

# Multichannel Analysis of Surface Waves (MASW) for Offshore Geotechnical Investigations

McGrath, T.<sup>1</sup>, O'Connor, P.<sup>2</sup>, Trafford, A.<sup>2</sup>, Long, M.<sup>1</sup>

<sup>1</sup>School of Civil, Structural & Environmental Engineering, University College Dublin,

<sup>2</sup>APEX Geoservices Limited, Knockmullen Business Park, Gorey, Wexford, Ireland

## Objectives

- To generate shear wave profiles from collected data
- To determine small strain shear modulus values from  $V_s$
- To compare these results with data obtained from seismic cone (SCPTU) measurements

## Site

The first stage of offshore practical work was performed in various locations in Dublin Bay (Figure 1), analysing several line segments, to ensure a comprehensive survey of the site and to maximise the quality of the data obtained. An arbitrary area was initially chosen in a shallow, sheltered area to the west of Dun Laoghaire Harbour for testing the equipment configuration and deployment/recovery procedures. Next an area for investigation consisting of two lines of boreholes, both extending from South Bull Wall by the Poolbeg Generating station. The first line extends from west to east, while the second is in a more south-easterly direction. These site locations were chosen as a good variety of subsurface layers with varying soil and properties is present, determined from good pre-existing geotechnical data for the area, which has been supplied by Geological Survey Ireland. The data presented here is for an area just offshore Dollymount Strand where it was possible to carry out underwater MASW work offshore (UMASW) as well as standard onshore MASW and in dry conditions at low tide. Here it was also possible to obtain data using a truck mounted SCPTU. This equipment allows direct measurement of  $V_s$  with which to compare with the MASW data

