Small Publications in Historical Geophysics

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An Investigation of the Tidal Conditions at the Loss of the World's Most Impressive Sailing Ship

Martin Ekman

Summer Institute for Historical Geophysics
Åland Islands

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1. Åland sailing shipping and the Herzogin Cecilie

Seafaring has long traditions on the Åland Islands, the autonomous group of islands in the central Baltic Sea. This tradition extends not only within the Baltic, but also internationally. Since 1865 Ålandic merchant ships have crossed the world's oceans. During the first half of the 20th century Gustaf Erikson at Mariehamn, the capital of Åland, built up a fleet of great deep-sea sailing ships, mainly for the wheat trade between Europe and Australia. This put Åland in the remarkable position of having the world's largest fleet of merchant sailing ships; see further Kåhre (1948), Greenhill & Hackman (1986) and Kåhre & Kåhre (1988). This was, according to Greenhill & Hackman, "made possible by the nature and history of the peculiar community in which they were owned, a Swedish-speaking archipelago society which averaged 23,000 inhabitants spread over some fifty islands, a distinctive minority group [inside Finland]".

The sailing vessels not only brought money into the Åland economy but also were a part of the Ålandic culture. In addition, these ships attracted a lot of international attention because of their impressive beauty. The most impressive and beautiful of them all was the Herzogin Cecilie ("Duchess Cecilie"), the flagship of the Åland sailing fleet.

The Herzogin Cecilie was bought by Gustaf Erikson in 1921 from the French state. France had, after the end of the first world war, obtained the vessel as a war reparations payment from Germany. Germany had originally built the vessel in 1902 as an imperial ship, named after the empress-to-be, the Duchess Cecilie of Mecklenburg. It was a four-masted barque, 102 m long and 60 m high, with 35 sails; see Figure 1. The total area of the sails amounted to 4050 m^2. Gustaf Erikson had this magnificent ship repaired and put it in on the wheat trade to Australia; see Derby (1937) and Greenhill & Hackman (1991) for details.

The ship usually travelled, as the other vessels on the wheat trade, from Åland across the Atlantic Ocean and the Indian Ocean to Australia. There wheat was loaded. Then the ship crossed the Pacific Ocean and the Atlantic Ocean to go to England for discharge. The different routes were chosen to make use of the dominating winds and ocean currents as much as possible. After that there was often a possibility for a brief visit home to Åland, until it was time for the next freight. The whole voyage around the globe normally took close to one year.

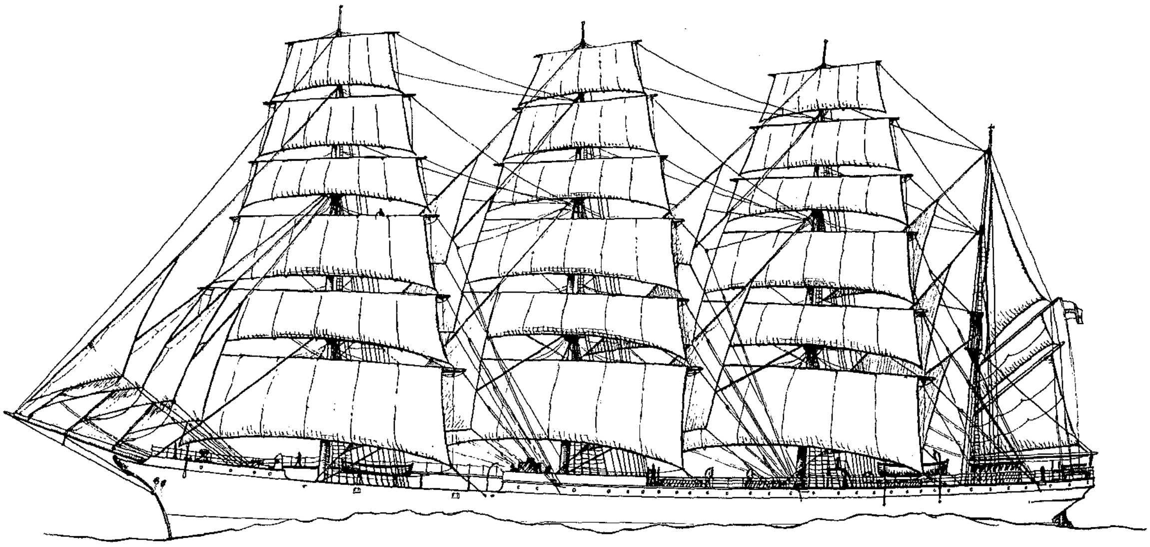

Figure 1. Herzogin Cecilie (from Villiers, 1972).

