High resolution over-water seismic reflection profiling

Principles of operation

High resolution marine seismic reflection (aka *sub-bottom*) profiling produces continuous seismic sections to depths typically less than 500 m beneath the sea bed. Sub-bottom profiling systems employ the principle that a vertically propagating seismic pulse will undergo partial reflection at boundaries between media of differing density and acoustic transmission velocity. The acoustic pulse is produced by a source such as an electromotive plate, ceramic transducer or small-capacity airgun, which may be either hull-mounted or towed behind the survey vessel. Source selection is determined by the penetration and acoustic frequency range required; this is dictated by the depth to the base of the zone of interest. The reflected signals are measured using a hydrophone streamer towed either behind or alongside the source, with data being displayed and/or recorded on board ship. Sub-bottom profilers generally record a single channel of data, although some systems (*e.g.* those utilising airguns) record multiple channels of data at greater offsets.

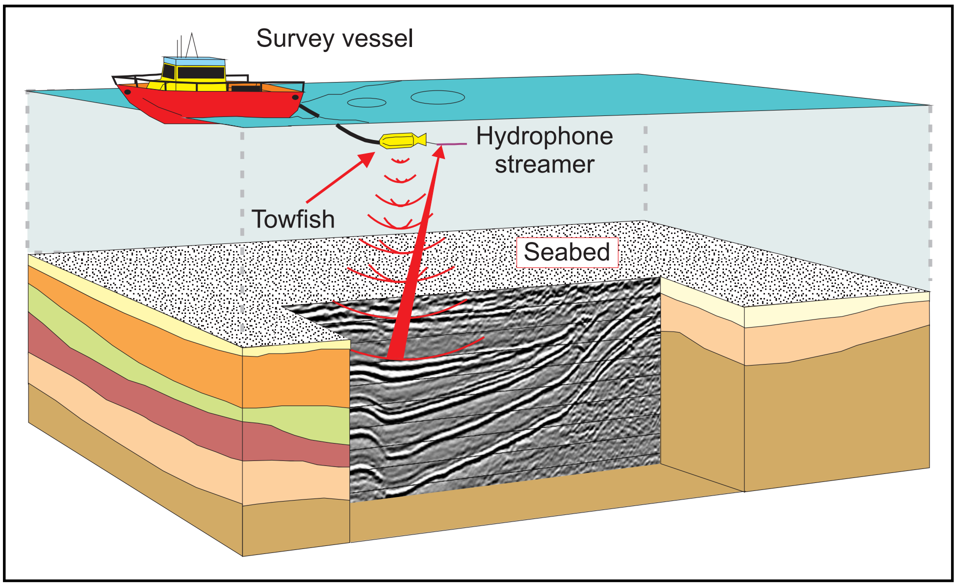

Figure 1: Acquisition of single channel sub-bottom profiler data using towfish

Applications and system choice

Choice of acquisition system depends upon the Client's requirements. Table 1 provides a rough guide to system capabilities:

Source	Penetration (m)	Vertical Resolution (m)
Airgun	500	5-30
Sparker	500	5
Boomer	100-200	0.5-2
Chirp	20-40	0.3-0.6
Pinger	5-30	0.1-0.2

Table 1: Typical penetration and vertical resolution values for some common sub-bottom profiler sources.

Vertical resolution can be defined by several criteria; the most common is that the resolution is equal to a quarter of the wavelength of the dominant acoustic frequency. Horizontal resolution is usually defined as being equivalent to the width of the first Fresnel zone, itself a function of signal frequency and sediment acoustic velocity (Figure 2, overleaf).

Digital data acquisition and processing

Digital data acquisition facilitates extraction of engineering parameters and post-survey processing of seismic data. Improvement of signal-to-noise ratios, removal of coherent noise and migration of data (Yilmaz, 2001) are common operations performed to improve section clarity. It should be stressed that the decision to post-process data should be made in light of the information required. Surveys with relatively simple aims (*e.g.* depth to bedrock), if properly performed, will require only hard copy output of raw data, whilst engineering or high-resolution stratigraphic investigations may require application of more complex data processing techniques. An example is shown in Figure 3.