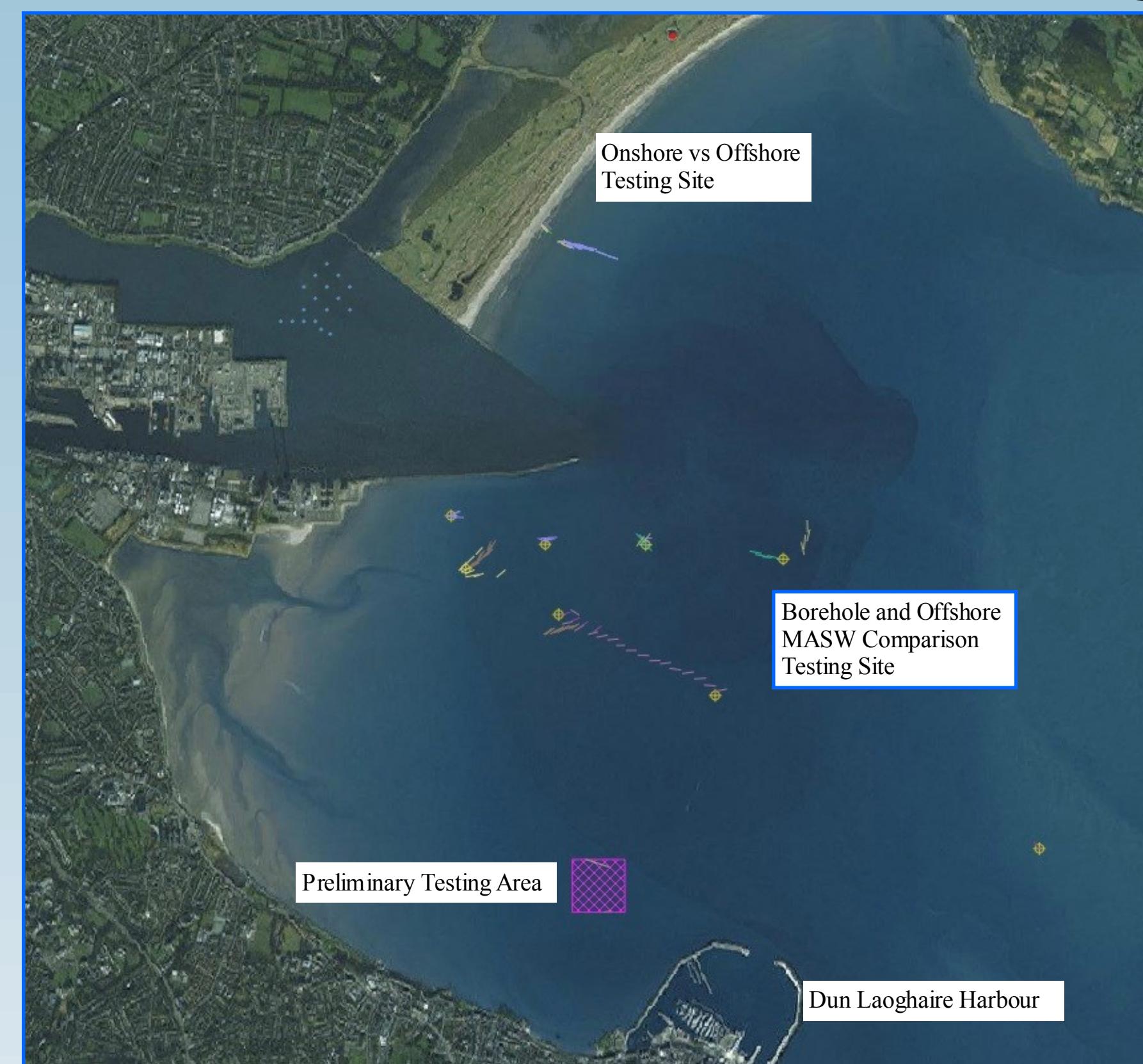


Figure 1: Dublin Bay site locations



Figure 2: INFOMAR's R.V. Geo

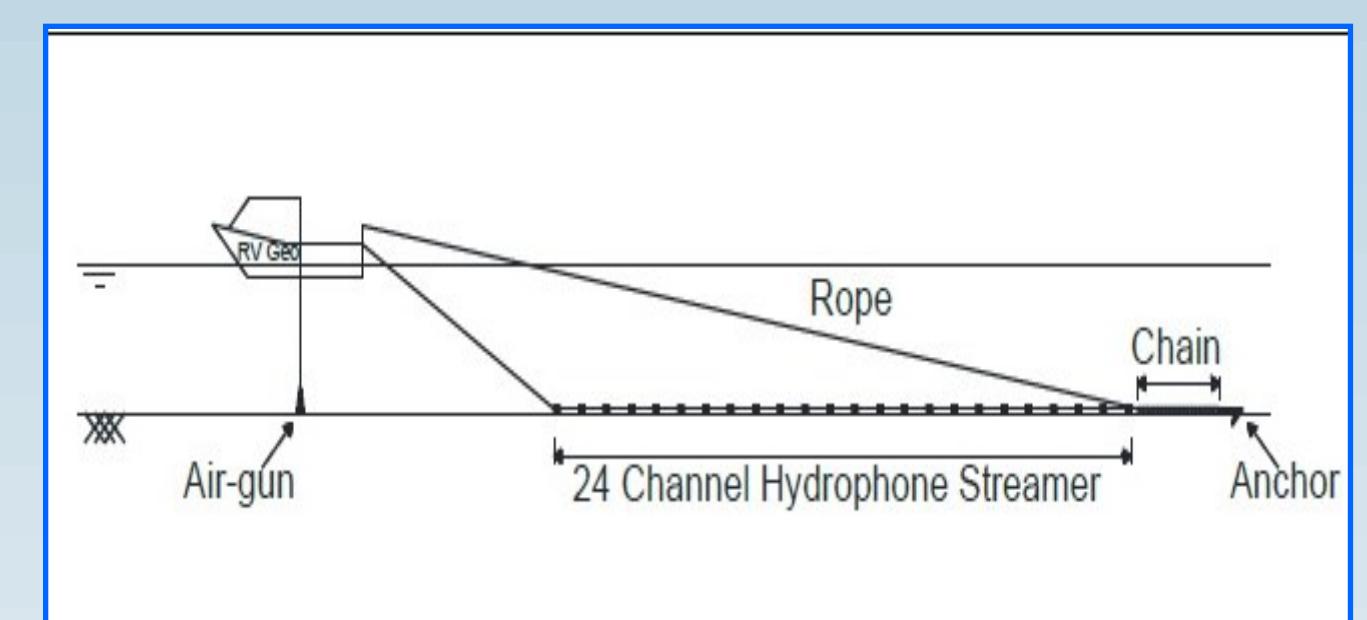


Figure 3: Stage 1 survey set up



Figure 4: 12cu.in MIN G



Figure 5: Geometrics DHA-7 hydrophone cable

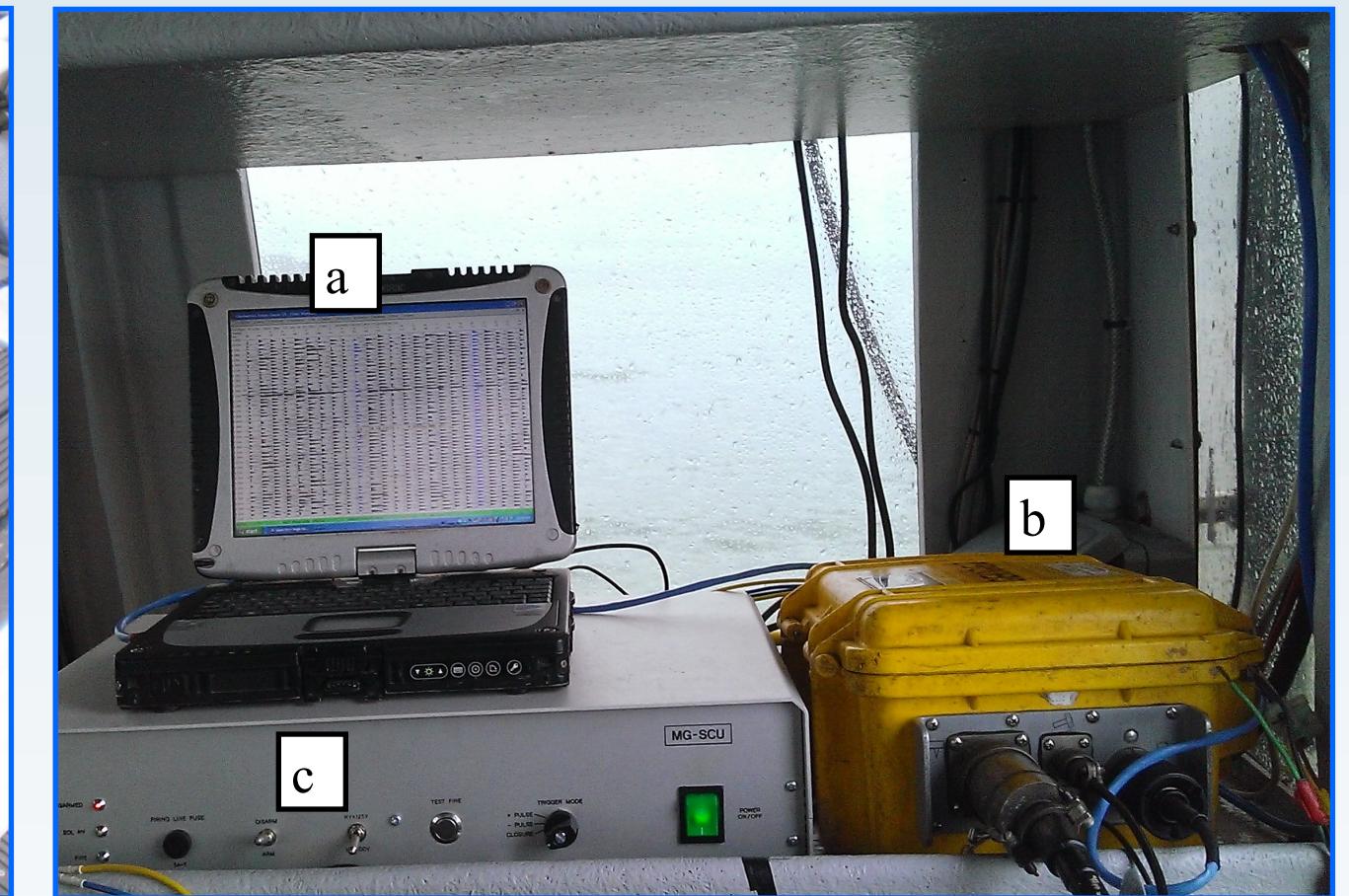


Figure 6: (a) Computer, (b) Geode Seismograph, (c) MINI G Source controller

## Equipment

To access the designated sites in Dublin Bay, INFOMAR agreed to hire one of their research vessels, the R.V. Geo, see Figure 2. See also Figure 3 for final set up. Some of the components required for use in the field trials of offshore MASW included a 12cu.in MINI G air gun (Figure 4) accompanied by a source controller unit which managed the triggering functions of the air guns, high pressure air which was provided using dive cylinders and a regulating manifold to maintain a working pressure of 100bar. The receivers for data collection consisted of a Geometrics DHA-7 24 channel hydrophone cable (Figure 5), which was laid on the sea bed to record the transmitted surface waves, and was connected to a Geode seismograph (Figure 6(b)). The seismograph converted the recorded data and transferred it to a computer for on site review and processing where possible.