2. The loss of the Herzogin Cecilie

In 1936 the Herzogin Cecilie was lost by stranding in the English Channel. The vessel had almost completed that year's voyage to and from Australia. The load consisted of nearly 5000 tons of bagged wheat. Master on board was sea captain Sven Eriksson, and officer on watch was chief mate Elis Karlsson. The crew consisted of 30 men. The loss has been extensively reported and discussed by Derby (1937) and Greenhill & Hackman (1991), in the latter book with maritime inquiries included. The captain's wife, who was on board during the whole voyage, as well as the mate have written books about the voyage (Eriksson, 1958: Karlsson, 1964).

The ship, arriving from Australia, had first reached Falmouth at the south coast of England. There orders were given to go to Ipswich on the east coast. Consequently one continued eastwards in the English Channel, now in foggy weather. After some eight hours, at 03 55 on Saturday night the 25th of April, the ship went ashore in thick fog. This happened at the rock of Ham Stone west of the peninsula of Bolt Head, near Salcombe southeast of Plymouth; see Figure 2. Half an hour later the ship was taken afloat by the rising tide and drifted further towards land, going ashore on the rocks there instead. Distress rockets were fired, and the crew was taken ashore by a lifeboat. The vessel was gradually filled by water, and later on, in spite of attempts to bring about salving, it was broken in a storm.

The event caused considerable excitement, especially of course on Åland and in England. English people came in enormous crowds to see the famous sailing ship in its tragic position. From the ship one succeded in salving, among other things, the captain's saloon including furniture, which was transported to Mariehamn and nowadays form a part of the Åland Maritime Museum. The captain and the mate ceased sailing after the accident and later on left Åland to settle in Africa.

The cause of the loss has not been fully understood. However, it can be said to be a combination of overoptimistic passage planning, some unknown navigational error, and thick fog. One relied in this case entirely on dead reckoning without control possibilities, a method containing risks for unfavourable error propagation in the positioning. This had the consequence that the ship, instead of going far enough out in the English Channel, went too near the coast. While the ship actually should have passed far south of the peninsula of Bolt Head, it went ashore approximately 1 ½ nautical mile north-west of the southern tip of the peninsula. The crew did not know then where they were.

