Port Phillip Heads Tidal Streams - way past time for a better story !

Safe boating at and near "the Heads" requires a good understanding of the tides and the strong tidal currents in this area. Sadly several factors seem to be working against this ideal. Firstly the common use of the same word "tide" for both the vertical and the horizontal components of tidal movements just seems to create confusion.

The vertical and horizontal water movements are distinctly different things, behave differently, have different causes, and so deserve separate and distinct names. Professional mariners use the two separate terms "tide" and "stream" to clearly distinguish between them. So "tides" only rise or fall, and "streams" only flood or ebb (ie. flow inwards or outwards respectively). Sometimes "stream" is replaced with either of the longer forms "tidal stream" or "tidal current". Care with the language is needed in this potentially dangerous region.

Secondly more confusion is caused by a failure to grasp the very different propagation behaviour of "tide events" and "stream events". The High or Low tide moment advances from the Heads to the northern edge of "The Great Sands" at roughly 6 kph, taking around three hours to reach there. In contrast, the exact Slack Water moment advances across that same distance at 100 kph or more. Slack water is therefore experienced all across the southern parts of the Bay with at most only around a dozen minutes of delay.

Not knowing this big difference in the rate of advance has led to some very dangerous "tidal myths". (Eg. Some folks try to add a "tide delay time" to a "Heads slack water time", yielding false and very dangerous slack water time predictions for many locations inside the Heads.)

The different rates of advance also create a progressive shift in the timing relationship between "tide events" and "stream events" over that distance. At the Heads, both flood and ebb streams cease flowing when it is around mid-tide there. A dozen minutes later when slack water occurs at either the Hovell or West Channel Piles, the tides there are near high tide (for slack after flood), or low tide (for slack after ebb).

Although newspapers and other sources often list a fixed time delay between high tide at the Heads and high tide at other locations in the southern part of the Bay, these delay times are really only long term averages. They aren't very accurate for day to day use because the time delay varies significantly for different tide cycles within the monthly lunar cycle.

In reality, at any location in the southern part of the Bay, the tide will rise if the INFLOW rate from the Heads exceeds the water's ONFLOW rate towards Melbourne on the other side of that location. This imbalance gives a net gain of water accumulating around that location and so a rising tide height. Once the INFLOW rate decreases to exactly match the ONFLOW rate, there is no net change in the amount of water around that location, so it has reached its High Tide moment. Shortly thereafter the INFLOW rate decreases below the ONFLOW rate, giving an ongoing net loss of water around that location and hence a falling tide height.

It is important to note that anywhere in this region the change over from a rising tide to a falling tide, or vice versa, does NOT signal any change in the direction of the tidal stream flowing past that location. Only for locations beyond The Great Sands and in the "main body" of the Bay does the change over from a rising tide to a falling tide (or vice versa) closely match a reversal in the tidal stream's direction of flow.

Once beyond The Great Sands and into the deeper main body of the Bay, the strength of the stream drops to values below 0.3 knots. Note however this is not the tidal stream "running out of puff". Instead a big increase in the underwater cross-section of the Bay at this point allows the tidal flow to run much more slowly while still moving almost the same volume of water each minute as is flowing through the Heads.

Once in the Bay's "main body" region, the rate of advance of the High/Low tide moment dramatically increases, needing only an extra 5 to 25 minutes to reach all the away up to Melbourne.

***** The Simple Story *****

The widely promoted and believed "official story" of Port Phillip's tides and streams is a simplified account of water flow in and out of the Bay. Unfortunately it has one particular danger for those who take it as completely factual. The three major points of that much told story are:-

1) Slack Water occurs around 3 hours before high tide at the Point Lonsdale headland, and then again around 3 hours after high tide at the entrance. The water floods inward during that interval and ebbs outward at other times.

2) When it is Slack Water at the Heads after a flooding stream, it will be close to high tide at Williamstown. Slack water after an ebbing stream means it will be close to low tide at Williamstown.

3) Slack Water occurs when the "outside" water level (in nearby Bass Strait) and the "inside" (or main body) level are the same.

While there is ample evidence that Point **1)** and Point **2)** are very close to the truth, **NO** evidence exists that Point **3)** is true. However many folk accept it as true because *"it sounds like it should be true"*. Unfortunately flawed human intuition has failed us in this case.

While that claim might be close to true for small bays and estuaries, it completely ignores both the mass and momentum of the moving water within a tidal stream. Upsizing to larger bays, the mass of water in motion tends to increase more quickly than the friction levels that oppose that motion. This means that in the larger settings the forward momentum of a tidal stream allows it to overrun the "same levels" time by quite some margin so that Point **3)** becomes significantly untrue for very large waterways such as Port Phillip.

Note that the Point **1)** timing implies that at slack water the "outside" level is at mid-tide, or around **M**ean **S**ea **L**evel (say MSL + 0.0m).

The Point **2)** timing implies that the Williamstown water level at slack time is either typically (MSL + 0.3m) for its high tide, or (MSL - 0.3m) for its low tide. We also know that the heights and timings of the tides in all Bay areas north of The Great Sands are quite similar.

Taken together, these points mean that at slack water a level difference of typically around 0.3m exists between the Heads and the northern edge of "The Great Sands". This directly contradicts Point **3)** so that part of the "simply story" is incorrect and needs to be discarded.

***** The Better Story *****

Port Phillip distinguishes itself from most other bays and harbours by the enormous mass of water involved in its fast tidal streams. Flows through the Heads may be up to 80,000 tonnes every SECOND, and with speeds up to 10 kph. Naturally these high mass tidal streams, typically involving a billion tonnes of moving water, develop high levels of forward momentum. Somehow this has to be fully dissipated before the flow stops moving forward to produce what we know as slack water.