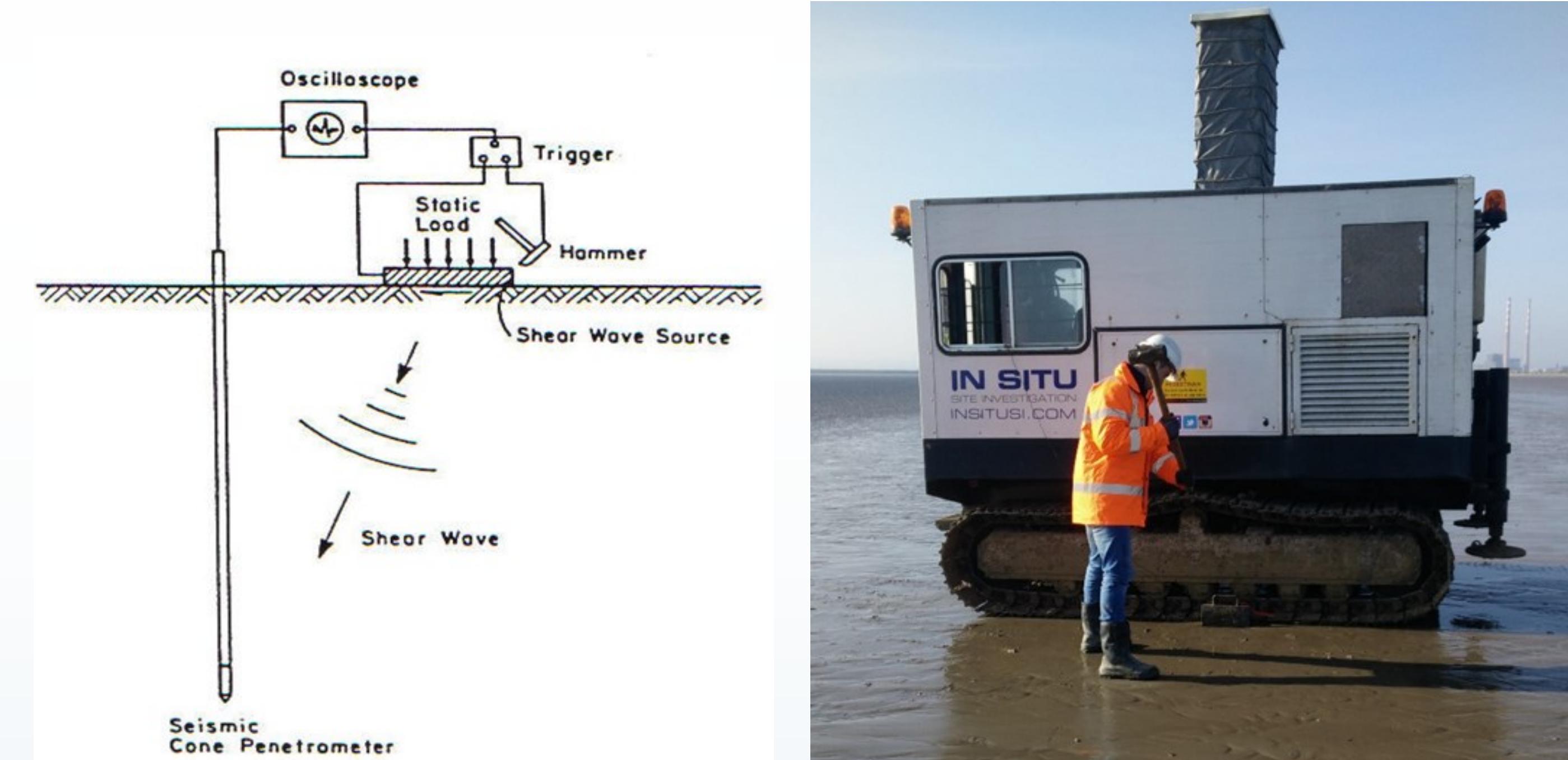


Figure 7: SCPTU principles

Figure 8: SCPTU on Dollymount Strand

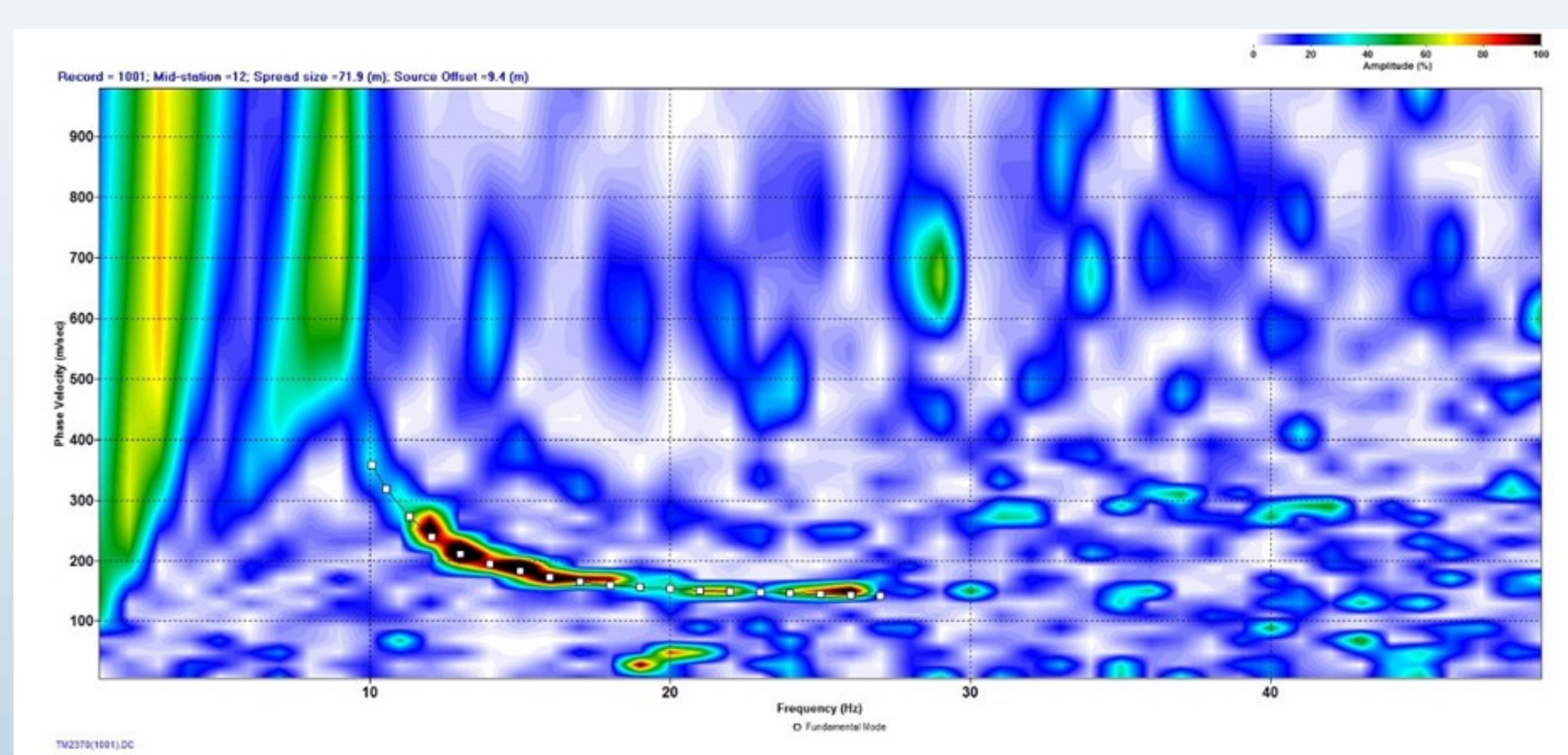


Figure 9: Dispersion Curve for underwater MASW (UMASW) produced by air gun

## Data Processing

SurfSeis 4.0 Seismic Processing Software was used to process the recorded data. Its processes include reading seismic recordings and producing a dispersion plot. The investigator would use this plot to pick a suitable dispersion curve (usually only the fundamental curve was visible in the plot) which the software would then perform an inversion upon to produce a curve of shear wave velocity ( $V_s$ ) in m/s versus depth in metres.

## Seismic CPT (SCPTU) testing

The principle of seismic cone (SCPTU) testing is shown on Figure 7. Ordinary cone penetration testing (CPTU) comprises pushing an instrumented cone into the ground at a steady rate of 2 cm/s and continuously recording cone resistance, sleeve friction and pore water pressure. In the SCPTU an accelerometer is added to the cone. A shear wave is produced by striking a beam with a sledge hammer and the arrival time for the shear wave is recorded by the accelerometer. A picture of the work in progress on Dollymount Strand is shown on Figure 8. Here the beam is coupled to the ground by being placed underneath the tracks of the testing vehicle. The shear wave is produced by striking the beam as shown.

## Results and Conclusions

A typical dispersion curve from the underwater MASW testing on Dollymount Strand (UMASW) is shown on Figure 9. Testing results in a high resolution fundamental mode curve in a bandwidth of 10Hz to 33Hz. There is also evidence of a higher mode between 20Hz and 30Hz, at higher shear wave velocities than the fundamental mode. To maintain consistency only the fundamental mode was considered for the inversion process. The results of 6 UMASW trials offshore Dollymount are shown on Figure 10a. It can be seen that the data are consistent and repeatable, in particular to a depth of about 10m.

Similarly results of two SCPTU tests are shown on Figure 10. Again the test results are consistent.

On Figure 10b results of an on shore MASW test, the two SCPTU tests and an UMASW test are compared. It can be seen for all practical purposes the results are identical.

This is a very encouraging result confirming the accuracy and usefulness of the UMASW process.

