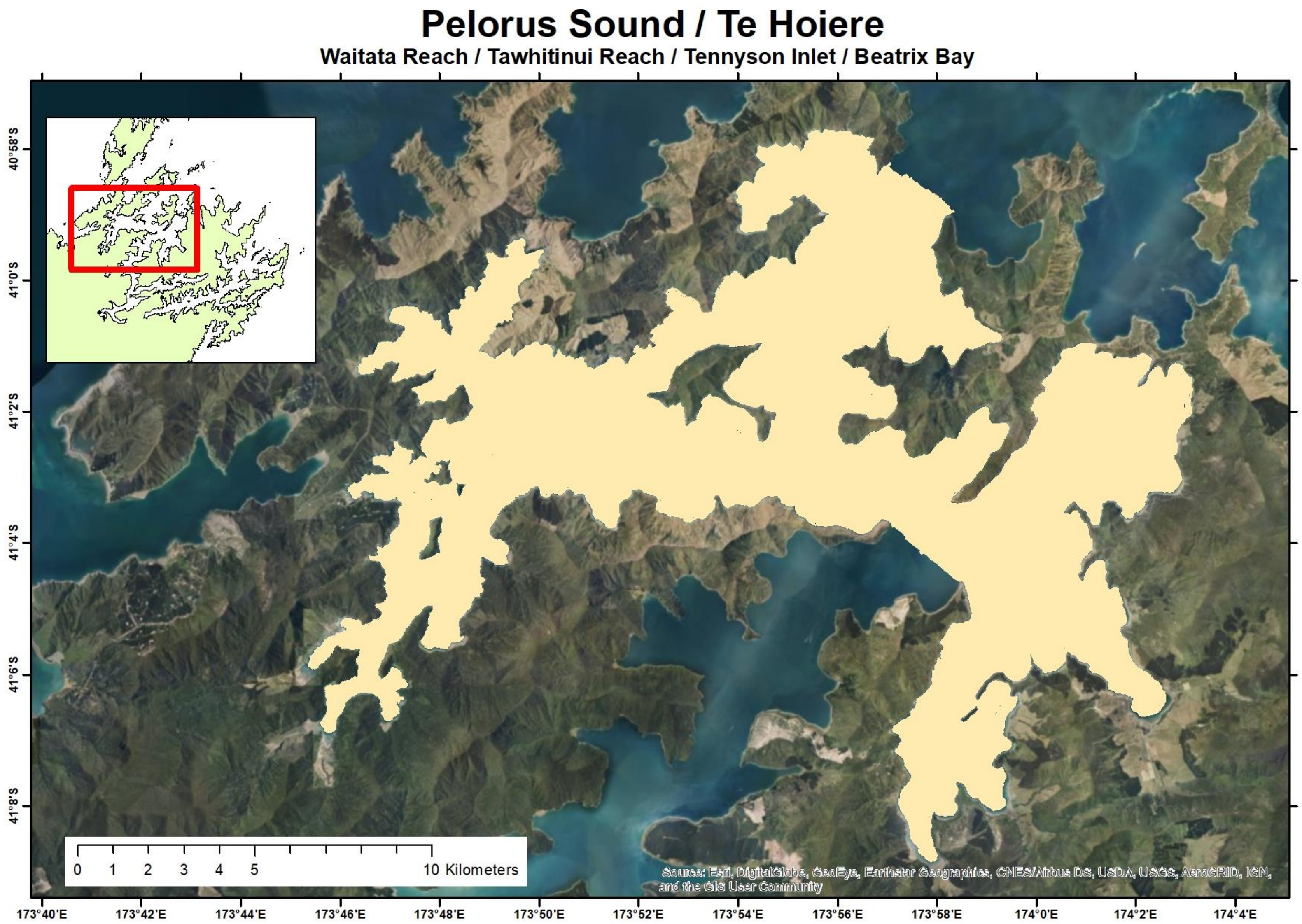

Figure A-2: Area examined for seabed and water-column backscatter quality in Waitata Reach, Tawhitinui Reach and Tennyson Inlet, Pelorus Sound / Te Hoiere.