It is their high momentum character that allows them to continue forward even when the driving force becomes zero as the "outside" and "inside" water levels become equal. Typically at this time the tidal streams at the Heads are still moving forward at between 1 and 2 knots.

The residual momentum still in the stream at this time allows the flow to continue forward for between another 40 to 90 minutes until the residual momentum is completely dissipated to give us slack water. During this extra flow period, the stream is effectively "flowing uphill", meaning that both a "reverse level difference" and a "reverse slope force" are growing.

The increasing "reverse slope force" assists the frictional drag in slowing the stream down. By the time slack water is achieved at the end of a strong tidal stream, the "reverse level difference" between the "outside" and "inside" levels may have grown to 0.3m to 0.4m. This is a sizeable fraction of the 1.0m to 1.2m forward level difference that three hours earlier drove the entrance currents at up to 6 knots.

***** So why is this more truthful account a "better story"? *****

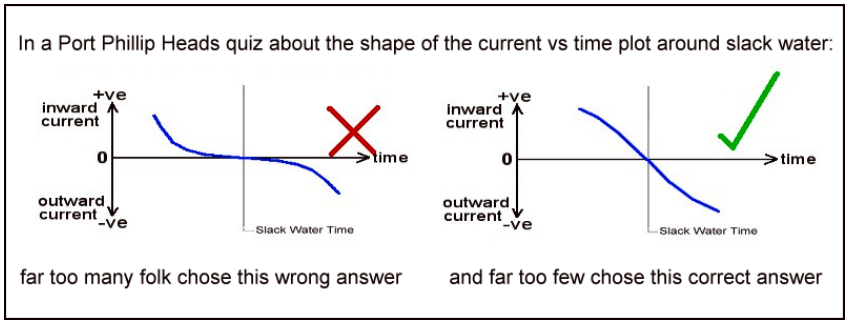
Well firstly note that this better story is not in any way claiming the slack water time predictions are wrong. The algorithm used for them already incorporates the momentum effects. Our better story is just saying that the "same levels", or "zero level difference" time, comes well BEFORE slack water, by between 40 and 90 minutes. The exact duration of the uphill flow depends on the particular sequence of tidal cycles.

What is really being contested here is that the "simple story" implies that no forces are acting on the water at slack water time because it claims the "outside" level now equals the "inside" level. This false claim has the unfortunate consequence that many recreational boaters then assume that if zero or only slight forces are in play, then the water mass can't be changing its speed very rapidly around slack water time.

The truth is that with a sizeable reverse force in play at slack water time, and with almost no frictional drag present, the tidal stream is then changing its speed at a higher rate than at any other point in the entire tidal cycle. So the danger of the "simple story" is that many boaters will have the wrong current versus time profile in their minds when targeting slack water at Port Phillip Heads.

If a skipper does not have a proper appreciation of how the tidal current at the entrance will change over time near slack water, they may be putting themselves, their crew, and perhaps even the vessel itself at increased risk.

A few years ago a survey of typical boaters in this area was conducted using a simple "quiz" question to learn how they thought the current speed changed over time around the slack water period. That quiz found that around 85% of respondents failed to pick the correct shape of the current versus time profile around slack water time:-



Furthermore, nearly all the wrong answers were in line with what you might assume from the false claim **3)** in the "simple story". So that very widely accepted story has a sting in the tail in that it reduces boating safety and the proper understanding of Port Phillip's tides and streams.

The fact that the current speed in the green tick sketch decreases roughly at a constant rate near slack water is an interesting quirk of having a combination of two stopping forces. One of these is the decreasing frictional drag. The other is the increasing reverse slope force. They add together to give a roughly constant force which produces an almost uniform rate of speed loss in the old tidal stream, and a roughly uniform rate of speed gain in the new reverse tidal stream.

However, note that depending on the exact sequence and strength of the tidal cycles, the reversing rate can be quite different for each slack water event. The "stream reversing rates" seen at Port Phillip Heads range from as low as a 0.15 knot change in speed every 10 minutes, to as high as a 0.6 knot change every 10 minutes. Maybe in the future, predictions of a stream's reversal rate could be published alongside the prediction of its slack water time. This better knowledge might improve boating safety in the potentially dangerous Port Phillip Heads area.

***** Better Story Too Complicated? *****

Perhaps, but you don't need to grasp all the details. All that is important to improve your safety is to remember that approaching slack water, the current speed behaves as in the green tick sketch, and NOT like the red cross sketch that most boaters will assume is the correct one due to taking the common "simple story" at face value.

The web resources below may be helpful in fleshing out and accepting the "better story" outlined here. They include images, animations, graphs etc, plus further links. You needn't read all the detailed text, the images alone might be sufficient. The full story is covered in quite some detail, with confirmation coming from CSIRO researchers.

https://jake-h5.neocities.org/PPH-Slack-Water.html <--- the full story of the poor quiz results
and
https://jake-h5.neocities.org/H2oSlopes.html <--- on the downhill and uphill sea surface slopes that drive the tidal currents
and
https://oceancurrent.aodn.org.au/tides/PPB_hv/2025/202502061130.html <--- results from CSIRO tides & currents modelling work.
This file shows a colour coded map of sea levels at slack water after a flood stream. Toggle the [SPD/SL] control to see the corresponding current speed map. Use [Next] to step forward in time to see how the new stream accelerates to its maximum speed and then decelerates to produce the next slack water roughly six hours later.

Note the reverse level difference at slack water. Also examine the graph plots where the pink and blue plots cross over at the "same levels" time. The black plot of the entrance current will clearly show that it has not yet reached zero by the "same levels" time.