Heaving the Log

A Traditional Way to Measure Speed at Sea

by Stuart Wier And Charlotte Tay Tahk

"Heaving the log" is a way to measure a ship's progress through the water that dates from the age of commercial sail, and was used well into the twentieth century. Heaving the log was performed many times each day, and is a scene often described in Patrick O'Brian's sea novels and in many other works on the age of sail.

Heaving the log may derive from an earlier practice of throwing a piece of wood over the side to see how quickly it is left behind, a practice known of old in the English-speaking world as the "Dutchman's log." Even today sailors sometimes throw things overboard to get a quick notion of speed, or to see whether the boat is even moving at all!

Eventually heaving the log involved dropping a small wood panel, the "log," into the water and measuring the length of line it pulled off a reel in a given period of time. We see in the O'Brian novels this operation carried out over the taffrail, at the stern of the ship, a seaman or boy holding the reel of line, possibly over his head, while someone else turned a sand glass. A midshipman or officer stood by and gave orders and wrote down the result. Since this practice was repeated every hour of the day, day after day, year after year, it must have taken on the character of a ritual, and anyone on board could do it in their sleep, and probably did on occasion.

We present here a detailed description of the process from Bowditch's *New American Practical Navigator,* the 1826 edition. Exactly the same text appears in the 1846 edition as well. While these dates are some time after the Napoleonic period, the time of the O'Brian and Forester novels, we do not think use of the log had changed much, if indeed any at all. The Bowditch text quoted likely originated in an earlier period, perhaps even before 1800, as elsewhere in these works navigation examples use observations made in the year 1800. The first work by Nathaniel Bowditch was published in Massachusetts in 1799, a revised version of the thirteenth English edition of John Hamilton Moore's *Practical Navigator* , so the log line description may be quite old, perhaps taken verbatim from Moore's work.

Just to work with these old volumes is a pleasure. Judging by their condition they have been to sea many times. Pencilled neatly after the Preface to Tay Tahk's 1826 edition is "Smyrna, Chios, Colophon, Salamis, Rhodes, Argos, Athenae, the seven cities that contended for the birth of Homer". This tag of classical erudition, surprising to modern eyes reading a navigation text, fits in nicely with the culture of 1800 as described by O'Brian, and a world where the favorite reading of a Captain Hornblower might well be Gibbon's *Decline and Fall of the Roman Empire* . We'd like to think these notes were written in the Mediterranean, on the quarterdeck, on some long-ago sunny morning, and we can picture a young midshipman trying desperately to acquire a little classical polish on his own, or some captain like Jack Aubrey trying to provide such polish and a squeaker cramming.

from Nathaniel Bowditch's *The New American Practical Navigator* , 1826.

OF THE LOG-LINE AND HALF-MINUTE GLASS

Various methods have been proposed for measuring the rate at which a ship sails; but that most in use is by the Log and Half-Minute Glass. The Log is a flat piece of thin board, of a sectoral or quadrantal form (see Plate VI. fig. 3), loaded, on the circular side, with lead sufficient to make it swim upright in the water. To this is fastened a line, about 150 fathoms long, called the log-line, which is divided into certain spaces called knots, and is wound on a reel (see Plate VI. fig 4) which turns very easily. The Half-Minute Glass is of the same form as an Hour Glass (see Plate VI. fig 2), and contains such a quantity of sand as will run through the hole in its neck in half a minute of time.

The making of the experiment to find the velocity of the ship, is called Heaving the Log, which is thus performed: - One man holds the reel, and another the half-minute glass; an officer of the watch throws the log over the ship's stern, on the lee side, and when he observes the stray line is run off (which is about ten fathoms, this distance being usually allowed to carry the log out of the eddy of the ship's wake), and the first mark (which is generally a red flag) is gone off, he cries Turn; the glass-holder answers Done; and watching the glass, the moment it is run out, says Stop. The reel being immediately stopped, the last mark run off shows the number of knots, and the distance from that mark is estimated in fathoms. Then the knots and fathoms together show the distance the ship has run in the preceding hour, if the wind has been constant. But if the gale has not been the same during the hour, or interval of time between heaving the log, or if there has been more sail set or handed, a proper allowance must be made. Sometimes, when the ship is before the wind, and a great sea setting after her, it will bring home the log. In such cases it is customary to allow one mile in ten, and less in proportion if the sea be not so great. Allowance ought also to be made, if there be a head sea.