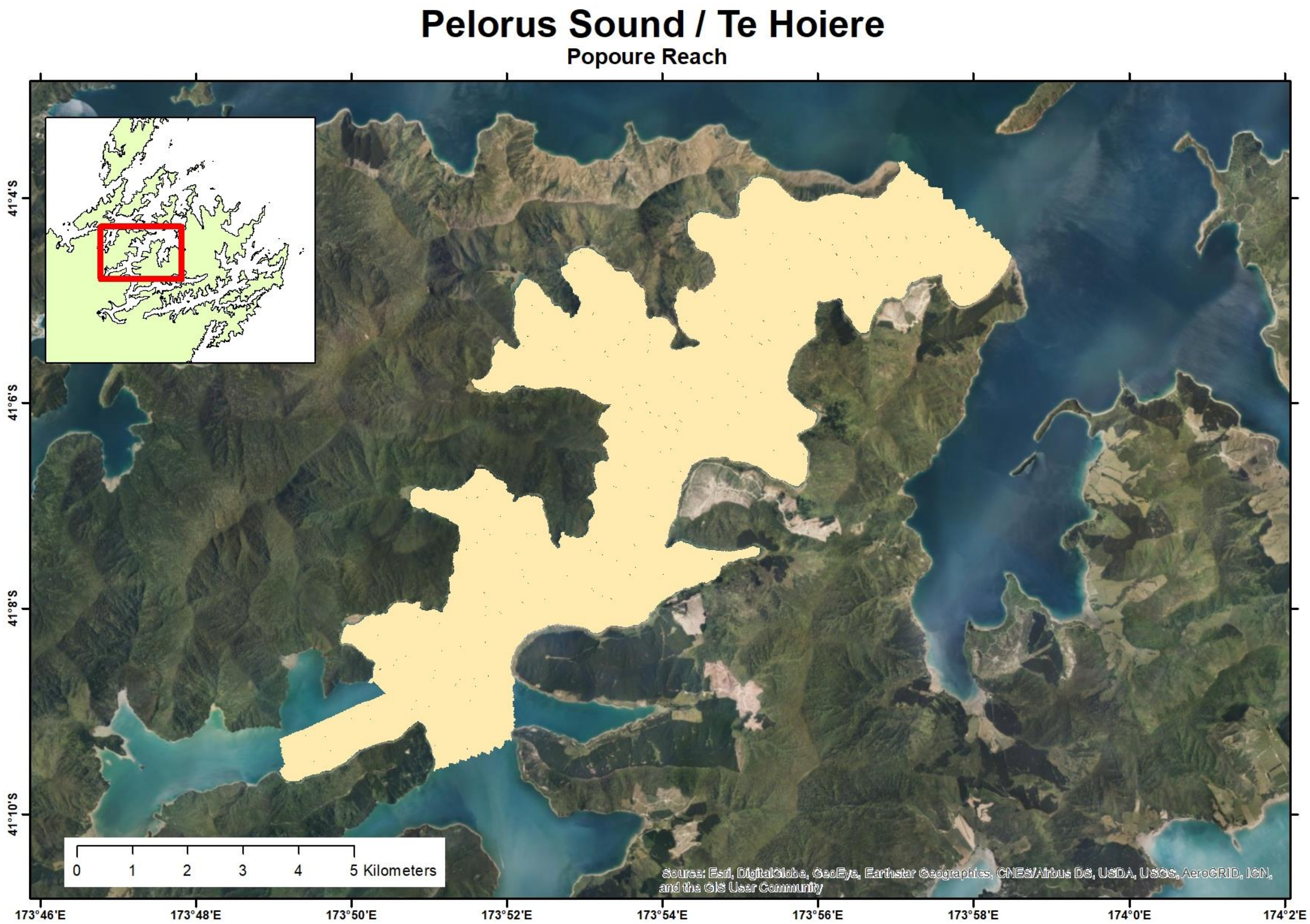

Figure A-3: Area examined for seabed and water-column backscatter quality in Popoure Reach, Pelorus Sound / Te Hoiere.