Sailing Vessel Handling and Seamanship – The Moving Pivot Point

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Introduction

The concept of the moving pivot point has been known to the handlers of commercial vessels for some time. The world leader in shiphandling training, the Port Revel Center for Shiphandling Training in Grenoble, France, uses 1/25-scale manned models of merchant ships on a ten-acre pond to demonstrate the forces and techniques of shiphandling to masters and pilots of commercial ships from around the world. In the one-week basic curriculum, over half the time is spent demonstrating and proving the validity and importance of the concept that the point about which a ship turns is not fixed but moving, and that the location of that point can be more or less controlled by the shiphandler.[1] In Port Revel, the instructors and students are concerned with large, power-driven cargo ships – tankers, freighters, containerships and the like. In this article, I will first take a look at how this principle applies to power-driven ships, and then discuss it in relation to sailing vessels.

The Principle of the Moving Pivot Point

As stated by Hooyer, shiphandling involves the application of various forces under the shiphandler's control to overcome, minimize, or take advantage of those forces which are beyond his or her control.' The forces which are under the shiphandler's control include the engine/propeller, rudder, tugs, thruster, docklines, and anchor. The forces not under control include the wind, current, resistance of the hull moving through the water, and hydrodynamic forces (pressure differentials) developed by the interaction between the ship, the water and the shore or bottom. The shiphandler must understand each of these forces sufficiently to predict which uncontrollable ones to expect and what effect they will have. Once identified, those forces might be used to advantage. If not, they must be compensated for by utilizing one of the forces under control. The moving pivot point, though not a force, is just as important, since it directly affects all of the forces mentioned.

Where do we find this pivot point? While it is beyond the scope of this article to get into the physics of locating it precisely,' the common rule of thumb has been convincingly substantiated by experimentation with the manned models on the lake at Port Revel. Experienced ship masters and pilots from around the world have agreed that this approxima-

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tion is in line with what they observe on board their ships. The empirical rule of thumb is that a ship under forward motion will pivot about a point approximately one-third of its length aft from its forward perpendicular (the point at which the load waterline intersects the stem). A vessel under sternway, however, will pivot about a point approximately one-quarter of its length forward of the after perpendicular (the intersection of the load waterline and rudder post). Finally, a vessel with no way on will pivot about a point approximately amidships.[4] The somewhat fine distinction of whether it is one-third or one-quarter of this distance is immaterial. The important point is that when a vessel is moving forward, its pivot point is forward; when it is moving astern, it is aft; and when it is stopped, it is amidships.

What is most important to appreciate is that you the shiphandler have control of the location of the pivot point. If a shiphandler is not aware of its location, it may well be fighting the ship, while if it is thought of as one of the "forces" under control it is possible to use it in a positive way. Unfortunately, as is the case with most of the forces with which shiphandlers work, the effects of the moving pivot point may be overshadowed by other, more substantial forces.

The trim of the ship will also affect the location of the pivot point, as a vessel trimmed down by the stern will have its pivot point generally farther aft than one on an even keel. Likewise, a vessel trimmed by the head will have her pivot point generally farther forward than one on an even keel. Also, a vessel heeled over will tend to turn more easily toward her high side than toward her low side.' While these effects are real and noticeable, for simplicity we will assume them to be negligible for this example, in order to more easily explain the specific tendencies attributable to the forward and aft motion of the vessel.

At Port Revel, the instructors use several demonstrations to prove the principle of the moving pivot point. In one exercise, a ship is stopped dead in the water. Both bow and stem thrusters are engaged at equal power, thrusting in the same direction — say pushing the ship to port. (They use thrusters to simulate tugs, because of the difficulty in operating scale-model tugs.) When the sideways motion of the ship has been observed, the ship's engines are engaged at slow ahead. Almost immediately, as the ship gains the slightest headway, it begins to turn, with the bow swinging to starboard. This is because with the pivot point forward the stern thruster has more leverage. When the ship's engines are placed astern, the bow swings to port as soon as it develops sternway. The same effect is demonstrated in a beam wind, and even in a beam sea.'

