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## **Understanding Lake Vänern.**

### **Science history perspectives on Sweden's largest lake, 1600- 1900.<sup>1</sup>**

After Ladoga and Onega, Lake Vänern in Sweden is Europe's third largest lake. This vast lake have for hundreds of years puzzled scientists, as well as farmers living around it. Lake Vänern did not act like other lakes – it did not rise during spring and was not at its lowest during winter. Its apparent and unpredictable water-fluctuations did not correspond to the weather in the lake area. The lake could for example suddenly increase without any rainy weather, and thereafter decrease for some years without an obvious correlation to the weather. For this reason Lake Vänern could not be understood. This puzzlement is the background to one of the world's oldest series of complete water level measurements in Lake Vänern, starting 1807.

Though Lake Vänern by its vastness is unique, the story of how it came to be understood, is attached to the history of how hydrological understanding have developed. It is a story of for example understanding the drainage basin as a concept, of explaining water level fluctuations and flooding and the role of climate to the water flowing through the landscape (Biswas 1970). The history of understanding Lake Vänern shows how societal needs form a driving force to the development of hydrological knowledge. In this case the use and control of water was significant (Tvedt & Jakobsson 2006). And the more complex the use of water became, the stronger the societal need to understand the water in the landscape became (Jakobsson 1999, Pickering 1992, Shapin 1979 and Biswas 1970). In the case of Lake Vänern, the driving force behind the search for knowledge first and foremost was the lake defined as a risk (Covello & Mumpower 1985). The risk of flooding over the flat shores of the lakes

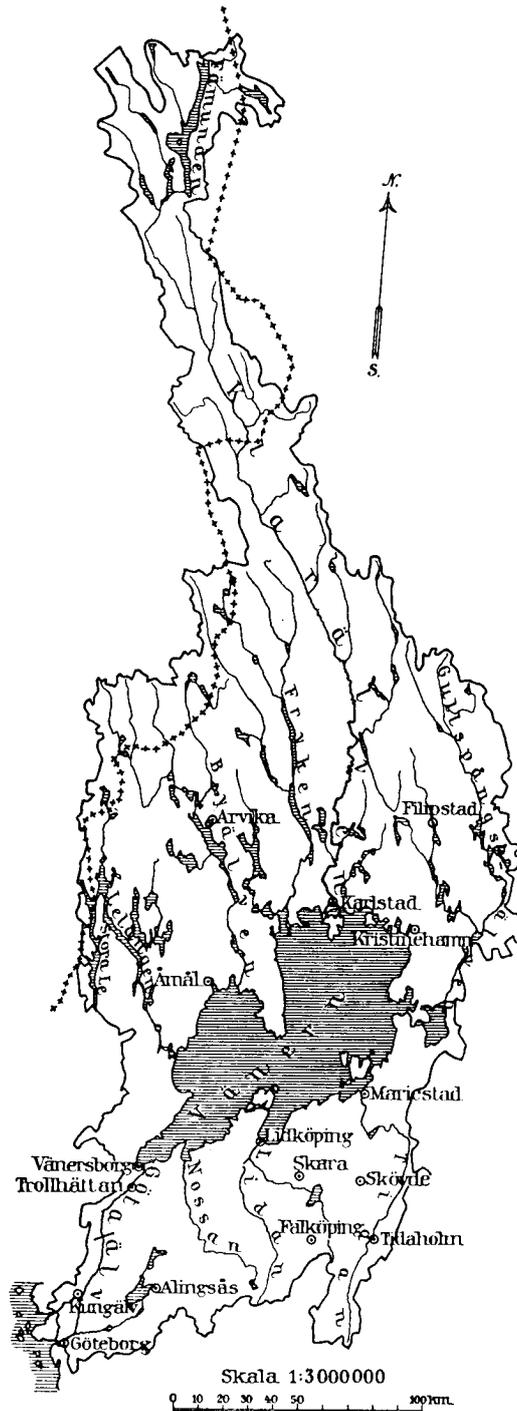
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<sup>1</sup> For a more extensive version see: Eva Jakobsson "Att förstå Vänern. Vetenskapshistoriska perspektiv på Sveriges största sjö 1600-1900". *Arbete, kultur, politik. En vänbok till Lennart K Persson*. Red Aijmer, Malmstedt m fl. Göteborg 2007.

affected all farmers around the lake and to some degree the cities near the lake. In the early 1900s the needs from the dawning hydropower industry grew strong. After the lake was regulated for hydropower production the risk scenarios weakened as it became more important to predict varying inflows for managing the hydropower reservoir.

### Lake Vänern drainage basin

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## Understanding Lake Vänern

Let us now follow how the Swedes slowly came to understand lake Vänern. The first description of lake Vänern in a water system perspective is found in Olaus Magnus "History of the Nordic peoples" (1555). In this book Magnus pays attention to the water in the landscape and he writes that the most excellent of all the lakes was lake Vänern. The most characteristic by the lake, says Olaus Magnus, is its 24 inflows, while the lake is drained only by one outlet. Olaus Magnus writes: "*The streams and rivers fall out into the lake with a great thunder and swirl. Because its lengthy shores are surrounded by mountains, one cannot anywhere find an outflow more than in one place. In this place the current is so rapid and noisy, that it can be heard in more than 20 Italian miles distance*" (Magnus, Andra boken, 30 kap).

The 24 inflows and only one outflow formed an idea that there must be another outflow somewhere – the theory of a tunnel to Sweden's second largest lake, Lake Vättern, was formed. This tradition leans on Aathanasius Kircher (1602-1680) and his book *Mundus Subterranus* where he described an underground water world of reservoirs where all the great rivers had their sources (Biswas 1970). Kircher also mentions that lakes Vänern and Vättern are communicating. Further this theory is mentioned in 1704 by the scientist Urban Hiärne in a text published in *Philosophical transactions* at Royal Society in London. The same stories are told about the Caspian Sea and its underground connection to the Black sea and the Persian Gulf (Hag 1982, Frängsmyr 1969, Högbom 1932, Richter 1959).

