2. Methods

2.1 Technical concept and realization

The benthic profiler NERIDIS III (‘Neritic Discoverer’) is a MARUM-built ‘Remotely Operated Towed Vehicle (ROTV) optimized for the electromagnetic characterization of surficial neritic sediments (Fig.2). Because of the required proximity (20 cm) of the sensors to the seabed, this submersible platform is realized as an enclosed, waterlogged fiberglass sled with outer dimensions of 5.2 x 1.2 x 0.8 m and a net weight of 950 (350) kg in air (water). The profiler is equipped with a controlled-source electromagnetic imaging (CSEM) system, whose function and applications are described in Müller et al. (2011, 2012), a 12V and 24V power unit for 8-12 hour operation, a computer with position and CTD sensors for navigation, data acquisition and DSL communication, and an automated rescue system.

Controlled Source Electromagnetic (EM) Imaging measures the magnetic susceptibility and electric conductivity of the surficial seabed (0-50 cm), yielding a sediment facies and porosity distribution map to be used for sedimentological, geochemical, morpho- and hydrodynamic studies (Figs. 3-5). EM identifies hard grounds, relict and active sand deposits, mud patches and seeps from porosity and magnetic mineral content. It can also detect metallic (conductive or magnetic) anthropogenic debris located near the profiler track.

![Figure 2 CAD image of NERIDIS III profiler with open lid to show arrangement of control and battery units, EM sensor coil, CTD and recovery system.](image-url)
Figure 3 Magnetic susceptibility measures sedimentary magnetic mineral content and is indicative of sediment petrology and grains size. It is applicable to:

1. discriminate sediment facies (by magnetite or clay content),
2. map lateral facies boundaries (infill, sand bars, mud belts),
3. detect shallow reductive diagenesis (sulfidic magnetite dissolution),
4. detect Fe metal objects (UXO/pollution by their ferromagnetic properties).

Figure 4 Electric conductivity characterizes sediment pore space and pore fluid content. In consequence, conductivity profiles are used to:

1. measure porosity (assuming homogenous porewater salinity),
2. detect freshwater or brine seepage (assuming constant porosity),
3. detect metal objects (UXO/pollutants by their high conductivity),
4. discriminate sediment facies (by grain size and sorting → porosity).
While the previous purpose of an EM survey in the Bay of Plenty area was purely oriented towards mapping of magnetic and electric sediment properties (see Badesab et al., 2012), the RENA incident and subsequent negotiations of the collaboration partners in late 2011 examined the idea of using the profiler’s long-distance bottom tracks in permanent proximity to the seabed for continuous digital imaging. Both partners had experience with underwater video systems and understood the great scientific value of overlapping stop-motion digital macro images of the seabed collected over hundreds of kilometers profile length. High-resolution (0.2 mm) images in statistically relevant numbers (2500/km, 100 000/day) create a range of research opportunities from object/specimen counting over ripple analysis and habitat mapping to facies identification by automated algorithms. To prepare NERIDIS III for such RENA-related work, a pressure-encased high-speed digital camera, a LED flash system and an image processing and mass storage computer were made available from partner institutions and physically and electronically integrated into the bow of the profiler.

Digital colour macro photographs of the seabed (each 40 x 40 cm ~ 1900 x 1900 pixel) were continuously recorded (5 images/sec, 200 usec exposure time) along all tracks to (1) identify benthic species (e.g. bivalves, echinoderms, sponges, seaweeds), (2) check for signs of of living, dead or damaged biota, and (3) map their abundances and habitats (e.g. scallop beds, sponge gardens), (4) detect anthropogenic debris (tar balls, plastics, cryolith etc.) from RENA spillage or other sources, (5) use seabed colour and texture as indicators of sediment composition and organic content, and (6) analyse small bedforms (ripple amplitudes, wavelength, orientation, scour marks) for transport conditions.
An optical resolution of 1900*1900 pixel over an area of 40*40 cm corresponds to ~0.2 mm at a tow velocity of 2 m/s = 2000 mm/s. The required stop motion flash time is 0.2 mm / 2000 mm/s = 100 µs (here 200 µs)

The overlapping image frequency at 2 m/s and 40 cm height must be at least 5 frames per second. The number of images recorded at3000-4000 images/km over 250 km profile is therefore at about ~1 Mill. Images * 6 MB = 6 TB image data.
Figure 7 Setup of new A-frame, winch, multibeam and camera cage at WWB Tauranga

Figure 8 Hull integration of camera after collision with hardground terrace