Currents of the Strait of Istanbul

Istanbul Strait, located between the Black Sea and the Marmara Sea, is a waterway 32 kilometers in length and with an average width of 1.5 kilometers.

The length of its coast measures 55 km on the European side and 35 km on the Asian side. From this we can see that the European coast is comparatively more indented. The axis passing from the mid-points at both ends of the Strait forms an angle of 25 degrees from Geographical North. The air route over the strait is 025 degrees towards the Black Sea and 205 degrees towards the Marmara Sea. These routes are also the average of total passing routes of ships in the Strait. If we convert this to wind direction, it is the NE-SW axis-which are the prevailing winds in the Strait.

Passengers disembarking from a local ferry at Beşiktaş pier may have noticed that the gangway slants upwards on some days and downwards on some. This is due to the changes in the water level which can reach up to one meter. One needs to be careful while getting on to the ferry during such times as there is a risk that you might hit your head. We should understand from this that the currents on the Strait are stronger on that particular day. This occurs when strong northeasterly winds have lasted for at least 2-3 days. When this happens the surface waters of the Marmara are pushed southerly by the wind and the water level drops 20-30 cm lower than usual. Then, the level difference between the Black Sea and the Sea of Marmara comes close to a meter. The reason for this is not tidal as it is the case in Nordic countries. Here is it because of the change in wind direction in the NE-SW axis. We will later analyze the results of this close relationship between wind and current.

The narrowest part of the Strait is 698 meters in the region between Kandilli and Aşiyan Points. Depth of water decreases in the Strait from North to South. The deepest point is in front of Kandilli Point, which is 109 meters. This means that the narrowest area in the Strait is the deepest area at the same time and it would not be wrong to say that it is also the place where the currents are the strongest. The downstream current makes an arc in the Küçüksu bay and after licking the Kandilli Point, leans towards the Akinti Burnu. This is known as Devil's Current. At the Southern part of the Strait, water depth is below 100 metes until Sivriada Island but beyond this point, depth sharply rises to 1000 meters. This transition is comparatively smooth at the Black Sea end of the Strait.

If you ask mariners about the most unique feature of the Strait of Istanbul, most of them would reply "the currents". Since ancient times till today, currents have made the passage through the Strait of Istanbul a nightmare for mariners. Even today, it is frustrating for captains of modern ships which we assume could pass through easily. The Bosphorus currents have no mercy if you don't take it seriously.

From its formation dating back to the middle of the Neolithic period up to now, the currents of the Bosporus have been notorious. The Black Sea was called as Pontos Axeinos, which meant "the inhospitable sea" and the currents of the Bosporus were no exception to this definition.

What causes the currents in Bosporus? What types of currents are there? What is the relationship between these different types of currents? How do they work? It is not very easy to get information on these different questions. In my research on the Internet, I was not able to find a chart which fully shows the situation in the Strait of Istanbul. One reason for this is the daily variations of the Bosporus currents. Experienced Bosporus pilots know how these currents effects the ship at any given location. It has been this way for centuries. This is because since ancient times, pilots were always there to help sailors passing through the Bosporus.

Mariners used to seek the assistance of a local sailor (pilot) in order to battle the