This practice of measuring a ship's rate of sailing, is founded upon the following principle - that the length of each knot is the same part of a sea mile as half a minute is off an hour. Therefore the length of a knot ought to be 1/120 of a sea mile; but, by various admeasurements, it has been found that the length of a sea mile is about 6120 feet; hence the length of a sea knot should be 51 feet. Each of these knots is divided into 10 fathoms, of about 5 feet each. If the glass be only 28 seconds in running out, the length of the knot ought to be 47 feet and 6 tenths. These are the lengths generally recommended in books of navigation; but it may be observed, that, in many trials, it has been found that a ship will generally overrun her reckoning with a log line thus marked; and, since it is best to err on the safe side, it has been generally recommended to shorten the above measures by 3 or 4 feet, making the length of the knot about 7 1/2 fathoms, of 6 feet each, to correspond with a glass that runs 28 seconds.

In heaving the log you must be careful to veer the line out as fast as the log will take it; for if the log be left to turn the reel itself, the log will come home and deceive you in your reckoning. You must also be careful to measure the log-line pretty often, lest it stretch and deceive you in the distance. Like regard must be had that half-minute glass be just 30 seconds; otherwise no accurate account of the ship's way can be kept. The glass is much influenced by the weather, running slower in damp weather than in dry. The half-minute glass may be examined by a watch, with a second hand, or by the following method: - Fasten a plummet on a string, and hang it on a nail, observing that the distance between the nail and the middle of the plummet be 39 1/8 inches; then swing the plummet, and notice how often it swings while the glass is

running out, and that will be the number of seconds measured by the glass.

A final section, omitted here, shows how to correct observations to obtain a true measure of speed "if the half-minute glass and log line are faulty," that is, if they do not indicate 30 seconds and 50 feet per knot. Simple proportions to 30 seconds and 50 feet are used to make the correcting factor.

Just one hundred years after the Bowditch quotation was published, a similar description appears in *Navigation* by George L. Hosmer and may well also date back to wooden ship days:

"The chip log, formerly much used on sailing vessels, consists of a light piece of board weighted on one edge so as to float in an upright position when thrown into the water. The line attached to the log is divided into lengths called knots, beginning 15 or 20 fathoms from the chip, at a point marked by a piece of red bunting. Each of these distances is marked by means of pieces of fish line run through the log line, one for the first, two for the second, etc., each one representing a nautical mile or knot. Every two-tenths of a knot is marked by a piece of white rag. The log was generally used in connection with a sand glass, and the distances between the marks on the log line must be figured such that the length of a knot on the line has the same relationship to the sea mile (6080 ft) that the time the glass has to one hour, or expressed as a proportion, for a 28s glass, x:6080::28:3600, from which x = 47.29 ft.

"When the log is hove the sand glass is started just as the red bunting passes out.... If the line is now given a sudden jerk it will free a wooden peg, fastened to two of the lines, so that the chip will lie flat on the water and can be easily hauled aboard."

Alan Villers, an experienced square-rigged ship captain of the 1920s and 1930s, says in his book *Captain James Cook* , "This method of measuring speed was still in use in big ships in the 1920's."

Assessment

These are clear and complete descriptions of the use of the log-line. The lack of standard dimensions for the equipment described by Bowditch is surprising, and at odds with much of this navigational handbook otherwise valuing a high degree of precision.

The uncertainty in the length of the log-line knots may come ultimately from lack of certainty about the length of the nautical mile, not to mention Bowditch's attempt to compensate for other factors affecting ship speed by modifying the log.

Traditionally there are sixty nautical miles per geographic degree, or one mile per geographic minute, giving a very handy unit in navigation. As early as the seventeenth century the length was known to be about 6100 feet, the current and international value of the length of the nautical mile being exactly 1852 meters, or 6076.11 feet. The length of one minute of a great circle of a sphere having an area equal to the earth's area is 6080.2 feet. This was the value used until the international value was adopted. Some navigation books still use 6080 feet per nautical mile. The difference is not significant for mariners! The reason there was not a clear single length for the nautical mile from the beginning is because the Earth is not a perfect sphere, but is flattened at the poles, the difference in polar and equatorial diameter being 23.4 nautical miles out of some 6880 nautical miles. A minute of arc is about 6046 feet at the equator and 6109 feet at the poles; the average is 6076.

Since the nautical mile was defined in terms of the dimensions of the Earth, rather than by arbitrary

dictate, its value has varied as geography advanced. Incidentally, the meter is also a seventeenth century estimate defined in terms of the Earth, being one part in 10 million of the distance from the North Pole to the Equator along the meridian of Paris. The original measurement is known to be in error, but that erroneous distance is now enshrined in platinum rods, cesium wavelengths, or some other form of arcana, giving it a superficial gloss of modernity. For all practical purposes the meter is three feet, three inches, and three eights, a kind of superyard.