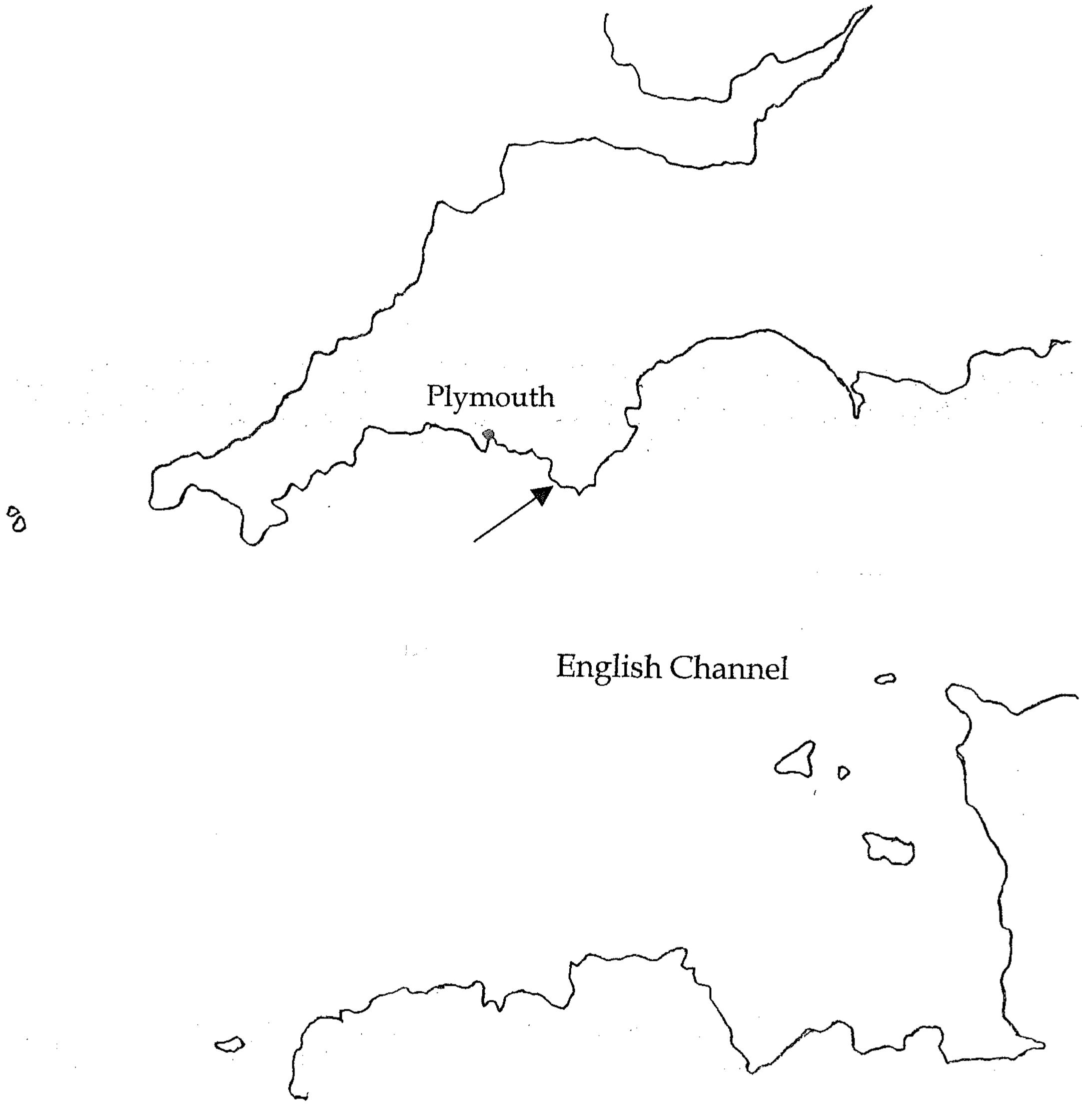

Figure 2. The place of loss in the English Channel (at the arrow).

Loose speculations on the tides having contributed to the loss were put forward already at the maritime inquiries in Plymouth a few weeks afterwards, both by the captain and the mate. A vessel that goes close to land in a tidal region like the English Channel takes the risk of being influenced by coastal tidal streams differing from the general tidal streams further out. Computations that may shed light on the role of the coastal tides at the loss of the ship never seem to have been made. We will here try to perform such computations.

3. Character of the tides at the place of loss

The tides in the English Channel are, as in the North Sea region in general, pronounced semi-diurnal. This means that the tides are dominated by the lunar prinicipal tide M_2 with the period 12.4 hours and the solar principal tide S_2 with the period 12.0 hours; in addition the lunar elliptic tide N_2 is important. The diurnal main components, K_1, O_1 and P_1, are very small.

In the English Channel, as partly also in the Irish Sea, there occurs a well-known resonance phenomenon in the tides, producing considerable eigenoscillations of the water mass (see e.g. Pugh, 1987). The resonance period is dependent on the length and the depth of the water basin; in the Channel these quantities yield a resonance period close to the periods of the semi-diurnal tides. Thus there are large semi-diurnal tidal variations at the ends of the Channel. At Plymouth near the western end, close to the place of the loss, the spring tidal range may amount to 6 meters.

The tides are mathematically characterized by their harmonic constants, i.e. by the amplitudes a and phase lags g of the tidal components. The bay of loss is, in this respect, probably best represented by an average of Plymouth (Devonport) and River Yealm Entrance, the principal harmonic constants of which then become:

M_2 $a = 1.65$ m, $g = 155°$
S_2 $a = 0.60$ m, $g = 207°$
N_2 $a = 0.32$ m, $g = 139°$

K_1 $a = 0.08$ m, $g = 123°$
O_1 $a = 0.07$ m, $g = 2°$
P_1 $a = 0.03$ m, $g = 128°$

Harmonic constants for Salcombe, on the other side of Bolt Head, have been used for check calculations.