currents of Bosporus. The other option was to wait for fair winds.
Efthimios Mitropoulos, Secretary-General of International Maritime Organization (IMO) declared the Bosporus as "Spiritual home of pilotage" in his speech delivered at General Meeting ıf International Maritime Pilots Association (IMPA), which was held in İstanbul in 2004.
Mitropoulos mentioned that the first pilotage service was rendered in the Strait of İstanbul in ancient times. He said that Jason, the legendary mythological hero, received the service of a local pilot while passing through the Bosporus Strait- coinciding with the citations in my previous articles. ¬
An example which confirmed this historical fact was the "Elderly Sailor" sculpture which had existed at Defterdar Point between Cemil Topuzlu Park and Bosphorus Bridge during 600 BC.
This "Elderly Sailor" was believed to be the "Pilot of the Strait" who helped Jason in finding his way to the Black Sea through the Bosporus, his name was Phineus. It was a ritual for the elders of the city and those trying to cross the Strait safely to offer a sacrifice to the "Elderly Sailor". Those who follow my articles might ask, "was it not Typhis, the pilot who helped Jason pass the Bosporus?" The answer to this question will be in my next article.
Sailors of ancient times used more rational methods than offering sacrifices to the Elderly Sailor sculpture. Sailors even claimed that they could fight the top current by lowering tethered weights to some 15-20 meters beneath their ships to take advantage the hidden river below running into friendly direction. This weight could be a tapered basket filled with little stones. In this way they tried to assist the progress of the ship using the power of the undercurrent.
Still, they were not able to overcome the "Maskara" current at the Hermaion Point (Akinti Burnu) where sailors went ashore and pulled the ship up by ropes.
Through these facts we understand that sailors of ancient times were aware of the undercurrent in the Bosporus. Fishermen were the first to understand this. When their nets were lowered deep into the sea, an S was formed by the effect of two different currents from the opposite directions- the surface current and deep current- this made them realize the existence of these currents. Petrus Gyllius, a Renaissance scholar who visited Istanbul during 1500s wrote that the current in the Bosporus were strong enough to turn water wheels and that there were mills established at 9 different places along the Bosporus. As was the case with water wheels, smart sailors always knew how to use the currents to their advantage. In the spring of the year 512 BC, Persian King Darius instructed Mandroklees, an architect from Samos Island, to build a bridge to help his army cross the Bosporus. Mandroklees connected boats to each other and left them adrift with the current while a rowing boat took them into desired direction from the Aşiyan point. The connected group reached the Kandilli point on the Asian shore with the help of the currents and in this way the first Bosporus bridge consisting of a group of ships was established. While the currents were a possible complication, thanks to the brilliance of architect Mandroklees who used this to his advantage (I always recommend mariners not to fight the powers of nature, but use them to your advantage to the maximum possible extent). These boats that were used in the formation of this bridge, used conical baskets filled with stones as sea anchors; left them adrift with the current and that helped to keep their bows upstream (These tapered baskets are called as "teyter" in the Black Sea region). This process prevented the boats from becoming abeam to the current's direction. I guess these baskets were lowered to a depth of 15-20 meters at which the undercurrent carried them to the opposite direction of the surface current. This helped to slow down the boats while kept them in parallel to the flow of current.

Wealth brought by the currents

Another benefit of currents for the Istanbul of ancient times or as she was known at that period, the Byzantine was economic. At that time, ships could navigate only

between May and September; their seaworthiness was not good enough to enable them to navigate during the remaining months. In the May-September period the SW winds that could enable them to sail towards the Black Sea were rare. Ships which wanted to pass would wait at the ports of Byzantine for the optimal weather conditions. During this time they paid port fees and contributed to the economy of the city. In fact, ancient sources have underlined that Byzantine was a typical port city. For instance, the historian Theopompos who lived in 4th century BC noted that Byzantine was a convenient location for business and most citizens spent their time at the agora and ashore, where they lived a hedonistic life enriched with women and drink. (Mehmet Fatih Yavuz- A Walk Through Bosphorus)

The causes of currents

As we have mentioned above, if we leave the counter currents and eddies aside, the system has two main currents in the Strait of Istanbul. The surface current which extends up to 15 meters, a buffer area of a few meters, and then the underwater current (mostly) in the opposite direction. There are two main mechanisms that control the two main currents. The water level differences between the two seas activate the surface current while salinity difference between these seas causes the deep current. Rivers carrying freshwater feed the Black Sea. The largest of these are the Danube, Dnieper and Don rivers, which, if there were no evaporation and no transfer through the Straits, would raise the level of the Black Sea by 30 centimeters each year. Evaporation is another important factor that takes out water from the Black Sea. About 354 cubic kilometers of water is estimated to evaporate from the surface of Black Sea every year. The water inflow to Black Sea through the rivers and rainfall is around 500 cubic kilometers.

Due to the continuous water inflow from the rivers whose names were mentioned above, water level of the Black Sea is 40 centimeters higher than that of the Marmara Sea. This level difference is the main caused of surface currents. Another difference between Black Sea and the Marmara Sea is salinity. Black Sea due to the effect of fresh water carried by rivers is less salty (1.8%), compared to the more saline waters of the Aegean and Marmara (3.6%). As salty water is heavier than fresh water, water becomes more salty as the depth increases throughout the Strait. This assumption also allows us to better understand the currents regime. As mentioned, the Black Sea is 40 centimeters higher than Marmara and 60 centimeters higher than the Aegean. Therefore, the waters of the Black Sea, flows through the Bosporus to the Sea of Marmara and then to the Aegean.