Bowditch's "fathoms" of five feet in length may be a disguised form of decimalization, replacing speed measured in knots and fathoms with knots and units that are really tenths of knots (not fathoms), permitting easier numeric calculations. This five-foot "fathom" did not catch on. An English fathom is always six feet. The division of each knot into two-tenths units in Hosmer's description makes explicit the "decimalization" suggested in Bowditch.

The origin for the 28 second glass, a rather unusual length of time, is not given in any source we found, but it clearly was a common log glass, judging by the references to it. It appears from what we have read that the original glass was the 30 second glass and the 28 second glass came later. A late description of the use of the log (Bowditch 1917) says the official U.S. Navy glass was 28 seconds at that time. (A guess: a 28 second glass used with a 48-foot "knot" - exactly 8 fathoms - measures speed with an error of only 1.5%, probably better than the intrinsic precision of the method. The 30 second glass would give a 5% error with the same line). When the 28 second glass came into use we do not yet know; it was in use by the Napoleonic war period if not earlier.

All this quibbling over small differences aside, it is clear that English-speaking seamen judged their progress using log lines with knot lengths near 51 feet and a 30 second glass, or using log lines with knots near 47 feet (or 8 fathoms) and a 28 second glass.

When the log is heaved every hour, then the numeric value found is both a measure of speed *and* a measure of nautical miles run in the past hour. Recall a nautical mile is one geographic minute, one-sixtieth of a degree. Charts usually have degrees and minutes marked along the margin, so a speed in knots easily gives a distance in nautical miles or minutes, easily picked off with dividers.

Heaving the log every hour, it may be many mariners thought of knots as the distance run, not the speed. This is especially clear to those of us who have had to try to explain the concept of speed to persons, such as seventh graders, who have never used it. This slight confusion between knots as speed or distance run is also found in the term knots per hour. Since speed has no tangible reality we need not demure when persons who otherwise know the value of precision in terminology on board ship use the phrase knots per hour. We all know what they mean so take it easy.

It is possible that the term "dead reckoning" is derived from use of the log: reckoning the ship's position from an object "dead" in the water, which the log should be when in use. More often one reads that "dead reckoning" is from "deduced" reckoning. Either could be correct. The Oxford English Dictionary refers back to the meaning "unbroken, uninterrupted" for dead (as in "dead silence"), perhaps suggesting that dead reckoning depends on an uninterrupted string of readings to keep track of the course of the ship.

Details of Construction of the Log According to Bowditch

Bowditch's account includes a very simple illustration (Plate VI in the early Bowditch's, not shown here) of the "log" itself, a quarter-circle of wood attached to a long thin line by a three-part bridle,

an ordinary sandglass, and a reel whose axle served as handles, very much like what is used today by some kite-flyers. The reel appears to have been two or three feet long and a diameter of perhaps five to eight inches. Bowditch's readers were more interested in using the log than making one, so the details of construction are not shown. He does not show how the knots were marked. The marks between the "knots" were real knots, with little flags of cloth or bits of line, and these knots passing over the stern rail and giving the measure of speed eventually became the modern term "knot" for one nautical mile per hour.

The bridle is arranged so that the log presents its flat surface to the flow of water, something like using a small parachute for a sea anchor. The drag is quite surprising for even a small log. Hauling the log back to the ship, at the speed of the ship, or actually a little faster, could be very difficult, and could break the thin line used. That is why the top bridle line (to the upper point of the log) is equipped with a peg which pulls loose when the log line is stopped. Then the log slides along sideways with little effort. One drawing shows the peg on the top corner, opposite the lead weight. Two other sources show the peg fitting in a socket at the junction of the bridle lines. Both of these drawings are twentieth century so we do not know what arrangement was used in 1800. The Bowditch's Plate VI is very simple and only shows the outline of the log and its bridle, with neither weight nor peg.

To make a log such as would have used 200 years ago you could use a piece of white oak or white pine in America, or English oak in England, or any of a number of other sorts of woods used in boat work. "Quadrantal" means a quarter of circle, and the two straight sides were in the range of five to nine inches long. You might treat it with "boat soup" to protect it from the water, an authentic old boating treatment: equal parts of boiled linseed oil, turpentine, and pine tar. The line should be "loosely laid flexible untarred hemp." You can still buy balls of hemp line (tarred), and pine tar, from Hamilton Marine of Portland and Searsport Maine, but they don't carry 30-second glasses! The reel is entirely of varnished wood. A photograph of an original rig appears in the 1962 edition of "Bowditch," and perhaps in other editions of Bowditchs, but there is no scale. This photo could be used to guide reel construction. Where you will find a 30-second glass we do not know. Perhaps use an egg timer glass with some sand removed, and make an old-style wood case for it.