Once the principle is understood, the applications begin to emerge. Moreover, the shiphandler will begin to think back to occasions when a manoeuver did not go as planned, and will realize that the reason might well lie in a failure to have understood and properly applied this concept. To move the stern over, get the pivot point forward. To move the bow over, get the pivot point aft. To pivot around the middle of the vessel, stop. To get the transverse thrust (propeller walk, or stern walk) of the propeller to have maximum effect, get the pivot point forward. For minimum effect, get the pivot point aft. If the wind is blowing the bow off, to reduce that effect get the pivot point forward. To exaggerate it, get the pivot point aft.

What is most impressive about the application of this principle is that very little forward or aft motion is necessary to shift the pivot point in the desired direction. If forward or aft motion is discernible, it is sufficient. This means that the shiphandler can employ this technique even in close quarters, by very sparing use of ahead or astern motion. All shiphandlers utilize a strong kick ahead on the engine, with hard right or left rudder, to turn the vessel in tight quarters.' If this is done carefully, it can be done while the vessel maintains slight headway (to move the stern more than the bow); it can be done while keeping the vessel stationary to pivot around the middle of the vessel; and it can even be done while maintaining slight sternway, to move the bow more than the stern. The latter technique will be more difficult to utilize, since the shiphandler will be working with the least leverage, but if there are no other strong forces at work, it will in fact have the desired effect. The exercise at Port Revel proved it. The key is that the kick ahead must not be sufficient to kill the sternway.

It is important not to overlook the fact that we are considering only the ship's headway or sternway *through the water,* not over the ground. If the vessel is stationary with respect to the shore, but is stemming a two-knot current, the pivot point will be forward, since the vessel has headway with respect to the water. Likewise, if she is tied to the dock, with a two-knot current from astern, the pivot point will be aft the moment the lines are cast off.'

Application to Sailing Vessels

There are several considerations which are important to the sailing vessel master, with regard to the use of the moving pivot point concept. (We will discuss auxiliary sailing vessels – those fitted with auxiliary power– primarily, since the majority of vessels today are so fitted. The principles apply similarly with or without an engine.) The first is the recognition of the fact that many sailing vessels are under-powered, with respect to their auxiliary engines, making the pivot point issue more important than with fully powered ships. The second consideration is to decide how significant the effect will be, given the underbody design of the vessel. The third consideration is how to relate the use of various sails to the location of the pivot point, when manoeuvring the vessel.

In the first case, while it is true that many sailing vessels are fitted with substantial power plants, many are not. Many sailing vessels have small engines, especially those which have been retro-fitted with auxiliary power, as well as small or offset propellers, giving the operator less-than-optimum handling characteristics. In this case, the shiphandler must understand every nuance of the characteristics to be able to handle it safely. The concept of the moving pivot point is an important part of this equation. With limited power available, thereby limiting the turning moment that can be developed with the rudder, the turning moment must be applied with the maximum leverage available. [9] Most shiphandlers will recall that when a vessel has sternway on, a kick ahead on the engine with hard-over rudder will have very little effect until the sternway is off. As soon as the vessel begins to creep ahead, it will start to swing. This is because when headway is established the pivot point moves forward, giving the side-force of the rudder a lever-arm to work on. With an under-powered ship, this principle is most critical.

In the second case, it is important to evaluate the underbody shape of a particular vessel to predict how significant the moving pivot point effect will be. The discussion so far has been based on a cargo vessel hull – basically a long box, with flat sides, a flat bottom, and a point at each end. Some cargo hulls are finer than that, and some sailing vessel hulls are not much better. But most sailing vessels are designed with fine ends, a distinct keel, and a good deal of cutaway forward. The underbody shape will dramatically effect the location of the pivot point, and in the extreme cases will disguise completely any of the effects we have been discussing. It should be apparent that a shallow hull with a large centreboard will undoubtedly pivot around its centreboard, no matter in what direction the vessel is moving. Likewise, a modern, racing-style hull with a short fin keel and aft-mounted rudder will pivot where the designer intended, around the keel. But since a large number of sailing vessels operating today have a hull configuration somewhere between the cargo hull shape and the ocean-racing hull shape, each vessel ought to exhibit some of the characteristics discussed above. A shiphandler must first predict the effects we expected and then be sufficiently observant to determine empirically what effect a particular vessel exhibits.

