DEEPER INTO DEPTH

FEATURE **PATRICK VAN HOESERLANDE**

At the end of my dive during which I have admired the attractive depths of the Spanish coast, I start rising to the surface. A glimpse at my dive computer tells me that I must perform a decompression stop of 6 minutes at 5 meters. My mind wonders off searching for an answer to the question: what does 5 metres mean?

As outlined in my previous article, 'It's about Time!' I suggest analysing this broad question with a two step approach by splitting it up into 2 distinct and smaller problems: the first one is, 'the unit of length' and the second is the 'reference'.

The depth of surface water is often referred to by the term water depth. Previously this was measured in fathoms. A fathom was the span of the arms of a small, adult man. This unit for depth could easily be measured by sailors using stretched arms while hauling in a line. Nowadays depth is, for reasons of standardisation, expressed in multiples of metres and for the deep sea, in multiples of kilometres.

THE METRE

The metre (symbol 'm') is one of the 7 fundamental units within the International System of Units ('Système International' or SI). As a unit for length, it is the basis of the metric system. The definition of a 'metre' has changed a number of times in the course of history – each time to become more accurate and to be more stably determined – because the development of science made more precise measuring possible. The first definition of the metre appeared in 1675 in the book of the Italian Tito Livio Burattini. He defined the metre as the distance of a pendulum that moves with a half period of 1 second. Although this was for the 17th Century an admirable performance in precision, the so defined metre was not truly universal. Firstly, the precision depended on that of another unit, the second. Secondly, the period of a pendulum depends on the local gravitational acceleration and thus on the position on earth and of the height above sea level.

Searching for a universal metre, the French Academy of Sciences defined in 1791 the metre as the distance at sea level from the arctic to the equator, measured along the meridian of Paris (and thus not the prime meridian through Greenwich!) divided by ten million.

Only until 1799, after scientists had measured the correct distance from pole to equator, that this new standard was determined. This metre, called the 'mètre des Archives', was then fixed through a bar of platinum. Later it was proved that the platinum metre was 0.2mm too short due to a miscalculation in the flattening of earth. However, the standard itself was not changed. It was even kept when in 1889, during the first 'Conférence Générale des Poids et Mesures', the metre was redefined more precisely as the distance between two notches on a bar made of 90% platinum and 10% iridium measured at the melting point of ice, the so-called X-metre.

Because a physical metre as the basis to calibrate precision equipment all over the world was extremely difficult to use, scientists were for decades searching for another, more appropriate definition. Thanks to the more accurate measurement of time by using atomic clocks, the current definition of the metre was fixed in 1983. The speed of light in a vacuum is now, by definition, exactly 299,792,458m/s. In turn this defines that the metre is the distance travelled by light in a vacuum in one 299,792,458th of a second. So, we are back to a definition by which time defines distance, but now the metre can be accurately determined in any laboratory around the world.

MOUNT EVEREST

Now that we have well defined the unit of length, we must still determine what 'depth' really is. This may seem simple, but like almost everything in life, this is not the case. For example there is the ongoing discussion on which mountain is the highest in the world. Is it the Mount Everest or the K2? Why is it so difficult to agree on the height of a mountain? You only need to measure the distance between the base and the top of the mountain right? Correct, however now comes the problem of, 'where exactly is the base of a mountain?' To answer that last question, you need to measure the height from the point on the earth's surface directly under the top of the mountain. Because we are not able to dig through the stone towards the base – even that would, however not prove the solution – we must come up with a mathematical model of the earth. This model is called a geoid. This name comes from geodesy, also called geodetics, the scientific discipline that deals with the measurement and representation of the earth, including its gravitational field, in a three-dimensional time-varying space.

The most simple form of a geoid is a sphere. But, as we know this is not correct because the earth is, due to the centrifugal forces, flattened at the poles. An important characteristic of the geoid is that the gravitational force is perpendicular to its surface. Now, gravitational vectors don't always point towards the centre of the earth, because they are also influenced by large masses, such as mountains. And so, the foot of the mountain is influenced by the mountain itself. The discussions are in fact not about the 'height' of the summit, but on the impact of the mountain on the exact position of the base.

DEPTH

But what about depth? There are no mountains in the sea (however, the deep sea explorers have found mountains and valleys), so there are no influences of large earthly masses. And the 'top' is the surface of the water. Nicely flat and visible. But, there are the waves. Must we simply wait for a calm day without wind? But what about the tidal movements? Easy? The determination of the reference plane depends on the 'why' you need the reference. For sea navigation you want to create a map that prevents vessels to run aground. You will therefore ensure that risks which lead to the overestimation of the actual depth are as low as possible. In other words, you want a reference plane that is as low as possible.