Making and Using a Traditional Log Today

Unlike the stone anchor, backstaff, and other primitive tools of seamanship, the log still has some use on board. It can show the speed with about as much accuracy as most modern devices. Roger Duncan in his *Sailing in the Fog* , an excellent guide to coastal navigation, describes and illustrates the log he made, very similar to what has been described here. I (SW) have made a log and line of modern materials and used it to measure boat speed with good accuracy.

Any strong line will do for the log line. Nylon of the proper size is commonly available but it will stretch quite a bit, so Dacron or some other non-stretching line would be better, if you can find it. Or just use the nylon and mark the distances while the line is on the stretch. Counting starts at a bit of red cloth. For a 30-second glass the knot intervals are 50 feet 8 inches (6076 feet/120). Tie a short piece of line at the end of the first knot, two pieces at the second, and so on out to whatever you think your boat's top speed is. As a rule of thumb a sailboat's top speed is usually less than 140% of the square root of the waterline length in feet. Sixteen-foot waterline length, 4 times 1.4 or 5.6 knots; thirty-six-foot waterline length, 6 times 1.4 or 8.4 knots. In these two cases I would make log lines for 6 and 9 knots. You will need a length of at least ten fathoms (sixty feet) for the "stray line" before the red flag, plus another 50 feet 8 inches for every knot your boat makes at top speed; probably 600 feet total would do for most private sailing vessels.

The bridle lines must be adjusted so that the log pulls exactly perpendicular to the log line. If not, then the may log will scoot off to the side, or even straight down, making speed measurement impossible and risking loss of the log. Tie the back end of the line to the reel; if the line is not tied on and the ship is sailing fast the entire line may run off the reel and be lost. Better to have plenty of line on the reel anyway.

My log was cut from 1/4 inch plywood about seven inches on the side, with a tire weight bolted to the curved lower edge, to help it "swim" upright. A big plastic spool from a wire manufacturer makes a fine reel, if not very authentic. A wooden shaft serves for axle and handles. A knob added to the reel rim is essential for winding in all the line that flies out in 30 seconds. A modern water-proof watch is better than the 30-second glass, but not a lot better! The irregularities of starting and stopping the line offsets any great precision in timekeeping.

There are precautions: If you are going to stream 600 feet of line astern, watch out for other shipping! And don't let the line run through your hands: it's going fast and could burn. You may be surprised how fast the line flashes out and how the reel spins. It seems impossible to "veer the line out as fast as the log will take it," as Bowditch suggests. Even at five knots it is going out at a rate of 500 feet per minute, eight feet per second. The log really gets a good grip on the water and frankly it does not "come home"; not enough to make an error in speed measurement, anyway, if the reel spins freely.

Three people are a big help in heaving the log: one to hold the reel, another to drop in the log (don't really heave it or the bridle will tangle) count knots and manage the line, and one to watch the watch or glass. It appears that heaving the log can be as accurate as modern electronic meters, and even can be used to calibrate an electric meter, though the log is clearly not so handy. On one boat where I tried this log the electronic log was clearly in error by at least 10%; in another the electronic gadget was broken but the log served well. The trick of using the log to make an accurate speed measurement is stopping the line exactly on the instant time runs out. A countdown and an strong grip will do. Remeber that the traditional (and therefore correct) word of command to start timing is "Turn!" and to stop timing is "Nip!"

Some folks feel comfortable only if they have the latest gadgetry on board. On the other hand, one can still be a respectable coast pilot, at least for recreational purposes, using a compass, lead line, log line, and good charts, provided you know what you are doing. If you are drawn to boating for the pleasures of older, quieter, simpler, ways (though they may be slightly less convenient) then this approach is right for you.

The popularity of traditional sailing vessels offers the possibility of heaving the log under the original conditions. Surely the U.S.S. "Constitution," the "H.M.S.Rose," the "Bounty," and other square-riggers that put to sea today should have an authentic log on the quarterdeck, and use it.

We are sure that others in touch with more extensive resources on maritime history, such as the major marine museums in Europe and North America, can add to this discussion, and we welcome their contributions. Surely some museums have original logs, lines, and glasses. A detailed, measured description of an authentic set would be very interesting.

Tay grew up in Huntington, Long Island, sailing Lightnings and other craft, and Stu is an amateur designer and builder of small craft. Stu has some sea time in very uninteresting diesel powered oceanography ships, and rates his Craft of Sail certificate from WoodenBoat school above all other

diplomas. They have never met but cooperated on this for the Searoom list.

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