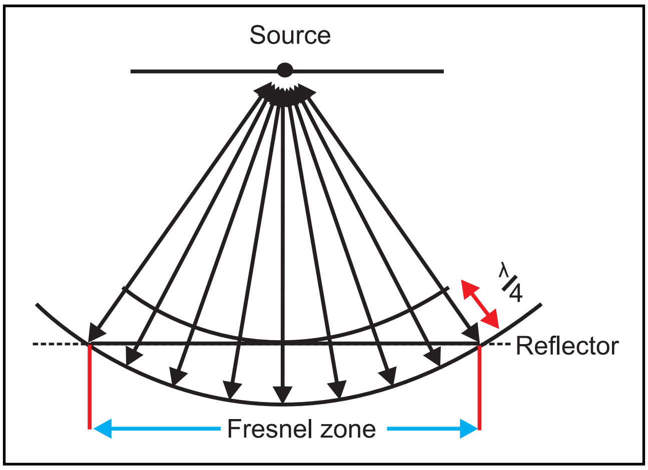

Figure 2: Vertical and horizontal resolution: the first Fresnel zone, after Reynolds (2011).

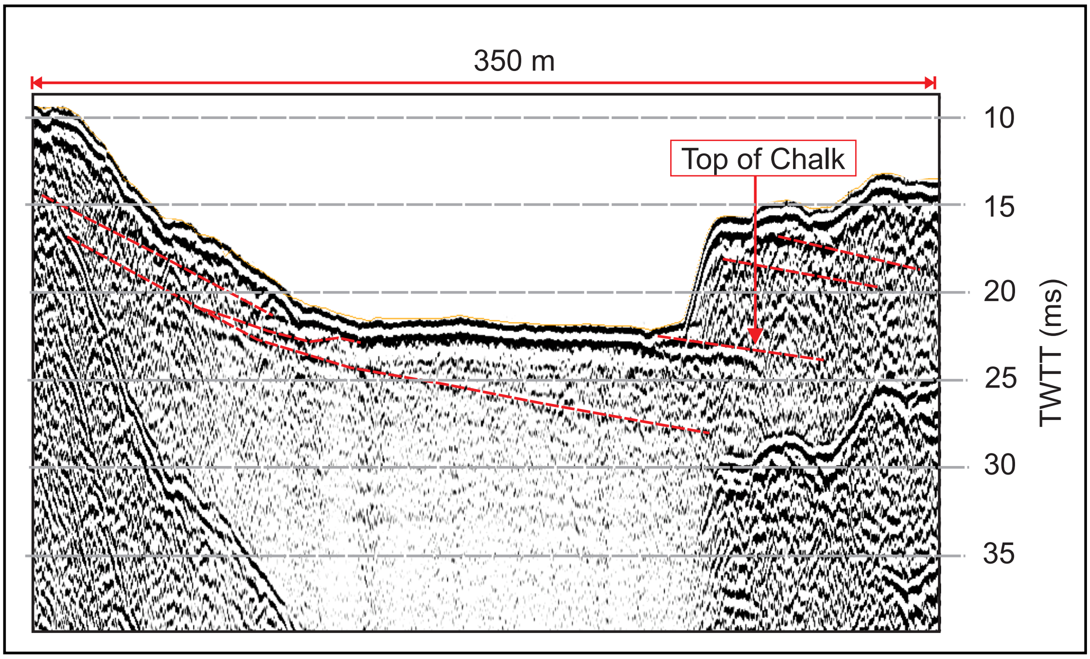

Figure 3: Example boomer data from Woolwich Reach, London, showing structure in the Chalk (Lenham *et al*., 2005).

References and recommended reading

Lenham, J.W., McDonald, R., Miller, S. and Reynolds, J.M. 2005. Seismic Investigation of Triassic sandstone bedrock depth, New Mersey Crossing. *Quarterly Journal of Engineering Geology and Hydrogeology,* **38**:7-22.

Lenham, J.W., Meyer, V.M., Edmonds, H., Harris, D., Mortimore, R., Reynolds, J.M. and Black, M. 2006. What lies beneath: surveying the Thames at Woolwich. *Proceedings of ICE, Civil Engineering*, **159**(1): 32-41. Paper 14177. *[Awarded the ICE Manby Prize 2007].*

Reynolds, J.M. 2011. *An introduction to applied and environmental geophysics*. John Wiley & Sons Ltd, Chichester & London, 2nd ed., 712 pp.

Yilmaz, O. 2001. *Seismic Data Analysis: Processing, inversion and Interpretation of Seismic Data*, Society for Exploration Geophysicists, 2,027 pp.