In the lower European countries, the water level for fresh waterways is given in relation to e.g. the 'Normaal Amsterdams Peil' (NAP). On nautical charts the depth from surface to bottom is given in reference to the NAP and thus the correct water depth can be calculated at any time. For convenience, the NAP is often equated to the average sea level. However, the NAP is nearer to the average high tide level of the river IJ, before the closure (the IJ was formerly an arm of the sea). In the beginning the NAP corresponded with the geoid, but nowadays this is no longer the case. The ETRS89 (European Terrestrial Reference System 1989) is now the official three-dimensional coordinate system.

Photo by Roland Wantens

British nautical charts sometimes use the Lowest Astronomical Tide (LAT) or the lowest tide level predicted under average meteorological conditions and under any combination of astronomical conditions. This very safe reference plane for nautical navigation is a rather pessimistic indication of the depth at sea. Therefore, we as divers, need another reference.

The sea level is the average height of the sea levels during a predefined, long period, after averaging out all the variations due to the tides. Therefore, determining our reference plane for the sea level (MSL or 'Mean Sea Level') will not be without difficulties. A sea level is the result from the volume of liquid water on earth and from the average temperature of that water as it affects the average density.

Changes in the absolute sea level (the so-called eustatic changes) occurred in the course of the geological timescale and even during our written history.

The changes in the absolute sea level are determined by the size of the polar icecaps and the temperature of the sea water. Both depend on the average climate on earth. When a climate change in the form of a temperature rise occurs, the icecaps may melt or the sea water gets warmer. In both cases,


Photo by M. Minderhoud

the absolute sea level rises. In the contrary case, a temperature drop may result in a lower sea level.

The relative sea level not only depends on the eustatic changes but also on the movement of the earth's crust and the supply of sediment to the seabed. If there is much sediment that remains on the bottom, the seabed rises and the relative sea level falls. If the earth's crust moves downwards, the relative sea level will increase. The sea level can therefore change locally while the absolute sea level remains the same.

Recently, the rising of the sea level has become a very hot topic because of the greenhouse effect and the much discussed climate change. Measurements of the absolute sea level over the last 130 years show a gradual increase of approximately 20cm in total. Scientists predict that the sea level will have risen to 1m by the year 2100 and will continue to rise at the same pace afterwards. This means that certain parts of the world will be flooded. Many human activities take place near the coast on pieces of land that are at or even below sea level. Low-laying archipelagos like Tuvalu may in the near future disappear below the sea.

But, let's return to the mean sea level. This is the measured level of a calm sea, i.e. one of which all movements, such as wind and tide are filtered out. This is done by taking the average of the results of hourly measurements over a period of 19 years. The measurement of the sea level is done in relation to a landmark. Therefore a change in MSL can be the result of a real change in sea level or a change in the height of the landmark.

That the sea level is not a constant given, is clear from the factors that have an impact on it. Think on things like heavy rainfall and the resulting feed of water by large rivers, differences in density by changes in water temperatures, 'el Niño', the wobble effect and the variation in the rotational speed of the earth, landslides, tsunamis, etc. The difference between MSL and the geoid is around 2m.

Now that we understand and know how to solve the problems of the reference plane, we can start determining depth. The water depth is partly calculated based on measurement data through the use of sonars, dipsticks and (recently) satellites. The depth depends on the composition of the bottom which muddles the distinction between water and soil. Differences in composition and the interpretation of it results in some incoherencies between the data coming from different sources. In a soft soiled bottom this becomes even more difficult because currents may really stir things up. Fortunately, there are guidelines. At a certain density of the water it counts as the soil, so normally there should be a clear boundary between the two.

We have defined the reference plane and we know where the bottom starts. With the definition of the metre at hand, we can now perfectly and accurately determine the depth. But what is our dive depth?

DIVE DEPTH

In fact, as divers we are only interested in the local, actual depth at our dive spot. As long as we can approach this properly, we are satisfied. During the dive we wear our depth gauge or dive computer telling us how deep we are. Although expressed in metres, we actually read the pressure surrounding our wrist. This pressure is the result of the weight of the water column above our head. And this pressure depends on the average heights of the waves, the temperature of the layers of water above us, the salinity (the concentration of salt) and the water. Therefore, my depth is not yours (and that is hard to verify).