In shallow waters near the coast of the English Channel - where the height of the tidal wave is no longer negligible in relation to the depth of the water - a special tidal effect occurs. It produces quarter-diurnal tides, the main ones of which are known as M_4, MS_4 and MN_4. These have periods of a little more than 6 hours, half of that of the semi-diurnal period. The quarter-diurnal tides are non-linear "overtides", which are more difficult to deal with than the ordinary tidal components. They were closely investigated by Chabert d'Hières & Le Provost (1970, 1973), using a scaled hydraulic model of the English Channel; this is nowadays replaced by numerical modelling. Their amplitudes and phase lags may be given as (from the POL data bank)

M_4 $a = 0.13$ m, $g = 142°$
MS_4 $a = 0.09$ m, $g = 197°$
MN_4 $a = 0.05$ m, $g = 112°$

Their non-linear character makes them sometimes more important than a quick glance at the amplitudes may reveal; at spring tides the quarter-diurnal tidal variation in the vicinity of the place of loss may amount to half a meter. This group of tidal components turns out to play a noticeable role in our computations.

4. The tides at the event of the loss

In connection with the tidal oscillations of the water mass in the English Channel there occurs a horizontal transport of water. This results in the well-known tidal stream going alternately westwards and eastwards, with some modifications depending on the shape of the coast. The speed of the tidal stream is in general a few knots. Already Derby (1937) has shown that this tidal stream could not to any considerable degree have contributed to the ship leaving its planned course, even if some drift towards land must have taken place. Greenhill & Hackman (1991) do not add anything new in that respect. In any case, on board the ship one should have had knowledge enough to correct for such a tidal deviation of the course.

When the ship for various reasons nevertheless had approached Bolt Head, the tidal situation becomes different. In the vicinity of the coast the tidal stream tends to follow the direction of the coast; we will return to that later, using a numerical model. Still closer to the coast the tidal stream tends to be directed more towards land when the tide is rising, and away from land when the tide is falling, especially if the coastal area is shallow and irregular. We will treat this coastal tide now.

There is no detailed information on coastal tidal streams in the area of the loss. In order to obtain some knowledge of the variations of the tidal streams there we will have to resort to a useful simplification: With good approximation the speed of the tidal stream is proportional to the rate of the rise of the tide. Thus we compute the rate of rise of the tide and use this as a kind of measure of the strength of the tidal stream.

The computation has been performed in the following way. The height of the tide has been calculated for a series of times during the 24 hours from April 24th, 16 00, to April 25th, 16 00, in the year 1936. This time span is symmetric with respect to the hour of the loss, April 25th 04 00. The tidal computations have been performed using harmonic constants as described above, although more constants than those listed there have been applied.

For every time interval between the times mentioned the rate of rise of the tide has then been calculated. The result is presented in Figure 3, in the form of a continuous curve showing the rate of rise, in cm per minute, as a function of time. Positive rates imply a rising tide and an in-going tidal stream, negative rates imply a falling tide and an out-going tidal stream. It can be mentioned that in the entrances to Plymouth and Salcombe a rate of rise of 1 cm per minute corresponds to a stream speed of about 1 knot.

We immediately note that the curve is somewhat asymmetric; it has a pointed maximum which also is shifted to the left. The reason for this is the group of quarter-diurnal overtides described in Section 3. The maximum rate of rise amounts to 2.2 cm per minute, which occurs at around 04 10.

Two interesting questions now present themselves: How large is the variation during this day compared to normally? Where on the curve does the loss occur?

The first question can be answered by comparing the continuous curve in the figure with the dashed one, showing the calculated rate of rise in the normal case (mean variation). As can be seen, the variation during the day of the loss is considerably larger than normal. This is partly due to the tide being fairly close to spring (combination of M_2 and S_2), but also to the moon being very close to the perigee of its orbit (combination of M_2 and N_2). The maximum is extra large, because of the influence of the quarter-diurnal overtides (combination of M_4, MS_4 and MN_4).

The loss occurred, as earlier mentioned, in two steps, a first stranding at 03 55 and a second one at about 04 25. They are marked with arrows in the figure. The second question above can, thereby, be answered: The loss