The third case is the most unique to the sailing vessel operator: the use of sails when manoeuvring. In this case it matters little whether there is an engine or not since the sailing vessel has in effect a bow thruster in the form of headsails, which can be set full or aback, or struck, to push or pull the bow around. There is some sort of sail aft – be it a spanker, a mizzen, or a mainsail – to push or pull the stern around. Depending on rig, there may also be a selection of other sails in between to bring to bear at various points along the length of the vessel. This is the cargo shiphandler's dream – a complete selection of tugs, always ready at hand, at no extra charge. The limitations of course are significant; the crew must be numerous and well trained, and there must be enough – but not too much – wind for the job. The professional sailing shiphandler utilizes these "tugs" to the extent judged appropriate given the parameters just mentioned. But if that shiphandler is not cognizant of the wandering nature of the ship's pivot point, he or she will not be utilizing these sails to their best advantage. They may in fact end up working in opposition.

Now to put all this information together in an example. In May 1996, I was fortunate to be invited to sail as Chief Mate aboard the barque *Elissa,* with Captain Steve Cobb. The Second Mate was Sean Bercaw, a Captain with the Sea Education Association, sailing the well-known vessels *Westward* and *Corwith Cramer.* With three experienced shiphandlers on the bridge, we spent a good deal of time comparing notes on many subjects, not least shiphandling. Since this topic of moving pivot points was in the front of my mind, we covered it in some detail. We decided to examine it in the context of turning *Elissa* in the Galveston Channel as we set out for a day sail (see figure 1).

The wind was brisk from the south (I am taking some liberties with true directions to simplify this discussion, but they are approximately correct). The channel runs approximately east-west, and *Elissa* was berthed alongside the south channel edge, port side alongside, facing west. We decided (to give onlookers a good show) to depart by heading upstream – to the west – as far as a highway bridge, then turn 180° and head out to sea, setting sail as quickly as possible in order to have full sail up as we passed the dock. We discussed the shape of the hull; since *Elissa* was built as a cargo carrier, it has a cargo hull – essentially flat bottomed – and we therefore expected her pivot point to behave as predicted for a commercial vessel hull.

We dropped our lines and headed west under power in order to get the guests settled and the lines stowed before beginning the sailhandling. As we approached the area in which we wished to turn, we talked about our options and the pivot point. Captain Cobb was kind enough to let me have the con for the manoeuver. The primary issue in my mind was to prevent *Elissa* from setting down onto the north (leeward) shore during the course of our turn. The current was setting us to the west, but not dramatically. Therefore I made my approach along the south shore. This had the added benefit that the transverse thrust of the propeller would be working for us as we backed and filled in a turn to starboard.