The next time you hear the question, "how deep are we?", you now understand that the answer is more complex than you originally thought before the start of this article. But such a complicated answer to your buddy's question is most certainly not what he/she expects.


Photo by Torsade de Pointes


Photo by LimoWreck

YOUTH DIVING – LIFE IN SALT WATER

FEATURE **KIKI VLEESCHOUWERS** AND **PATRICK VAN HOESERLANDE**


Bobtail or Sepiola. Photo by Sven Van Langenhove.


Seaweed Pipefish. Photo by Gery Beeckmans.

In the last June issue of 'Divers for the Environment', Scrimpy, our nice little shrimp from our book 'Youth Diving for Youth Divers', took you on a tour to his fresh water friends. In this article, Scrimpy will guide you in the salty water of the 'Oosterschelde'. That is a branch from a big river in the Netherlands that gives out to the sea. Exciting!

Because it is in contact with the sea, the waters over there are not as quiet as one would expect in a slow flowing river. There are waves and strong currents. Nonetheless, many animals feel at home in that salty, sometimes violent world. So, eyes wide open and let's go diving!

Scrimpy now wants you to meet his salt water friends and match them up with their descriptions.

JANOLUS

What is this? Do you see that slow moving creature on top of a small beige coloured 'bush' over there? The 'bush' is a colony of moss animals, the popular food of this beautiful creature. Only a half-finger long, with transparent papillae (a difficult word for the organ that filters air out of the water, a bit like the gills of a fish) that end in blue coloured dots. This is the Janolus!

SOMETHING SPECIAL

This is a Nudibranch or naked slug, not because it has no clothes on, but because it is a slug that does not drag its house around.

Slugs lay eggs and not just in any way. The eggs are placed in a special design. Each type of nudibranch lays its eggs in a different way. That design tells you which species laid those eggs.

FACT

Salty waters house many different types of Nudibranchs, more than 50 different types. And they all have a special form or nice bright colours. This is a big difference with slugs you find in the garden; those are just brown or grey coloured and don't look special at all. And these slugs do not nibble on the vegetables in the garden either.

BOBTAIL OR SEPIOLA

What is this? There is a small creature in the sand the size of a Lego block. It moves with small arms and it constantly changes its colour. This is the Sepiola or Bobtail squid.

SOMETHING SPECIAL

This cute squid is small and it is afraid to be eaten, so he defends himself very courageously. If the situation is really dangerous, it sprays a small cloud of ink! Or he quickly hides in the sand.

FACT

There are more squid like animals in our salty waters which are quite nice and much bigger such as the Sepia, or the Cuttlefish. You know its skeleton. It is the flat, oval, white thing we sometimes give to singing birds to nibble on. You can also meet a real Squid, but these are very fast. He usually shoots away before you can even see him, just like an arrow and disappears into the dark.

MOON JELLY, COMMON JELLYFISH, OR SAUCER JELLY

What is this? There hovers a transparent hemisphere with some strings underneath. In the hemisphere you see 4 circles and the jelly like thing closes and opens again. This is how a Moon Jelly swims.

SOMETHING SPECIAL

Have a close look at the 4 circles in the hemisphere. Sometimes these circles are coloured violet, that is a female jellyfish. And if the circles are white, you have just found a male one.

FACT

You may observe the jellyfish very closely. This jellyfish will not sting you. That is, its stings are not toxic to humans and you feel nothing. Beware, this is not the case for all jellyfish. Some may sting you very badly!

NOW THE DIFFICULT SEARCH IN THE SEA

After the previous article, you have already proven that you know how to find the difficult species in fresh water. Are you as good in the sea? Sure and with Scrimpy as your experienced guide, you'll be surprised who and what you can meet in salty water. There are large animals, but also small and very tiny ones. Eyes wide open, torch in hand, camera ready and brains on maximum alert! Here you go!

SEA GOOSEBERRY

What is this? An oval sphere, approximately the size of a grape, floating past your mask. There are 2 long strings, tentacles, attached to it. Turn the light of your torch towards it! You see a lot of beautiful colours. You are dealing with the sea gooseberry.

SOMETHING SPECIAL

A Sea Gooseberry is a Comb Jelly. No, this is not a 'real' jellyfish because Comb Jellies do not have stinging tentacles. Not so long ago biologists thought this was a kind of jellyfish (hence its name), but now we know better. So no pain when a Gooseberry slides along your cheeks with its tentacles. These tentacles have