The internationally well known 18<sup>th</sup> century scientist, theologian and philosopher Emanuel Swedenborg (1688-1772) wrote on Lake Vänern in "*On the descending and rising of lake Vänern*" (Swedenborg 1907), probably written in connection to an assignment for planning a new water way between Lake Vänern and the Sea. Swedenborg wrote that by its "*dreadful large width*" it was one of the world's largest lakes. Swedenborg describes how the lake could rise up to 1,8 metres during five to six years, leading to the riparians losing their fields and meadows. Swedenborg rejects explanations like wind pressure, tunnels, variations of in- and outflow. For Swedenborg the question still remained why the lake raises and drops over time. Finally Swedenborg found his solution in the different characteristics of fresh and salt water. According to Swedenborg fresh water is a liquid more light and tough than salt water. By this, freshwater cannot as easily as salt water keep its horizon and surface flat. It was

the fresh water's toughness that caused a height in the middle of the surface of the lake. When this height became too high it flattened out and the lake rose at the shores and harmed the riparians.

The first to make an empirical study on the water levels was the 18<sup>th</sup> century mayor of the small town Mariestad, Jonas Vallin - a man of the enlightenment. By way of systematic observations, Vallin was the first to open for an understanding of Lake Vänern in perspective of its position in its drainage basin. He writes that his motivation to start his observations was to find the solution of the "*unpredictable sufferings of Lake Vänern's flooding*" (Vallin 1818). From 1729-1756 he could establish a difference of three metres between the lowest and the highest water levels. As a critique of many of the former grand theories Vallin wrote, that the shifting water levels reflected: "*whether the fall of snow has been heavy or light: so that the saga commonly told, that this lake for seven years grow and for seven years decrease, is lacking any foundation and is without any truth*". In the Vallin explanation it is the present years precipitation and the great amounts of snow that fall both in the Swedish and Norwegian mountains that causes the water level variations. In this perspective Lake Vänern is dependent of the spring and summer precipitation and temperature in its drainage basin. The most apparent pattern is between water levels and the amount of snow fallen in the northern parts of the drainage basin, especially in the Norwegian mountains.

The mystery of the Lake Vänern's apparently unpredictable water level fluctuations was solved when the lake was placed in its comprehensive and lengthy (756 km) drainage basin, stretching out and into the Norwegian mountains. The key was to understand the importance of the drainage basins extensiveness (50 115 km<sup>2</sup>) and its different types of climate and drainage regimes. The lake was dependent of the precipitation and climatic conditions in a very long drainage basin. This was the first step to understand the role of the whole drainage basin for the water level fluctuations of Lake Vänern.

The role of evaporation from the lake's surface (5 648 km<sup>2</sup>) was described at the same time by the astronomer Birger Vassenius in his article "*Remarks on the lake Vänern*" (Vassenius 1758). As Vallin Vassenius holds that the weather in the drainage basin explained the raising and lowering of the lake. However, he brought in the evaporation that was absolutely absent in the Vallin analysis. The evaporation from the large water surface could be described as a local source of variation.

Still new insights in the nature of Lake Vänern were to be disclosed. As for example that the inflow to the lake was dependent on the *speed* of the snow melt. During a cold summer a lot of snow did not melt in the mountains and was left to the next snow-melting period. The vastness of lake Vänern was another variable; “*He swings between the shores, as the wind drives the water from one shore to another*” (Hagström 1825). Since the 1600s there have been plans for opening or widening the outlet of the lake with the purpose of lowering Lake Vänern – and as late as the late 1990s, a couple of years after some flooding, a tunnel from Lake Vänern shortest way to the sea have been proposed (SOU 2006). But as one 19<sup>th</sup> century writer concluded – after having proposed a widened outflow of the lake – who could predict the consequences, especially what would happen down stream in River Göta (Ericsson 1861)?

In the late 19<sup>th</sup> century one had to take into consideration a very complex system of competing interests that had developed in the Lake Vänern – River Göta water system: the interest of lowering the lake – to protect riparian and towns from flooding; the interest of navigation - not to lower the lake as much that it harmed navigation; the interest of protecting Sweden’s second city – not to flood Gothenburg situated at the outlet point of the whole drainage basin.

Simply to open and widen the outlet of Lake Vänern to create a non-controlled outlet was because of this complexity of interests impossible at the end of the 19<sup>th</sup> century. It was not until 1938 that the State Power Board was given permission to regulate Lake Vänern, and the main purpose was not flood-protection. Now the value of the lake was to use it as a reservoir for the state-owned hydropower plant located just south of the Lake Vänern outlet. The largest hydropower reservoir in Sweden was created, with a 9,4 km<sup>3</sup> volume and a regulation amplitude of 1,7 meters.

To predict the water level fluctuations in Lake Vänern today is not enough to understand the water flow in the drainage basin – we also have to take the strategy of hydropower production in a deregulated European electricity market into account.

### **Lake Vänern - an outlook**

At the same time a new agenda for understanding Lake Vänern is emerging. The new assignment for the hydrologists is not to understand the lake in its present state, but as a future lake. As the climate changes will bring more precipitation and milder winters, new drainage patterns in this large drainage basin will develop and new risk scenarios emerge (SOU 2006, Carlsson 2006). Lake Vänern will once again puzzle us and new

efforts will have to be put down to understand Lake Vänern. And still the societal context of controlling the water is present - again we need to know when the lake surface raises and floods out over its shores.

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