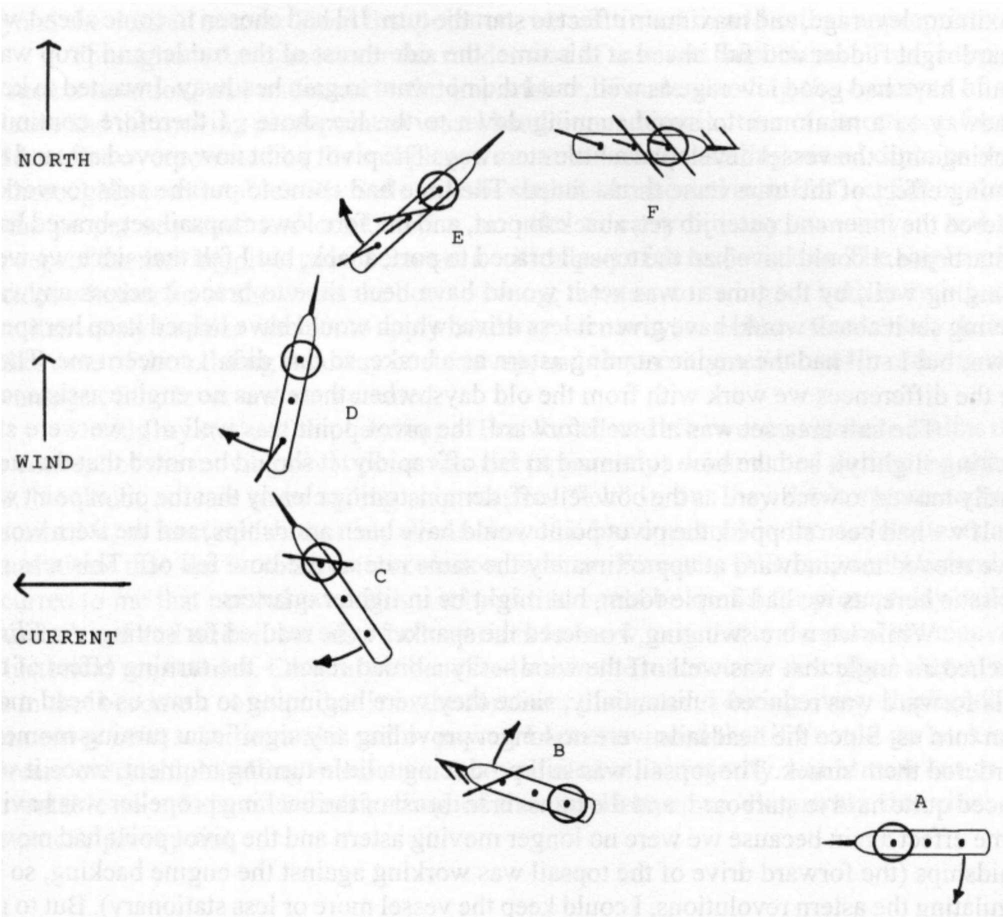

Figure I: The manoeuvring of *Elissa* in the Galveston Channel. The circle represents the pivot point. At A, the vessel is backing its engine to remove headway and begin the turn using the transverse thrust of the propeller. Though backing the engine, the vessel still has headway and therefore the pivot point is still forward. At B, the fore lower topsail and inner and outer jib are set, helping the turn to starboard. The vessel is backing (and now has sternway), and the pivot is aft, giving those sails the maximum lever arm for turning. At C the headsails are struck. The vessel is allowed to gain a little headway (moving the pivot point forward again), then the engine is given a kick of full astern to utilize the transverse thrust to walk the stern to port again. At D, the stern is across the wind and the spanker is set, sheeted to port. With a little headway again, the pivot point is forward and the spanker has maximum leverage to push the stern to port. At E, as the vessel swings onto the new course, more sail is gradually added, beginning with the main lower topsail and continuing with the staysails. No sail area is added forward of the foremast until the craft is nearly on course, thus allowing its head to come up. At F, the vessel is steadied on course and all plain sails are set.

Source: Courtesy of the author.

As we approached slowly along the south shore, I gave a full astern bell. At this point, with headway on, *Elissa 's* pivot point was forward, and the transverse thrust had the maximum leverage, and maximum effect to start the turn. If I had chosen to come ahead with a hard right rudder and full ahead at this time, the side thrust of the rudder and prop wash would have had good leverage as well, but I did not want to gain headway. I wanted to keep headway to a minimum to avoid running down to the lee shore. I therefore continued backing until the vessel developed a little sternway. The pivot point now moved aft, and the turning effect of the transverse thrust faded. The time had come to put the sails to work. I ordered the inner and outer jib set, aback to port, and the fore lower topsail set, braced hard to starboard. I could have had the topsail braced to port, aback, but I felt that since we were swinging well, by the time it was set it would have been time to brace it across anyway. Having set it aback would have given it less drive, which would have helped keep her speed down, but I still had the engine running astern as a brake, so that didn't concern me. These are the differences we work with from the old days, when there was no engine assistance.

The sail area set was all well forward, the pivot point was well aft (we were still backing slightly), and the bow continued to fall off rapidly. It should be noted that the stern hardly moved to windward as the bow fell off, demonstrating clearly that the pivot point was aft. If we had been stopped, the pivot point would have been amidships, and the stern would have moved to windward at approximately the same rate as the bow fell off. This was not an issue here, as we had ample room, but might be in tighter quarters.