This stream is the “surface currents”. In the bottom, in the opposite direction of surface currents, a deep current occurs due to the difference of salinity between the two seas. Surface currents both in terms of volume, as well as the speed are more than that of the deep currents. The speed of surface currents may reach up to 6-7 knots while the speed of the deep current was measured at a maximum of 3 knots (1 knot corresponds to 1 nautical mile per hour). In terms of volume, the amount of water carried by surface currents is 1.5 times more than the deep current. If we refer to it in terms of cubic kilometers; surface currents carry 409 cubic kilometers of water per year from the Black Sea to Marmara; and the amount of water carried to the Black Sea with the deep current is about 290 cubic kilometers. Therefore, there is a net water transfer of about 120 cubic kilometers from Black Sea to the Marmara side per year. Given that the Black Sea has a total of 547 thousand cubic kilometers of water; this is an insignificant amount.

The effective depth of surface currents and starting depth of deep currents are most frequently asked questions. In fact, these values vary along the Strait. There is also a buffer zone between the surface currents and deep currents. Thickness of this buffer zone also varies along the Strait. It can be said that this thickness is around two meters, however, this increases towards the Southern end of the Strait.

How does salinity change?

In the mouth of the Black Sea, surface salinity measured is at 1.8%, this rate increases to 2.5% in the Marmara side. The bottom salinity is 3.8% on the Marmara side which drops to 3.3% on the Black Sea entrance. Due to the stratification created by the salty waters reaching the Black Sea by deep currents, there is no fauna below 200 meters due to anoxia. This is because a dense layer blocks the vertical movement of water and thus oxygen at surface cannot go deeper. Therefore it was not surprising when towards the end of the 1990s, the American researcher Robert Ballard, found a shipwreck which more than one thousand five hundred years old in anoxic waters of the Black Sea at a depth of 325 meters which was intact. The same researcher found another wreck, that of a cargo ship, off the Bulgarian coast from 4th-century BC cargo which also was in good condition. It was proved that water had flood the Black Sea Coast 7500 years ago, when the same scientist found remains of human life at a depth of 95 meters.

Scientists today have no consensus about the formation of the Black Sea and the Straits, although, according to a generally accepted thesis; fifteen thousand years ago, the Black Sea was a freshwater lake and the water level was 140 meters below the present level. Fourteen thousand years ago, the Black Sea's water level rose to 15 meters below the current level; at this time the water level was 60 meters below the current level of the Marmara Sea.

During this period; The waters of the Black Sea rapidly ran through the Bosporus and filled the Sea of Marmara. About 9 000 years ago the Black Sea dropped to -120 m from the current level and the Marmara Sea level rise from -60 m to -30 m from the present level. Threshold of a dam north of the Bosphorus was effective for maintaining the Black Sea in isolation. About 7500-8000 years ago, the Marmara Sea level rose from -15 m and the Black Sea dropped to -156 m from the current zero. Threshold at the northern Bosphorus collapsed forming a huge waterfall that runs at a rate of 50 to 100 km3/day. The Bosporus was again used as a passageway after 2000 years, but this time, on the opposite direction. Waters flowed so fast that the water level at the Black Sea increased by 150 meters in one year. Within this period it was estimated that from 50 to 100 cubic kilometer of water flowed into the Black Sea per day.

Some scientists associate this event with the Gilgamesh legend and what is known on the Bible as the "Big Flood".

The other dynamics of the Bosporus Currents

We mentioned the major causes of the Bosporus currents: the difference in water levels and the difference in salinity between the two seas. But besides that, there are other important factors affecting the dynamics of the currents. One is the seasonal changes in the water volume of the Black Sea rivers and the other is the winds. The volume of water from the rivers flowing into the Black Sea increases or decreases depending on the season, and the water level of the Black Sea increases or decreases accordingly. Winds can also effect level changes in short term and thus also affect the currents. In fact, if the strong SW winds last longer than 2-3 days, they may reverse the surface currents to the opposite direction. The main factor here is the ability of winds to push the waters at the sea surface and create movement in the same direction. For example, when SW winds are effective; the surface waters of the Black Sea are pushed towards the Ukrainian-Russian side and the surface waters of the Sea of Marmara are stacked to the south entrance of the Bosporus. The water level in the Black Sea side of the Strait decreases, while it increases in the Marmara side. In this way, the water level differences between the Black Sea and the Marmara, is reversed in favor of Marmara. In cases where strong south winds continue for 2-3 days, the level of the Black Sea becomes 60 centimeters higher than Marmara –at the entrance of the Strait. With the help of the wind, the currents start to flow in the opposite direction. This upstream current is locally called as "Orkoz". Orkoz is rarely experienced in summer months when the season is stable. It can be seen 3-4 times a

