Frequently asked questions

Guust Nolet (Geoazur) answers some of the questions that are regularly posed to him about the potential of using Mermaids in seismic tomography.

How does a Mermaid get its location?

Mermaid takes its position from GPS, within a few minutes after surfacing. For the seismograms that did not trigger an immediate surfacing but were stored in the buffer, an interpolation between the GPS positions is required. Joubert et al. (*Seism. Res. Lett.*, 2016) estimate the standard error in such interpolation to be 500 m. For a P wave with phase velocity of 10 km/s that is equivalent to a timing error of 0.05s.

But isn't there is also an unknown drift while coming up to the surface?

Repeated GPS fixes while transmitting data measure the drift at the surface, which allows us to extrapolate back in time to the point where the Mermaid entered the layer dominated by surface drift. This correction is very precise. Below that we assume abyssal drift as measured by differencing with the previous surfacing, and use this to extrapolate to the position when recording at cruising depth. This correction is less certain but small. We are confident that most locations are accurate to 200m or much better.

Are the Mermaids noisier than island stations?

Though they may be noisier than the best island stations, they compare well with most of them. In the examples on the last page, PAYG is an island station in a borehole 8km from the shoreline.

Can you observe S waves?

This requires conversion at the seabottom to P, which is very weak for teleseismic events. We have therefore not (yet) made a serious effort to detect S waves.

What is the smallest magnitude you can observe?

Much depends on the noise conditions (and thus the weather). The algorithm often recognizes an earthquake signal, but sometimes there is not sufficient high frequency energy that allows one to distinguish the P wave *onset* in the noise. Shallow earthquakes at teleseismic distance pose problems, but can often be picked even below magnitude 6 at regional distance ($\Delta < 40^o$). Events at intermediate depth or deeper can usually be picked at teleseismic distances if the magnitude exceeds 6.5. In the Indian ocean, a Mermaid crossing the triple junction has recorded very near quakes of magnitude below 3 during a swarm (Sukhovich et al., *Nature Comm.,* 2015).

Can one do cross-correlations?

The waveform is often dominated by the microseismic noise, except for the very strongest earthquakes. Picking onsets is therefore our preferred method of analysis. Also, onsets satisfy ray theory and therefore offer maximum resolution for small size anomalies.

What is the danger of a mispick?

We try to minimize this danger by correlating onsets by eye for nearby Mermaids, and with island stations if any. A powerful diagnostic is the surface reflection or ghost. Since seismic signals travel almost vertically in the water column, the ghost arrives after exactly 2s if the Mermaid floats at 1500 m depth. It has a reversed polarity and is often visible. We have also found that time-domain filtering of the microseismic noise may significantly enhance the signal-to-noise ratio of the onset. The main factor that determines how well an onset can be picked is the high-frequency content of the P wave. Paradoxically, this may allow for weaker magnitudes to be easier to pick than larger ones with complicated P waves.

Why not use OBSs?

You should certainly use OBS if you have the means to launch and retrieve them. They have the added advantage that you get S waves and surface waves (we still plan experiments without the usual high-pass at 0.1 Hz on the hydrophone to see if Mermaids can record Rayleigh waves). However, filling in a large area with OBS's is costly in terms of material and shiptime. Mermaids provide an affordable alternative to cover large areas at low cost (about $6K/year if the Mermaid is abandoned at the end of its life, much less if retrieved). The most effective strategy is to use both instruments if you can, and let Mermaids fill in the space in between an array of OBSs.
Much of the data management for Mermaids is automatic and in quasi-real time, which is another plus for Mermaids compared to OBSs.

How fast move the Mermaids?

Typically from a few to ten km/day, but velocities higher than 20 km/day have been observed occasionally. And sometimes a Mermaid hardly moves for two or three weeks if caught in an eddy current.

How does one do clock corrections?

At every surfacing, clock drift is measured from GPS and corrected for in the data.

Can Mermaids be retrieved at the end of their lifetime?

Since they are equipped with two-way communication, one can command a Mermaid to come permanently to the surface and transmit its position regularly.
Mermaids do not require a research vessel, but can be launched and retrieved from any small or large boat.

How costly is satellite communication?

This depends on (a) your appetite for data, (b) the regional seismicity and (c) the local provider of Iridium satellite communication in *Rudics* mode (meaning you get data volumes per email). We have set the trigger algorithm such as to come to the surface rather often, and we paid of the order of $100/month per Mermaid in communication costs. With every surfacing, you can tell the Mermaid to change the parameters of the trigger algorithm to adapt to local noise conditions and limit the number of false triggers.

Can one locate earthquakes with Mermaids?

Not with a high precision, because of the error in the Mermaid location. At least not until we have implemented Mermaid-to-Mermaid pinging for small arrays of them, which we may test in some future version.

Can Mermaids detect tsunamis?

Again, no. They will drift up and down with the water in the wavefield, and any signal will be too low a frequency to be detectable.

How sensitive are Mermaids to biofouling?

So far we have only retrieved remarkably `clean' Mermaids. The second generation has a large pump capacity such that it may correct itself if there is an unexpected change of mass. The glass sphere that holds the second generation Mermaid (instead of an aluminum cylinder) is extensively used in OBSs and well tested against leakage.