While we were swinging, I ordered the spanker to be readied for setting. As *Elissa* reached an angle that was well off the wind — say a broad reach — the turning effect of the sails forward was reduced substantially, since they were beginning to draw us ahead more than turn us. Since the headsails were no longer providing any significant turning moment, I ordered them struck. The topsail was still producing a little turning moment, since it was braced quite hard to starboard, and the transverse thrust of the backing propeller was having some effect again because we were no longer moving astern and the pivot point had moved amidships (the forward drive of the topsail was working against the engine backing, so by regulating the astern revolutions, I could keep the vessel more or less stationary). But to get the rate of turn back up, more was needed. It was still premature to set the spanker, since it was not quite across the wind. The solution lay in the pivot point. By easing off on the astern revolutions I allowed the ship to gain a little headway, moving the pivot point forward. Once it was moving ahead, I gave a full astern bell, and the transverse thrust now had a long lever arm to work on. The rate of turn increased again. (In this case, it only took one shot, but if more were needed, one would let it get moving ahead again and give the ship another kick astern.)

In a few moments, the vessel had turned enough to allow the spanker to be set, with the certainty that it would fill to port, where it would push us on around. For it to work to best advantage it was necessary to keep the pivot point forward now, so I had to maintain a little headway. With ample sea room ahead and to leeward, the engine was no longer needed, so I ordered a stop bell. The fore topsail was likewise no longer helping, since it was going to block the head from coming up, so I ordered that taken in. With only the spanker set, a little headway, and a pivot point well forward, the vessel started rounding up nicely. Since headway was now desirable I began ordering more sail set, starting with the main lower topsail to give her some drive (but keeping the centre of effort aft of the pivot point) and adding staysails to help pull the ship forward as it came up to a reach. Once it was clearly through the turn, and coming up onto an easterly course, I reset the headsails and the fore lower topsail as well, to provide balance and to prevent the ship from rounding up beyond the desired course. From that point on, we continued to add sail as appropriate.

Throughout the manoeuver the rudder was of minimal importance. This is typical of such a situation, and underscores the importance of understanding the concepts of sail balance and the moving pivot point in vessel handling under sail. It is not uncommon for the rudder to be overpowered by the sail plan, a circumstance that sailing vessel captains must be thoroughly comfortable with. Sails must be set, struck, sheeted in, luffed, set full or aback in the proper sequence and combination in order to carry out any manoeuver, and the concept of the moving pivot point becomes a critical part of those decisions. The shiphandler decides whether he or she wants the bow to swing, the stern to swing, or both to swing, and simultaneously decides whether to apply headway, sternway, or neither. Conversely, he/she makes note of the existing headway or sternway, and chooses the sails to set in order to take advantage of the lever arm thus created.

During my study of shiphandling at Port Revel, and afterwards, I came to realize that the concept of the moving pivot point was not (apparently) documented during the age of sail. No doubt at least some sailing ship masters "felt" it, but they don't appear to have described it, at least not so that any discussion of it has appeared in the novels, texts and descriptions that are in common circulation, such as Forester, O'Brien, and Harland. It occurred to me that not only was this a subject that could be useful for present day sailors to understand and utilize, but also for historians to know to better understand manoeuvres of historical importance. Certainly it benefited me in the manoeuver described above, and has in fact become a concept that is in the forefront of my mind during every shiphandling manoeuver now, whether under sail or power. I am convinced that if I could go back and recreate every shiphandling manoeuver I have failed at, a majority would turn out to be attributable to a lack of understanding of this (as Hooyer so eloquently describes it) peripatetic pivot point.

NOTES

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1. Port Revel Ship Handling Training Center, Course Manual.

2. Henry H. Hooyer, *The Behavior and Handling of Ships* (Centreville, MD, 1983).

3. See Hooyer, *Behavior,* chap. 1, for a complete discussion of "The Peripatetic Pivot Point."

4. Hooyer, chap 1.

5. Graham Danton, *The Theory and Practice of Seamanship* (2nd rev. ed., London, 1987).

6. See note 1.

7. *Ibid.*

8. Hooyer, *Behavior,* chap. 5.

9. *Ibid.,* chap. 2.