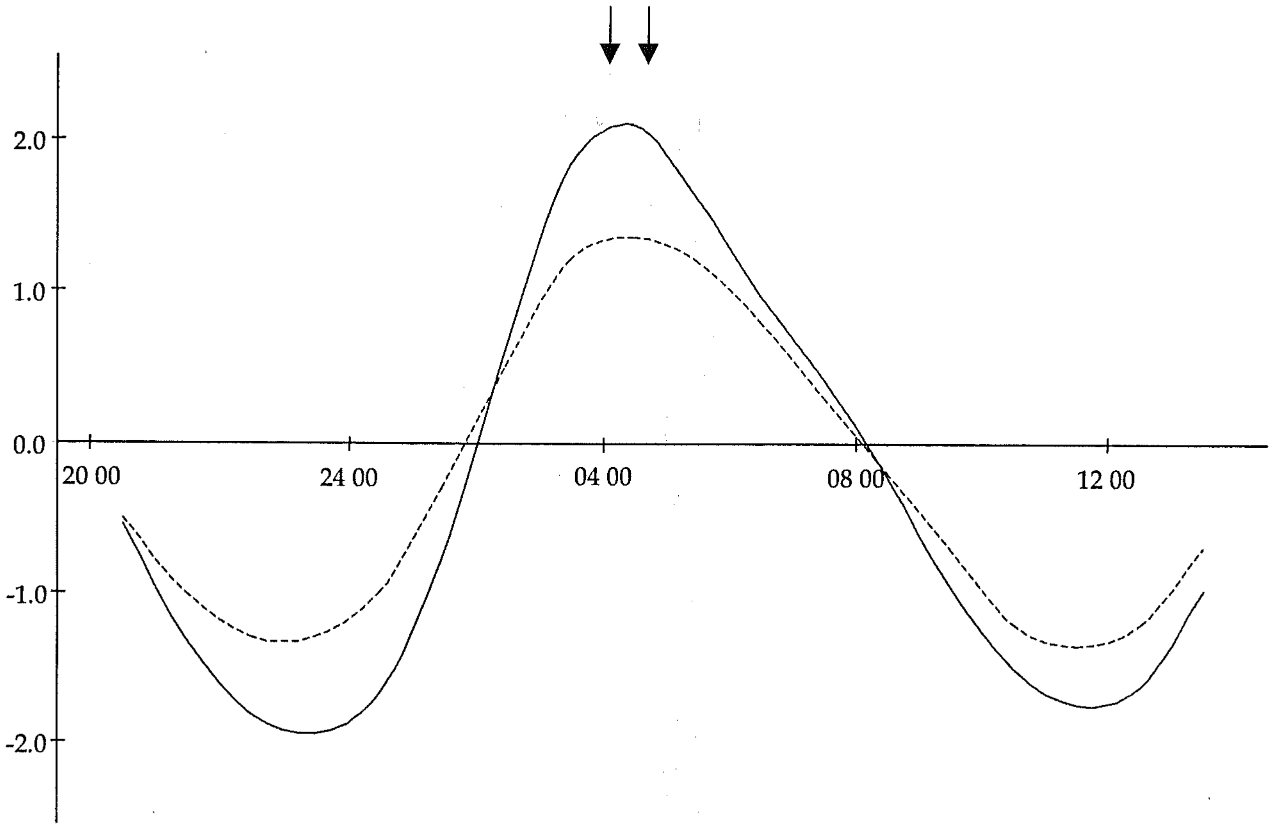

Figure 3. The rate of rise of the tide, in cm per minute, during the day of loss (continuous curve) and in the normal case (dashed curve). The arrows show when the strandings occurred.

occurred precisely at the maximum of the curve. Thus the loss occurred when the rate of rise of the tide was at its greatest. This implies that the in-going tidal stream towards land, i.e. towards north or northeast, was the strongest possible one.

In order to further illustrate the tidal conditions at the loss we can estimate the rareness of rates of rise exceeding 2 cm per minute. It turns out that, over a long time period, such rates occur during only 0.5 % of the time, whereas rates below 2 cm per minute occupy 99.5 % of the time.

In addition to what has been found above, the tidal stream situation further out from the coast, some time before the accident, is of interest. Within an area extending to five nautical miles west of Bolt Head, numerical modelling according to Flather (2000) shows a roughly northwesterly tidal stream exceeding 1 knot during the last hour before the accident, when there are indications that the ship passed through the area. This, together with the coastal northerly to northeasterly tidal stream discussed above, should have put the ship at least 1 nautical mile further to the north than otherwise. This would be sufficient to prevent the ship from passing south of Bolt Head.

5. Conclusion

Altogether, the computations above show that the loss of the Herzogin Cecilie occurred at extremely unfavourable coastal tidal conditions. As the ship due to various other causes had approached a critical situation close to land, the tides, therefore, acted as a strongly aggravating factor.

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