month between December to March, which is the stormiest period. The most perilous month is February. Like the southerly currents, Orkoz currents might also reach up to 6-7 knots in speed. According to Turkish Straits Maritime Traffic Regulations; when Orkoz currents rise above 4 knots in the Istanbul Strait, vessel traffic in the Strait is suspended. Orkoz currents may reach up to Yeniköy point and even up to the Northern part of the Strait. This will in turn create challenges for the vessels coming from the Black Sea when taking the 80 degrees turn at Yeniköy point.

An example to this was in 1999, when the M/T Spites, a supertanker laden with 100,000 tons of crude oil. While passing from the Black Sea to the Marmara Sea, strong SW winds and Orkoz currents; prevented her from turning to starboard at the beginning of 80-degrees turn at Yeniköy point, and as a result she drifted to the opposite coast and barely managed to stop by using both her anchors in front of Çubuklu area. This accident occurred right in front of the fuel tanks at Çubuklu area and we came close to a disaster. The SW winds locally named as Lodos. The origin of word "Lodos" is "Notos" in Greek. This means the South. From 16th century, it has been used in Ottoman naval terminology. The other wind which is closely associated with currents is from NE and named "Poyraz", which is also of Greek origin. This word originated from the Greek word "Boreas", the God who sits in a cave at northern Bosporus and cools the wind blowing down, according to Greek mythology. Poyraz is the prevailing wind at Istanbul and the Dardanelles Straits.

Effect of currents on a vessel's passage

The prevailing currents in the Bosporus flows from the Black Sea to Marmara Sea. Leaving Orkoz as an exception, there is a constant Southerly current in the Bosporus 365 days a year, which varies from 2 to 7 knots. So how does this affect passing ships? At first, it slows the speed of ships proceeding towards the Black Sea.

According to the Regulations, ships should be able to proceed with at least 4 knots of speed over the ground against the current in the Strait. So, if the speed of current is 7 knots, the ships to pass should have at least 7 knots of speed. Nearly half of the ships in the area today cannot exceed this speed. It was the same in ancient times, such ships needed to wait for fair winds and currents. Humans have made big leaps in the fight against nature but we have not yet won this fight.

Let's take a Northbound vessel passing through the Strait as an example.

The ship must struggle with the strong current off Haydarpaşa Breakwater first. Experienced captains would approach the starboard side after passing the breakwater. Here the current is neutral or more or less Northbound. But strong currents take over the ship again abeam of Maiden's Tower literally pushing the ship from the starboard side. Until 1982, ships used to cross directly towards Ortaköy from this point with a course called Thalweg Line. After crossing the Maiden's Tower, they would alter course to the opposite shore. This is because currents which are strong on the Anatolian shores are weak on the European side. In fact, a reverse current close to the coastline at Dolmabahçe and Beşiktaş leans towards Ortakoy and Galatasaray Island up to the Akinti Burnu, or Hermaion Point as it is known in mythology. Following this route can save up to 45 minutes in a Strait passage.

Further up there is Kandilli Point which is accepted as the most challenging turn in the Northbound passage. If captains don't make a good plan for this turn the ship could drift to Aşiyan area, on the other coast. This is because of the strong current here which is called as Devil's Current. This current would prevent the ship from turning on her starboard side by hitting her from the starboard bow. If the captain does not start to turn at a very early stage then a difficult situation could develop. Previously, when the lane was open to two-way navigation, ship captains approaching Kandilli point preferred not to encounter a north-bound ship without a pilot. This is because these vessels most of the time would not make the turn at the correct time and as a result would drift in front of their vessels. In other words, the Devil's Current would paralyze them. There been a number of such accidents in the

area. The most infamous one occurred in 1991. On November 14, 1991 Philippine-flagged cargo ship Madonna Lily collided with livestock carrier Rabunion-18 in Kandilli area and after the accident Rabunion-18 sunk, eight crewmembers died and 20 thousand livestock went down with the ship.