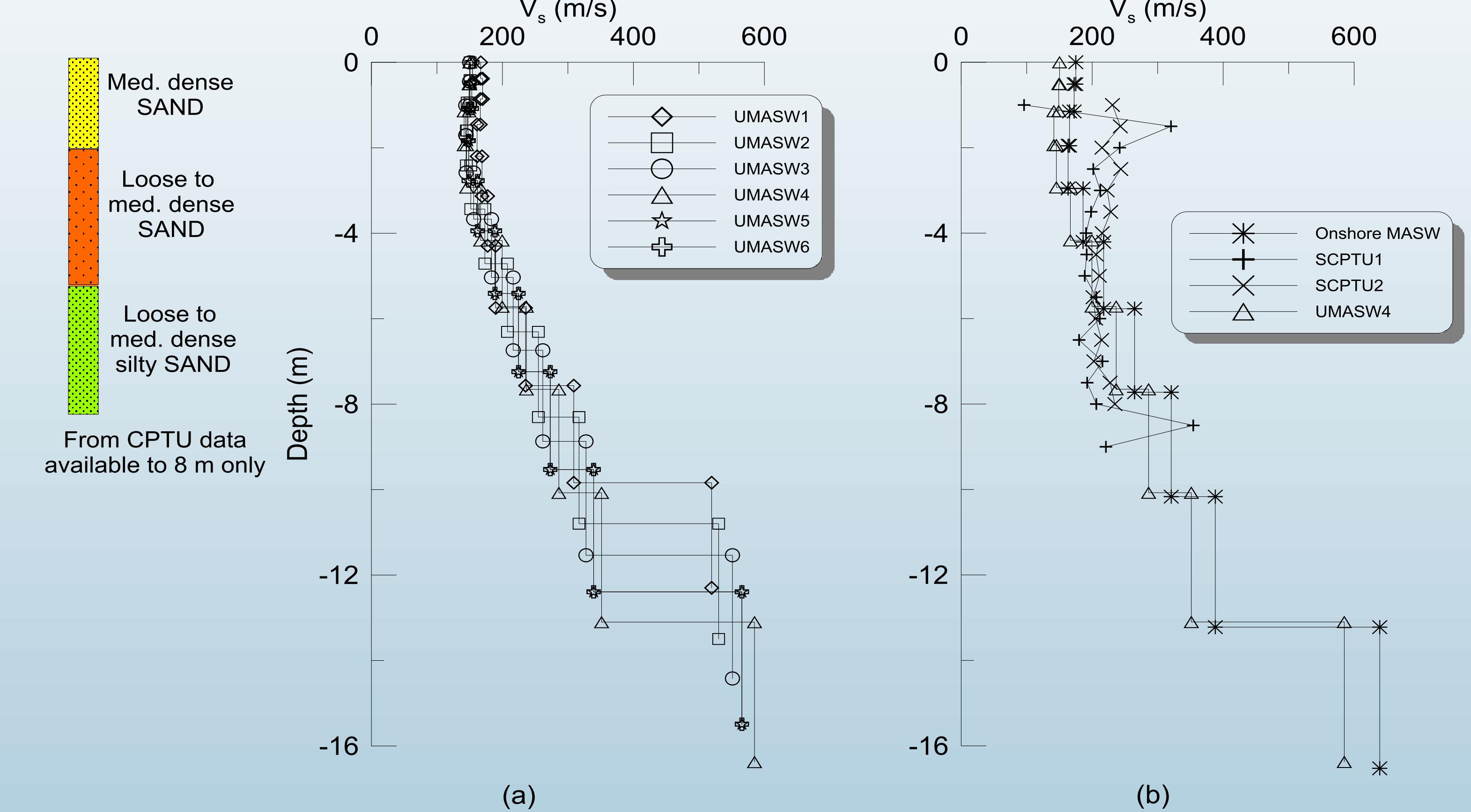


Figure 10: Offshore MASW results compared with Onshore MASW testing and SCPTU test results

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