After successfully completing the Kandilli turn, the captain can relax. This is because the currents in the Strait decrease north of Kandilli. The current decreases by half. Ships struggling with more than 4 knots of current until Kandilli point may now feel comfortable with a current of just 2 knots. Even so master mariners would follow the Asian coast until Kanlıca point and from Kanlıca cross to the European side again to take the advantage of the counter flow starting from İstinye and proceeding until Köybaşı Point. This was another Thalweg Line which ships used to follow until it was cancelled in 1982. After reaching Köybaşı Point, the counter current meets with the mainstream southbound current. At this meeting point eddies occur. Captains approaching this area warn their helmsman by saying “Pay attention to eddies”. A ship caught unprepared may be drift and get out of control. A question may arise here: why does the speed of current which is steady at 2 knots southbound until the Kandilli point, suddenly double? We can explain this with Bernoulli’s Principle. Readers who want to learn more about Bernoulli’s Principles should have a look into it as we will not go into detail here. Bernoulli’s Principle causes elevated currents in this area”.

The starting point of the elevation is at Kanlica point but the effect of the current actually begins after Kandilli point.

If we continue upwards from Köybaşı Point; in front of Hunkar İskelesi area there is a counter current again which is northbound and close to the shore. Therefore, ships approaching the European shore after İstinye bay would cross to the Asian shore again after the Köybaşı Point and take advantage of this current until they reach Umuryeri Banks. From Umuryeri Banks until the Black sea there is a southbound current, which is not so strong.

Now let us take a look at the Southbound passage starting from the Black Sea. While passing Southbound, there are challenges until Köybaşı Point, however the turn at Umuryeri Bank may be problematic for some laden vessels. The turn at Köybaşı point is an 80 degrees turn and is the most critical turning point in the Southbound passage. Here sailors must be particularly careful about the eddies which we talked about before. The main challenge here is that the fore and aft of the ship are affected by different currents. Which are these currents? There is a counter current north bound close to shore after Köybaşı point and the port bow of the ship may be affected by this flow while the stern is pushed by the main southbound current. If the Southbound turn at Köybaşı point is not neatly carried out then the bow and stern of the ship are affected by different currents. As a result, the ship might not stop turning at Köybaşı point and will proceed towards the Yeniköy area where she will most probably run aground. Thank God that there is a natural shallow here. Ships with a draught of 10 meters or more would go aground here when at a distance of 125 meters from the shore. But there have been accidents in which ships with a draught less than 10 meters have crashed into waterfront houses.

Let’s continue towards the south. For the ships that have successfully managed the turn at Köybaşı Point the most critical area begins. From this point on you can associate a ship’s captain or pilot to a skier. Only the propeller and helm are at your use while the ship is drifting with the current and you need to do this job neatly. Key actions here are preventive maneuvers. You must guess the action of the current in advance and act accordingly before the current does; otherwise you lose the duel with the current. If you manage to come until Kandilli you can pass Aşiyan point as close as possible. Another key action is to give a wide turning arc and in order to do so, you must start early at every turn. When the waypoint designated on the route has been reached, the turning maneuver needs to be ended already and counter helm to stop

the turning of the ship must be started. The name of this game is to be the first-mover against the current.
While on the Southbound passage, the Akinti Burnu is not a very challenging area. No sharp turns are present and the ship continues skiing. In fact, you can be relaxed until the turn at the Maiden's Tower. The turn at the Maiden's Tower is another point that you should never underestimate. This is because the current pushing the stern on the port bow might take control of the ship. For that reason, the turn to port here should be carefully done and reduction of speed must be avoided. Strong currents cause the ship to drift towards the Sarayburnu area. In 1998, two large tankers went aground here near the Maiden's Tower within a month intervals after the above mentioned turn.
The entrance to Haydarpaşa Port is also under the influence of strong currents. The port pilots rendering service to ships in that area have developed safe maneuvering tactics here in order to overcome this current.
Currents have been a nightmare for ships since ancient times. Pilots have also been used since ancient times. Their sculpture is no more in there but however, it is a very easy to say "Collaborate with the Pilot against the currents of the Strait of Istanbul".